GEOTRACES #4 - Hydrothermal Vents and Megaplumes - Q & A Transcription

Q. What drives the flow of water under and into the crust? Is there negative pressure there that's causing that water to be drawn in?

A. Let's see. So you're talking about not at the ridge axis, but just in the crust in general. So yeah, I think you have pressure differences just the same way you would get water to flow on land. What was always surprising to me is that Andy Fisher, the scientist that gave us permission to use this image, their research shows that there's preferential recharge and discharge at these mounds, at these high locations at the seafloor. I think it is somewhat counterintuitive, but their research has shown several times that it is true. These topographical highs tend to be places where water enters and leaves the seafloor. The sediments here in this image with the brown material labeled sediments, tend to be a pretty low permeability, and so it's really just the topographical highs the way the crust comes up and meets the seawater when you get these preferential flow patterns away from the ridge axis.

Q. How long does it take the iron to travel those 2000 kilometers before it was detected there? What's the kind of speed for that journey for the iron?

A. Typically we think of deep waters moving about .1 to .5 centimeters per second, so really slow. Using those you can calculate that it takes on the order of 50-70 years to travel 2400 km. away. That's definitely shorter than we think dissolved iron in the ocean can survive. If we calculate that distance and we calculate that time, and we say we think the residence time of dissolved iron in the deep ocean is on the order of 100-200 years, then it makes sense to us that iron would persist that long that distance in the deep ocean.

Q. What would be the anticipated time scale for iron from this plume to reach the surface ocean?

A. That's the magic question. It really depends on where this iron is coming from, and what exact path it takes. In this image that Annette has up here, this path going all the way through the Indian Ocean and coming up would be many many thousands of km., and that would take at the rate I just described more than about 200 years to make that journey. So we wouldn't necessarily expect on the exact flow path that is drawn for iron to make it, but as many oceanographers know every water parcel in the ocean travels a slightly different path. And so the question is, overall, does iron make it to the surface ocean? Right now our global circulation models which have the residence time for iron built into them would suggest that iron does make it to some extent to the surface ocean, but certainly not in the extremely elevated concentrations that we recorded in the deep South Pacific. It's going to be a somewhat attenuated concentration by the time it is upwelled.

Q. You mentioned that some of your collaborators were looking at microorganisms. How long can microorganisms survive in a plume like this?

A. That's a great question. I think that microorganisms can survive very long time periods. I think maybe the question for us to think about is how long can they access the nutrients and energy sources that they need to be actively growing and dividing. We know that from recent work that we think probably within 58-100 km. from the plume there's still enough energy there in terms of methane, or some of these other more slowly consumed products, that they can sustain microbial activity for quite some time in the plume. Then those organisms should be able to follow the water pocket and hang out in a less active state until they find themselves in a place where there's more nutrients, or more energy sources.

Q. What is the most accepted method for tracing where these hydrothermal plumes are travelling? How do you guys know where they go?

A. I'm happy to take a first stab at this. So the helium is a really great tracer, but to my knowledge you can't get the helium measurements done on the ship. So helium is the kind of measurement that you take a water sample back to your laboratory to get the information. So when you're on a ship if you'rehunting for plumes, there's other tools that you can use. You can look for temperature anomalies very close to events in the water column, and for that you don't need a robot; you can just do that from the ship. You can also look for something that we would call particle anomalies, so places in the water column where there are more particles than you expect to see. And those are the 2 easy tools that we tend to use when we were hunting. You could also look at older datasets that show metal rich sediments at the seafloor to look for places where we think hydrothermal venting might be important. We actually have quite a few options for hunting plumes, but for those long distances, helium is one of the best.

I would also add to that nowadays we can make trace metal measurements on ships. So we can collect water samples and measure the iron or manganese concentrations in those samples, and when they're elevated we can confirm right away like we did on GEOTRACES that we're in the plume, and we know that we're seeing hydrothermal waters in our samples.

Q. Are you guys measuring helium-3 through typical radiometric techniques, or are there other technologies used to find out the helium-3 amounts?

A. I've only witnessed myself the way the water samples are collected. Jess, do you know the type of instrument that they use to make that measurement?

I'm pretty sure they use a mass spectrometer, but again I've only witnessed the way that they've been sampled.

Q. On Jess's deep ocean concept [map], in this video that shows iron, is the iron being taken up by the phytoplankton at the surface? What's the reason that it's purple at the surface of the ocean?

A. Yeah, so that's where the phytoplankton are living. They are using iron as a nutrient, so they are taking it out of the dissolved phase of seawater and putting it into their selves. So we see that in this distribution here some iron is missing, and that's where it's being taken up by phytoplankton.

Q. How can you be sure, if only 5% of the seafloor has been explored, that there aren't many other vents emitting helium-3 and/or iron in the Pacific?

A. That's a really good question. We think the East Pacific Rise megaplume is not coming from a single event. We know that there's hydrothermal venting moving 'northish to southish' for long distances. So we don't think it comes from a single vent, we think it comes from a long series of vents. I think in Jess's map where she showed the plumes and waters moving 800 km., and then 2400 km., she has little "x's" showing confirmed vent sites, and they were over the distributive source. So that distribution, that exploration of 10% of the ridge axis has been explored. It's not evenly distributed. Yeah. There they are. All those "x's" are confirmed, if I understood what she was telling us. So we think the helium is coming from many vents along the ridge.

Q. For GEOTRACES, you mentioned some of the technology you are using. Are there other groups that already use mass spectrometers in situ on an ROV? Is that some of the things that you guys do, or is that all done shipboard?

A. I know that there's at least one seafloor mass spectrometer that's operated at the seafloor, but I've not seen one used on the ROV Jason, but that doesn't mean it hasn't been tried or it's not being done.

I'd like to say that when we attend these hydrothermal vent meetings, putting mass spectrometers on the seafloor, and expanding the use of live mass spectrometry in the ocean is stuff that people are actively working on now. As Brandy said it could have been done maybe last year or the year before, but this is all cutting edge research which is what we're moving towards.

Q. Going back to the end of Jess's presentation, does your conclusion mean that the feedback cycle for upwelled iron that leads to these phytoplankton blooms could have an impact on CO2 levels, maybe several centuries or thousands of years from now?

A. Well, so this is something that we are trying to figure out. We think that the production of iron from hydrothermal vents is at least right now pretty constant. Right now, this isn't any kind of pulsed flux. If it is coming to the southern ocean, it's coming and it's a constant supply. So it's almost buffering, or providing some amount of iron in a constant way. Now over the geologic past as the crust is moving and has plates that are moving around, the pathways of that water to the Southern Ocean or other places of the earth would have changed, and also the supply rates potentially, or the rates of hydrothermal venting could have changed. Over the geologic past we have a much less clearer idea of both the circulation and the supply time of iron to the ocean. This raises a bigger question of what the role of iron in regulating productivity could have been over glacial and interglacial cycles and even farther back into the past. So this is something we're thinking about and models are actively crunching.

Q. What technology Brandy is being used to study the evolving seawater as it seeps into the ocean floor? Basically, how do they know what's happening in the plumbing part of this?

A. That's a good question. So the temperatures—so let me tackle it from 2 perspectives. People are actively drilling into the ocean crust, and installing wells and instrumentation. Data on the hydrogeology, or how water moves on the ridge flank, so away from vents, is being done that way. It's basically putting in wells and doing hydrogeology and other kinds of in situ measurements. Near the ridge axis we get after it in a few different ways. The geochemistry is pretty much understood by geochemical modeling, looking at rocks, and thinking about what processes could have generated those vent fluids. But people also do a wide variety of the geophysical observations and seismologies to try to understand how water and heat move through these systems. There's a variety of approaches that can be helpful in understanding water movement right near the ridge axis.

Q. Sometimes I have a hard time getting my students excited about chemistry. What got you excited about chemistry and kind of on your career path as scientists?

A. I can take that first. So yeah, what I really like about chemistry, and particularly about metals, is that each one of the metals has a different personality to me. There almost like—it's really nerdy to say this—my friends. Iron has a certain personality. Manganese or cadmium, all of these metals have different personalities. When you add understanding how the earth system works, you know each of them interacts with the earth system in a different way. You can use them to interpret each other, and it's just really great on those days that your running sample and you're getting y data, and you're immediately learning things about how the earth works as this data is coming in. I'd say that's what makes me most excited about it.

That is a great answer. So I come out of an environmental science and engineering background. I got interested in chemistry almost by accident because I was interested in 'drinking water' qualities. It turned out if I wanted to understand water quality in terms of metals like arsenic, or organics like PCBs, or any other contaminant, chemistry is really important, so for me I got interested in chemistry through environmental sciences and human exposure to pollutants.