SCIENTIFIC OCEAN DRILLING

CREDIT: Patty Standring & IODP

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SCIENTIFIC OCEAN DRILLING

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Happening now...
Expedition 401: Mediterranean-Atlantic Gateway Exchange

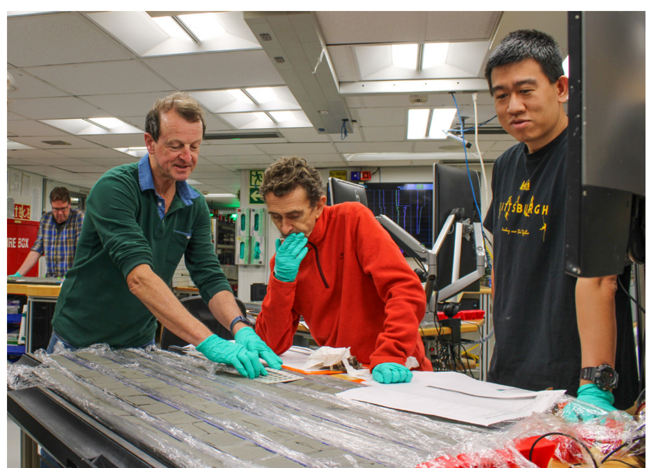
Rachel Flecker and Emmanuelle Ducassou,
Expedition 395 Co-Chief Scientists;
Trevor Williams, Expedition 401 Project Manager

written by Erin Winick Anthony and Kellan Moss, Expedition 401 Onboard Outreach Officers

As the *JOIDES Resolution* (JR) enters the final days of Expedition 401, the scientists aboard can already say the mission has been a wonderful success. The aim of this expedition is to recover late Miocene to early Pliocene paleoceanographic records on both sides of the Gibraltar Strait, which will give researchers a clearer view of the exchange of water between the Mediterranean and the Atlantic 4-8 million years ago, and the impact of this exchange on global climate.

The JR and Expedition 401 scientists left Amsterdam on December 13, 2023 and headed south through the Atlantic, collecting sediment cores at three of the expedition's four drilling sites on their way. For their final location they sailed through the Gibraltar Strait and into the Mediterranean Sea. Expedition 401 has been remarkably lucky so far. The Atlantic during the winter season is known for its rough weather, but this science party has successfully avoided two major storms and even eaten many meals outside.

The luck doesn't stop there. Expedition 401's core recovery at the first three sites has been unbelievably high, with the current total sitting at 86.7%. This wouldn't be unusual if the sediments were just a few hundred meters below the seafloor, but in this case, because the scientists are after older sediments, the target samples are buried much more deeply. Some of them are more than 1km below the seafloor.



TOP: A set of sample request tags next to the working half core sections (Credit: Xunhui Xu & IODP). BOTTOM: Expedition 401 scientists describe core sections (Credit: Patty Standring & IODP).

LEFT: Expedition 401 scientists tour the rig floor to learn about drilling operations (Credit: Erick Bravo & IODP JRSO). RIGHT: An onshore audience learns about shipboard chemistry during an outreach tour (Credit: Erick Bravo & IODP JRSO).

To work out how Earth's climate changed in the past, scientists need as complete a sediment record as possible, so high recovery rates are important. The other thing that really matters is the composition of the sediment. The science party anticipated sandy cores, particularly close to the Gibraltar Strait where the current is faster. But rather than sand, the team recovered lots of mud. This is brilliant news, as mud preserves shells and organic molecules, with their delicate structures, much better than sand. It's the chemistry of these tiny fossils that records how the ocean responded to climate change millions of years ago.

Expedition 401 is part of a much larger scientific endeavor to reconstruct the last 8 million years of Earth's climate, taking us back to a time when there was ice only at one pole, covering the Antarctic landmass in the south. Cores from this part of the eastern Atlantic are critical because water masses, formed at both poles and in the Mediterranean, flow through here, leaving their signatures in the sediment. Expedition 401 is the latest in a suite of previous *JOIDES Resolution* expeditions (IODP Expeditions 399, 397, 339, ODP Leg 161, and DSDP Leg 13) dating back to the 1970's that, through high-resolution sedimentary records in the Mediterranean, provide an incredible legacy for future research on global climate, plate tectonics, and sedimentary processes.

Expedition 401 hasn't just been successful in terms of recovering core; its outreach has been multi-faceted and far-reaching. This expedition scheduled over 70 ship-to-shore tours, and has so far reached more than half a million people in 10 countries. The research was also covered by media outlets including The Weather Channel, BBC, CBS Mission Unstoppable, H5News, and more. Various universities from across the globe attended tours held in six languages by the outreach officers and science party. This enabled the message of Expedition 401 to be a global one, and for the scientists to connect with communities local to the drilling sites. Tours have connected with students as young as five years old, inspiring the next generation of ocean explorers.

Expedition 401 also has had unique outreach featuring over 40 social media videos that dive into life at sea and the science aboard. The scientists have participated in a series called "Science in 60 Seconds" where they are challenged to tell the audience the specifics of their science field in one minute. These social media videos have received hundreds of thousands of views in total. A visual artist aboard has also captured the science party and drilling crew at work. This stunning artwork varies from charcoal sketches of equipment to detailed chalk pieces to digital portraits.

The expedition is scheduled to conclude on February 9, 2024 in Naples, Italy.

In the works...
Expedition 402: Tyrrhenian Continent-Ocean Transition

Nevio Zitellini and Alberto Malinverno
Expedition 402 Co-Chief Scientists
Emily Estes, Expedition Project Manager

written by Tessa Peixoto and Larkin Bohn, Expedition 402 Onboard Outreach Officers

The Tyrrhenian Sea takes its name from a population settled in Italy that ancient Greeks called Tyrrhenians, also known as Etruscans. This civilization flourished in the 1st millennium B.C., largely based on the iron trade fueled by mines on Elba Island, which is located at the northern tip of the Tyrrhenian sea. The Etruscans ended up taking part in the early Roman civilization, conforming to Rome's cultural and artistic traditions, including the spectacle of gladiatorial combat, hydraulic engineering, temple design, and religious ritual. Known for their navigational expertise, they became a major Mediterranean trading power. Taking a cue from the seafaring Tyrrhenian people who embraced innovation and sea voyaging, so too will the adventurous crew of Expedition 402 venture out to sea to get answers about our Earth.

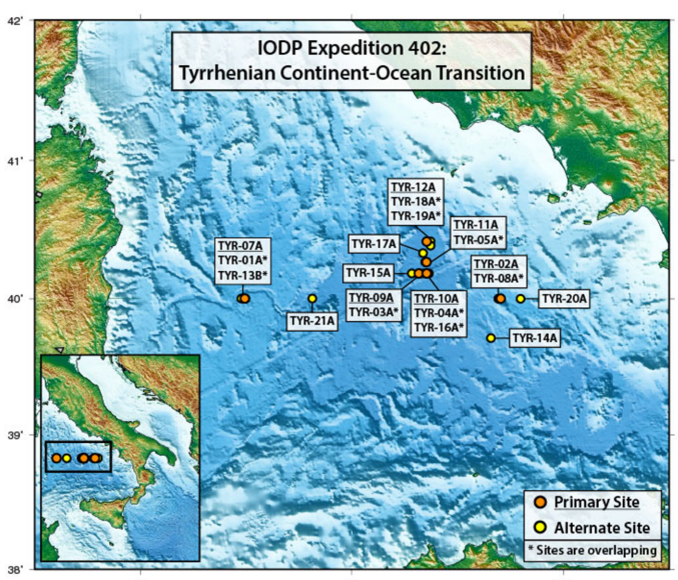
A 3rd century mosaic from the Roman villa Dougga shows young Dionysus transforming Tyrrhenian pirates into dolphins (Credit: Dennis Jarvis and Bardo National Museum).

Although there is a rich history on the water's surface, Expedition 402 is more interested in what has been going on beneath the sea surface and the seafloor (around 12,000ft below!!). The Tyrrhenian seafloor is special because the tectonic plate that forms it stretched until it ripped like taffy being pulled, exposing the elusive rocks of the upper mantle that typically lie several kilometers below the Earth's surface. That part of the seafloor is the target of Expedition 402.

The samples of the oceanic crust and exposed mantle will provide tangible data to build on current knowledge and answer the following questions:

- How does tectonic plate movement and stress lead to volcanism and earthquakes? The more we know about these events, the better safety measures we can take.
- How do ocean basins form? The sediment record will offer a rich, detailed archive of climate history of this part of the Earth, i.e., when it was more wet, dry, hot, or cold, and when the Earth had higher or lower sea levels.

- How do continents form and move around? By better understanding the formation of continental margins and ancient supercontinents like Pangea, we can better predict plate motions and their future effects.
- How does magma push through existing crustal rock to make new oceanic crust? This adds to our understanding of natural geological processes like volcanic eruptions. It also can help us understand what kinds of minerals we can expect to find in different geological formations that are economically important to society.
- How does gaseous carbon dioxide get trapped to form solid minerals within crustal rocks? This process, a key aspect of carbon sequestration, can help us understand and combat climate change.



TOP: The Tyrrhenian Sea (Credit: World Atlas). BOTTOM: Map of Expedition 402 drill sites (Credit: Zitellini et al., 2023).

The Tyrrhenian Sea basin is very young, geologically speaking: 15 million years compared to the Atlantic Ocean pushing 150 million! While humans like to think age is nothing but a number, in this case it's important because it means less time for sediment to pile up and cover target rocks from the mantle and oceanic crust. While the Tyrrhenian Sea has a sediment thickness of about 400m, the margins of the Atlantic Ocean are covered by several kilometers of sediment. Sediment is all the sand, mud, clay, and microfossil shells that fall onto the seafloor. A thinner sediment layer means the *JOIDES Resolution* won't drill for long before hitting the hard rock targeted by Expedition 402 scientists. Nevertheless, that doesn't mean the sediment is less important than the hard rock! Sediment holds lots of information for micropaleontologists, microbiologists, and sedimentologists to study. For example, the age of the oldest sediment will reveal the time when the deep Tyrrhenian Sea formed.

Retrieving samples from the Continental Oceanic Transition (COT) is another major focus of the mission. Typically, the COT, which is the boundary between continental and oceanic crust (hence the name "transition") is hard to sample because of the thick layer of sediment that sits at the top, but due to the Tyrrhenian Sea's youth we will have an easier time drilling into the COT. The less time spent drilling through the overlying sediment layer, the more time operations can focus on drilling into and recovering rocks from the crust and mantle. By sampling both oceanic crust and exposed mantle at six different sites in the Tyrrhenian Sea, Expedition 402 scientists will better understand how COTs form globally.

Over the course of the expedition, the *JOIDES Resolution* will drill two perpendicular transects. One transect will go from east to west and target the part of the seafloor that progresses from basaltic crust to exposed mantle. Meanwhile the second transect will go from north to south and will map the fault zone or the "rip" in the plate that exposes the exhumed mantle. Drilling in these two directions helps answer questions about what is happening to the tectonic plate as it is being stretched, how the mantle and crust change over time as they are exposed to seawater, and the characteristics of the crust at the continent-ocean transition.

The deepest drill site sits under 3600m of water while the shallowest site is about 2700m. Each drill site will bring up samples of sediment and hard rock, which will keep everyone busy.

TOP: The Amalfi Coast overlooking the Tyrrhenian Sea (Credit: Mihael Grmek). BOTTOM: Expedition 402 will begin in the port of Naples, Italy on 9 February 2024 (Credit: Lance Mountain).

Please join the two outreach officers, Tessa and Larkin, to learn more about Expedition 402 and follow along as they publish blogs on the *JOIDES Resolution* website and post to X (formerly Twitter), Facebook, and Instagram. Sign up for a ship-to-shore connection to get onboard virtually with a personalized tour of the ship's drilling operations, scientific laboratory, the ocean views, and the Captain's bridge.

How to...
Find IODP Citations and Bibliographic Information

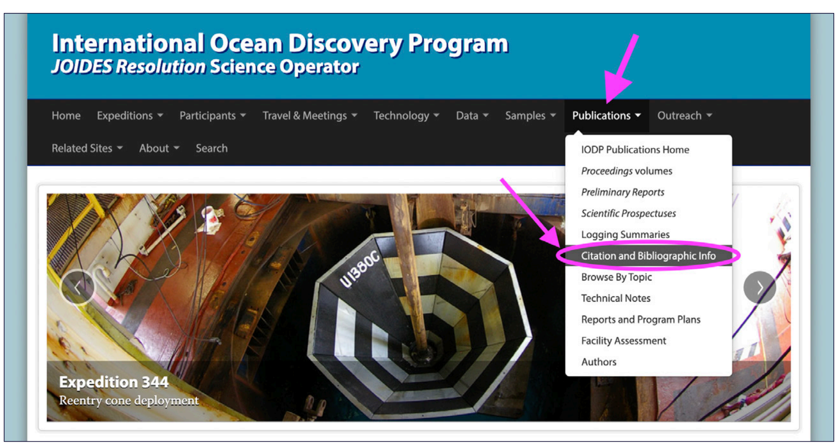
written by Maya Pincus (USSSP)

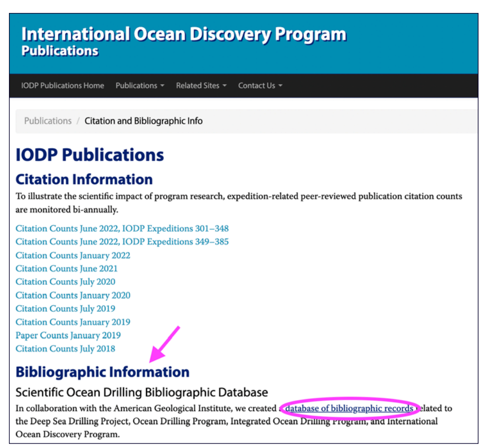
Many scientists are familiar with the quote attributed to Isaac Newton: *If I have seen further than others, it is by standing on the shoulders of giants*. This idea traces back to a 12th century metaphor, rooted in Greek mythology, in which a dwarf climbs the back of a blind giant so they both can extend their vision. Whatever the origin, the message is clear: as scientists, we are able to accomplish so much because of the work that was done by those who came before us.

In the case of scientific ocean drilling, our giants are the countless researchers who have contributed to the field since the very first Deep Sea Drilling Program expedition. They have chronicled their work in countless publications, the number of which increases with each new expedition. These articles, invaluable sources of data and implications about our planet, can fuel a new era of scientific achievement. To tap into this rich fund of knowledge, look no farther than the IODP Publications Bibliographic Database! To search for publications relevant to your work, follow the steps below.

- **Step 1:** Navigate to the IODP JRSO website (https://iodp.tamu.edu/)

- **Step 2:** Select "Publications" from the main menu, then click "Citation and Bibliographic Info" from the dropdown menu.

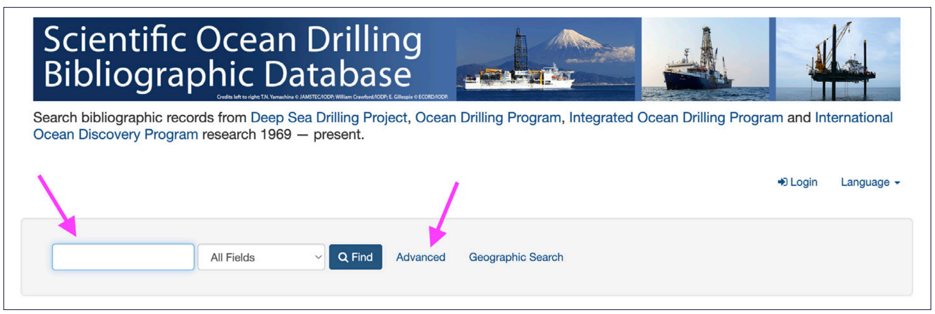




- **Step 3:** To access a database of bibliographic records related to scientific ocean drilling, click the eponymous link under the "Bibliographic Information" heading.

- **Step 4:** Step 4: Click the "[Search the Database]" button.

- **Step 5:** Enter a key search term, or click "[Advanced]" for more detailed options. You can specify author, expedition, region, year published, language, or any relevant topic.



- **Step 6:** Give credit where credit is due—once you find the article you were looking for, click "Cite this" for formatted citation information.

FEATURED VIDEO

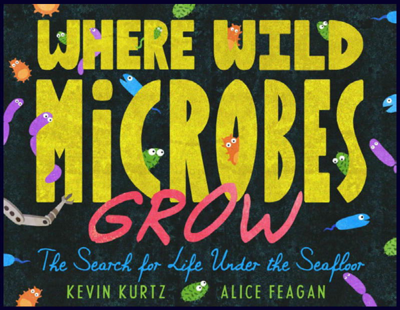
EXP401 Investigates the Messinian Salinity Crisis

Sailing from December-February 2024, Expedition 401 aboard the *JOIDES Resolution* is looking back millions of years to when the Mediterranean looked very different from today. From getting cut off from the Atlantic to the formation of a more than 1,000 meter thick salt giant, this region has had major impacts on the world's oceans.

For your calendar

- **Submit a LEAP proposal**
  (open 15 February - 15 April 2024; learn more)
- **U.S. Advisory Committee for Scientific Ocean Drilling Meeting**
  (29 January - 1 February 2024; La Jolla, CA, USA; learn more)
- **Ocean Sciences Meeting**
  (18-23 February 2024; New Orleans, Louisiana, USA; learn more)
- **Workshop on the Future of Scientific Ocean Drilling: Toward Submission of Drilling Proposals for IODP³**
  (18-20 March 2024; Nachikatsuura, Kii Peninsula, Japan; learn more)
- **Future of U.S. Marine Seafloor and Subseafloor Sampling Capabilities Workshop**
  (26-28 March 2024; Woods Hole, MA, USA; learn more)

SCI COMM RESOURCE OF THE MONTH



This free ebook introduces readers to some of the most amazing discoveries of the *JOIDES Resolution*: life below the seafloor!

Where Wild Microbes Grow

Spotlight on...
Dr. Matthew Jones

written by Maya Pincus (USSSP)

Credit: Matt Jones

Deep below the ocean floor, buried under countless layers of sand and bioturbated mud, is a strikingly dark layer of shale. The mysterious layer represents a time when Earth's oceans were suddenly deprived of oxygen, their acidity drastically increased, and global temperatures averaged almost unimaginable highs. Characterized as both scientifically and economically valuable, these rocks tell the story of a time when Earth was barely recognizable, but may provide insights into our not-so-distant future. This is Cretaceous Oceanic Anoxic Event 2. It also happens to be the subject of one of the many lines of research that 2023-2024 Ocean Discovery Lecturer Dr. Matthew Jones has pursued throughout his career, first as a graduate student sailing aboard the *JOIDES Resolution* and now as a research geologist at the U.S. Geological Survey.

Matt first learned about the renowned research vessel as an undergraduate student at the University of New Hampshire, where he ended up after a childhood full of hikes with family members, scenic drives along county backroads, and a deep fascination with maps. A geology course in his first semester only fueled this passion: "Seeing the geologic perspective was really fascinating to me, kind of like 'oh, there's more to maps—there's everything underground too!' At that point I was pretty much hooked." Coming to know that the best way to a career in geology was through field work and research, college-aged Matt made sure to involve himself in as many of these opportunities as possible. For his senior thesis, he worked on outcrops in the Western Interior Basin of the U.S., studying the Cretaceous-Paleogene boundary. To augment the work, Matt's advisor encouraged him to correlate his observations from the heart of the continent to samples collected offshore during ODP and IODP expeditions. Reading studies from these earlier expeditions, he learned about the brilliant adventures offered by the *JOIDES Resolution*, planting the seed to one day join the science party of an ocean expedition.

This thought was put on the backburner, given that he graduated into "not the best economy or job seeker's environment." Eventually he found a mining job in upstate New York, which gave him the chance to see cross-sections of the stratigraphy of the Northeast U.S. uniquely exposed in quarries across the region. Over time, he grew more and more interested in natural resources and how rocks tie back to the human environment, reestablishing his hunger for research. He decided to go to graduate school at Northwestern University, where he studied stratigraphy and paleoceanography with advisor Brad Sageman. The connections between the outcrops of Cretaceous marine strata they studied in the U.S. Western Interior and deep sea cores were apparent, and the *JOIDES Resolution* was never far from his mind.

In the years leading up to his first expedition, he assumed sailing with IODP was something "so competitive and so exclusive" that it could only be done by an elite crew, while he could resign himself to merely

As the Physical Properties Specialist aboard the *JOIDES Resolution*, one of Matt's tasks was to process natural gamma radiation data (Credit: Debadrita Jana & IODP)

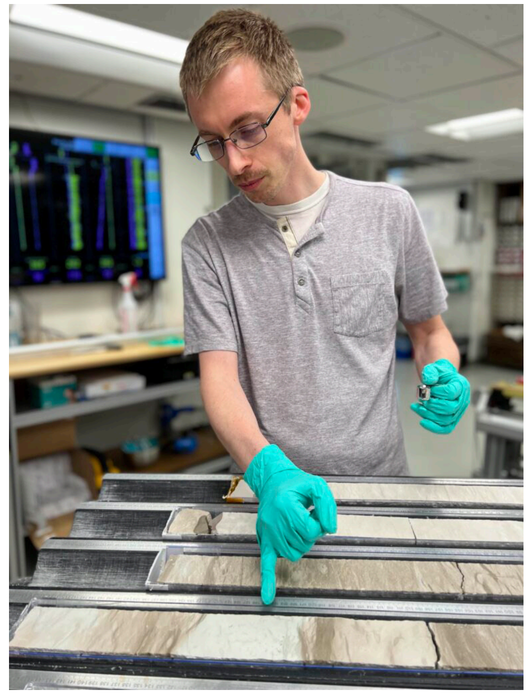
"read the papers and enjoy the papers" published by shipboard scientists. Still, even though it seemed like "getting on the ship would be a different hurdle to clear," when the call to sail for Expedition 369: Australia Cretaceous Climate and Tectonics was announced, Matt informed his PhD advisor that he wanted to get involved. In the face of Matt's determination, his advisor was nothing but supportive, saying "Okay! We'll shoot for it and see what comes of it."

Matt will argue that the primary reason he was accepted was his willingness to take on shipboard roles that most people typically do not consider applying for (though I'll add that his prior research acumen must also have been a factor), and "It turns out that there were fewer people than I realized who want to spend eight weeks at sea, confined on a ship, working twelve-hour shifts!" Between being flexible and being resoundingly qualified, Matt was invited to sail, and so he joined Expedition 369 as a Physical Properties and Downhole Measurements specialist.

His experience at sea was formative, academically and professionally. In the years since that expedition, Matt has written several papers with his science party, exploring the Cretaceous greenhouse paleoclimate in southern high latitudes. In particular, he interrogates sediments from the Mentelle Basin and Australo-Antarctic Gulf, which formed as Australia rifted from Antarctica. These materials act as a window to better understand Cretaceous Antarctic conditions, given that modern ice cover makes much of the Antarctic continent inaccessible to direct geologic sampling. As Matt describes it, "The next best thing you can do is find a sedimentary basin that has rifted away from its original high-latitude setting." To study these sediments, he works extensively with collaborators, including Expedition 369 co-chief and microfossil specialist, Brian Huber, at the Smithsonian, and isotope geochemist Sierra Petersen, at the University of Michigan.

From the samples he collected during Expedition 369, Matt and his colleagues are producing "a lot of interesting research and findings into just how warm the planet was during the Cretaceous," understanding that the Cretaceous Oceanic Anoxic Events may be "among the best geologic analogs for what happens to the planet when large amounts of CO_2 get released into the ocean-atmosphere system." This research attempts to quantify exactly what global factors contributed to such an extreme environment: *What does it take to plunge the ocean into anoxic and acidic state for close to half a million years? How much CO_2 and other volatile gasses from large igneous provinces had to be emitted to get Earth's oceans to that point? Were ocean gateways critical? Was it just bad luck of where the continents were located when the large igneous provinces erupted? Was it something fundamental to the Wilson cycle? What are the* numbers *from proxies that will help us understand?* The way Matt tells it, these are not just big questions with regards to the Cretaceous and its oceanic anoxic events, but to Earth's history and Earth science as a whole.

It would be five years before Matt had another opportunity to sail ("because that's how long it took to forget how seasick I was the first time!"), this time on [Expedition 392: Agulhas Plateau Cretaceous Climate](). This region captured his attention because again the cores could provide insight into the formation of different ocean gateways and the rifting of Gondwana. Additionally, the Cretaceous-aged Agulhas Plateau was hypothesized to be a large igneous province—a type of volcanic feature linked to the triggering of the Cretaceous ocean anoxic events—and Expedition 392 provided the first chance to conclusively test the idea by drilling into its basement rocks.



Matt has always been reflective about his work, but the Expedition 392 Onboard Outreach Officer, Maryalice Yakutchik, took this to a new level while they were at sea. For her project [3.9.2.haiku](), she asked scientists to write a poem about each section of core recovered from one of the holes they drilled. For Matt, "it was nice to take a step back from the day-to-day of measurements and think a bit more broadly about what we were recovering, what these sediments represent from the history of our planet, what conditions would have been like, and what life would have been like for those little microbes at the end of the Cretaceous… I loved having [Maryalice] come in and ask the question of *Why?* 'Why is this important? Why are we so focused on this dataset or this interval?' That's the crux of this all."

TOP: Matt points to evidence of the Cretaceous-Paleogene boundary in an Expedition 392 core (Credit: Maryalice Yakutchik & IODP). BOTTOM: One of the two haiku Matt wrote about Hole U1580A (Credit: Maryalice Yakutchik and Marlo Garnsworthy).

(An aside: In an unrelated call with Maryalice, I happened to mention that I had a chance to talk with Matt about his work. Maryalice gushed. "He explained things in a way that never made me feel stupid. He made me feel excited," she raved. "I can honestly say that of all members of the science party, I was most moved by his patience and generosity of intellect.")

Beyond acquiring samples for his own research, Matt acknowledges his participation in an IODP expedition as a contributing factor to his success as a scientist. "I feel so lucky to have been involved in these expeditions because I now get to apply what I learned," he says. Being a member of the science party is a "really rare opportunity to learn about the distinct research sub-disciplines within Earth science and how they combine to create a much fuller understanding of sedimentary basins," allowing participants to develop "a plethora of skills they can tap into later on."

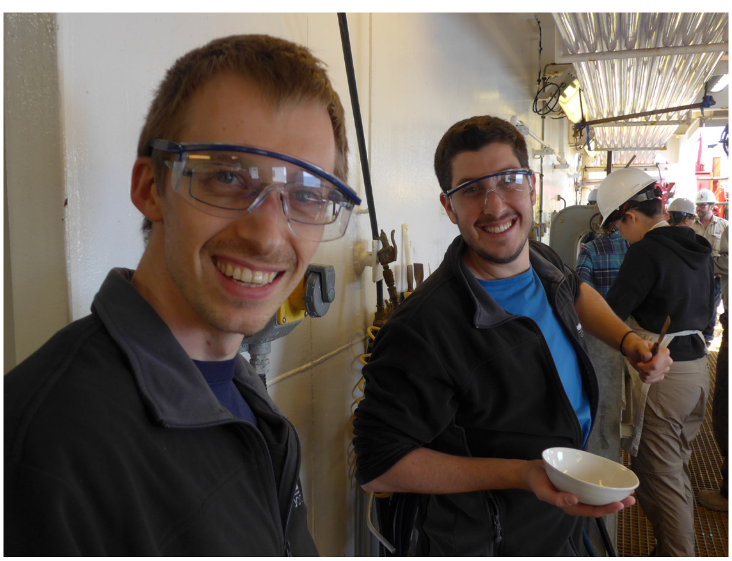
These days, Matt is certainly tapping into these skills, but from a new perspective. A year ago from the day of our interview, he began a new position in the Geology, Energy, and Mineral Science Center of the U.S.

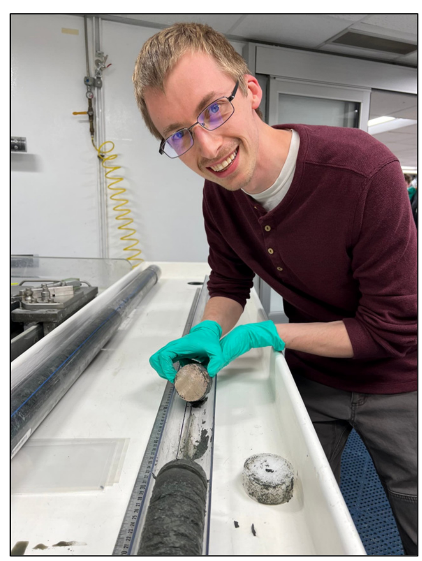
Geological Survey (USGS) in Reston, Virginia. In this role, he not only continues to tackle the mystery of Cretaceous Oceanic Anoxic Event 2; he also applies concepts from scientific ocean drilling to new USGS research initiatives. As a part of the USGS Energy Resource Program, he works with teams of geoscientists who are researching how pore space in sedimentary basins can play a role in the energy transition and be utilized to reduce and mitigate greenhouse gas emissions. He is involved in assessments of the resource potential in the U.S. for emerging technologies like CO_2 sequestration and mineralization, as well as geologic storage of hydrogen, which may be established as an important green energy source in the future.

Matt also brings his sweeping insight to the Ocean Discovery Lecture Series. Though his presentation has the quite specific title "Anomalous Volcanic Carbon Dioxide Release and Cretaceous Ocean Anoxic Event 2," Matt is using the platform to present IODP research as a "retrospective on what scientific ocean drilling has contributed to study of the Cretaceous and greenhouse paleoclimates." In his words, "the whole sub-discipline wouldn't exist as it does without DSDP and the subsequent drilling programs." And as thrilled as he is at the opportunity to present his work to universities around the country, he is perhaps more grateful that it provides him a chance to meet other researchers. In ocean drilling research, "you have ideas that are based just on this couple-inch-diameter core." Matt has enjoyed testing his ideas on the lecture series, by talking to students and faculty studying the same time periods or considering similar questions about Earth history and paleoceanography.

This appreciation of his colleagues is apparent whenever Matt talks about scientific ocean drilling. Several times throughout our interview he interrupted himself to laud the expertise of the technicians who sailed with him, citing them as the main source of success in each expedition. (He also edited my first draft of this article to make sure the names of his mentors and colleagues were included). When I asked if there was anything else he wanted me to know before we concluded he said, "I want to focus on the international aspect of IODP and how important that has been in my career… So much of scientific ocean drilling has been very visible—breakthrough papers, flashy expeditions—but in the background is unspoken work going on linking scientists from around the world to share knowledge and expertise, and push science forward."

It's clear from his record that Matt knows a thing or two about pushing science forward. It's also clear that he's nowhere close to done. He has several research projects lined up for him at the USGS, many of which build on his work with IODP and concepts learned at sea. And as to the future of scientific ocean drilling? He says, "I'm very intrigued to see what comes next."





LEFT: Matt and Odysseas Archontikis eagerly anticipate core on the catwalk (Credit: Thomas Westerhold & IODP). RIGHT: Matt shows off a fresh core from the Agulhas Plateau (Credit: Maryalice Yakutchik & IODP).

Spotlight on...

Dr. Elizbeth Trembath-Reichert

written by Maya Pincus (USSSP)

Credit: Elizabeth Trembath-Reichert

Life. One of Earth's great mysteries. Also one of the great mysteries of the worlds beyond Earth.

Solving this mystery—or even just learning more about it—is at times as difficult as looking for a needle in a haystack. Or, to put it more accurately, like searching for a *single cell* in a cubic centimeter of sediment.

This challenge is not for the faint of heart or the easily discouraged; rather, it requires someone curious, creative, and energized by "the sort of team-based problem-solving where everyone is contributing their own knowledge to answer a larger question beyond what one person would be able to answer themselves." Enter Dr. Elizabeth Trembath-Reichert, assistant professor at the Arizona State University School of Earth and Space Exploration, microbiologist extraordinaire, and 2023-2024 U.S. Science Support Program Ocean Discovery Lecturer.

Elizabeth describes scientific ocean drilling, and science in general, as an "evolved interest." When she first started her undergraduate degree at Barnard College she planned to major in international politics. That path got her interested in environmental policy, which led her to change her major to environmental science. She also threw in a physics minor for kicks. Realizing her love of field work and eagerness to address new, big problems, she continued her journey to the California Institute of Technology for graduate school in the field of geobiology.

As for her introduction to the International Ocean Discovery Program, Elizabeth may just win the "most unexpected" superlative: "I got into IODP basically because a tsunami happened," she recounted, straightfaced. Long story short, her grad school labmate had planned to sail on Expedition 337: Deep Coalbed Biosphere off Shimokita aboard the *Chikyū*, but after the expedition was delayed due to a tsunami off the coast of Japan, her no-longer-available labmate passed off the spot to Elizabeth. And of course she was hooked. To her, the expedition was a "science paradise"—"You're only there to think about your own part of the pie, but you also get to learn from other people and try to answer big questions."

When Elizabeth calls them big questions, she means it. She interrogates the deep biosphere for signs of life with an "astrobiology bent," and will be the first person to tell you that in her field, the term "extremophile" is a misnomer—when working with deep subsurface samples, it's a more a matter of "who's just

Aboard the *Chikyū,* Elizabeth crushed rocks to prepare samples for 888 incubations (Credit: Elizabeth Trembath-Reichert).

not dead yet." The methods to do this work are painstaking. After drilling to record depths (Expedition 337 still holds the record for deepest ocean borehole, at over 2,111 meters below the seafloor), samples must be incubated for a couple years to encourage the rare cells to reproduce, or even grow at all. While at sea, the Expedition 337 microbiology team managed almost 900 individual incubations. Elizabeth justifies this unfathomable workload with "When you have these super rare, precious chances to look within the Earth, you want to get the best you can out of it."

Each incubation is its own experiment to learn more about the microbes that might be hiding in the samples. Elizabeth adds different types of food sources with rare isotope tracers to see what makes the organisms flourish, to better understand the ecosystem deep below the seafloor. For example, if a system that is provided methane is successful, the community may contain methanotrophs. If carbon dioxide is consumed, there may be autotrophs in the community. A precise mass spectrometer, NanoSIMS, "detects tiny amounts of activity in tiny things," allowing her to measure birth rate and repair rate as proxies for ecological success. In some cases, Elizabeth "plays games" by adding more complex molecules like methylamine, which is composed of both carbon and nitrogen, to see what gets consumed and what gets produced. Running hundreds of these self-contained biomes allows her to better understand what these extreme lifeforms can do, and work toward larger-scale questions of how carbon is cycling through the deep sea environment and what we might expect to see from life on other objects in the solar system.

As a contrast to her samples from *Chikyū*, Elizabeth has also collected samples from several CORKs (Circulation Obviation Retrofit Kits) emplaced in the North Pond region of the North Atlantic Ocean and alongside the mud volcanoes of the Mariana Trench. In addition to helping us understand how life works on Earth, fluids from the Mariana system can be considered proxies for fluids on icy moons in the solar system, which may have a greater concentration of dissolved ions than our oceans.

Elizabeth's interests can be summed up to the "really interesting question of how survival is possible," in other words, "survival and persistence questions" about extreme life. She is now also applying her techniques to organisms in the atmosphere, attempting to uncover the secret of "who ends up there and survives," based on the unique characteristics of these communities.

Elizabeth shows her excitement as the first fluids were recovered during a North Ponds cruise (Credit: Elizabeth Trembath-Reichert).

Her “State of the Lab Address,” which she holds at the end of each calendar year, is an opportunity for Elizabeth to evaluate the scope of her work, considering the questions “What *are* we doing? How is everyone connected?” This year, her atmosphere team focused on developing new techniques to collect samples and data. She also worked closely with a lab group that frequents Yellowstone National Park to study hotsprings systems “on land, where you can actually poke at them.” Some of her students analyzed samples from dry permafrost systems, which, with the primary stressors being the cold and the dry, can be analogous to Mars.

A central theme to Elizabeth’s work is her respect for diverse perspectives and fields of expertise: “If you’re going to try to claim that there are organisms that are still alive 2.5 kilometers below the seafloor and nothing has seen sunlight for twenty-five million years, you probably need a lot of evidence. So a lot of [this work] is being able to build that story.” She acknowledges that it takes the synthesis of many sub-disciplines of geology and biology to mature her observations into edicts about Earth systems and processes.

Though “on paper” her professional time is split 60% to research, 30% to teaching, and 10% to service, Elizabeth is taking a break from the classroom this semester to prepare her tenure portfolio. That makes it a perfect time to tour the country with her Ocean Discovery Lecture, titled “What lies beneath: Who lives miles beneath the seafloor and what are they up to?” As much in praise of the scientific and technological feats that make it possible to sample microbial communities thousands of meters below the seafloor as it is a deep dive into her research, the lecture is an opportunity to share her ideas with new, untapped audiences.

While it’s true that her participation in the Lecture Series is a way for Elizabeth to give back to the community, it is not without personal advantages. As she plans her visits to some less conventional venues, such as museums and science centers, she looks forward to “seeing what awesome questions I get asked, and what proposals I end up writing next year based on the fifth grader who comes up to me and asks me something I never thought of before.” It is this kind of open mind that is uniquely prepared to answer the big questions of our time.

Call for contributions

If there's one thing that can be said about the International Ocean Discovery Program (and the Integrated Ocean Drilling Program, and the Ocean Drilling Program, and the Deep Sea Drilling Project), it's that we are a tight-knit community. Just as much as this newsletter is for you, we want it to be from you, too! In future editions we will highlight our readers by featuring the following community contributions:

- **From the Field** - Have you had an experience with scientific ocean drilling that you want to share? Write a piece to tell us your perspective "from the field" for our next edition. Bonus points if you include some pictures!

- **Scientist Spotlight** - Do you know someone who's making waves in the ocean drilling scene, whether it's a grad student or accomplished scientist? Send us a nomination! Briefly tell us why this person deserves a shout-out, and ideally how to get in touch with them. Self-nominations are also accepted.

- **Photo Montage** - We'll take any photos you want to share!

- **Creative COREner** - Scientists are creators too! Send in your paintings, drawings, digital designs, poems, short stories, sculptures, or any other ocean science art you've made.

Send your contributions (and questions and concerns) to **mpincus@ldeo.columbia.edu** no later than February 20, 2023 to be featured in next month's newsletter.

See you next month!