Video Transcript - Global Change - Reading Ocean Fossils

Announcer: During its long history, the Earth has seen radical changes that alter the destiny of life on the planet. How can we look into the past to discover how living things reacted to these changes? Scientists are tapping deep into the sea floor, the land, and ice to discover fossilized remains of microscopic creatures that reveal the chemistry of the oceans [00:00:30] long ago. Join us now for a conversation with Paleobiologist Brian Huber to learn how small lifeforms can tell big stories about climate change on Earth millions of years ago and today.

Announcer: Now, here's your host, Maggy Benson.

Maggy Benson: Welcome. Thanks for joining us for another episode of Live from Q?rius, Smithsonian Science How? I'm Maggy Benson. We're really excited to have you here today, and thrilled to have with us paleobiologist [00:01:00] from the Smithsonian's National Museum of Natural History, Dr. Brian Huber. Thanks for joining us, Brian.

Brian Huber: It's great to be here.

Maggy Benson: Let's start off with learning what a paleobiologist is and what you do as one.

Brian Huber: A paleobiologist studies evidence of past life, like fossils, and we try to understand the environments in which those fossils occur. We study sediments and then the shapes and sizes and locations of fossils.

Maggy Benson: Interesting. I know that you focus your research on tiny [00:01:30] organisms called foraminifera.

Brian Huber: Yeah.

Maggy Benson: There has to be an easier word for that.

Brian Huber: Well, the nickname for foraminifera is forams, and these are microscopic organisms that are protistans, single-celled, and they secrete a shell. The shell is what forms the fossil record of these organisms. We've got two kinds. One's called a benthic foraminifera, and they live in the top few centimeters of the ocean floor, and these have a fossil record that goes back [00:02:00] 540 million years. Planktic foraminifera, shown on this screen, have a fossil record that goes back 180 million years ago. They float in the upper 200 meters of the ocean. They are found together in the ancient sediments and so by studying these things we can reconstruct the ocean bottom environments and the ocean surface environments.

Maggy Benson: So you mentioned that they are found in these sediments. Where are these sediments found, and how do you collect them?

Brian Huber: Ocean sediments have foraminifera worldwide in the deep sea. But also [00:02:30] in the geologic past we've had oceans that flooded the continents because of much higher sea level. So you can actually find foraminifera in chalk in Kansas, in Colorado, in Montana because the oceans flooded the continents all the way across North America during the geologic past.

Brian Huber: And so, by studying these sediments worldwide, from the Arctic, to the Antarctic, to the tropics, you can reconstruct Earth history.

Maggy Benson: So if I find some marine sediment, can I just get a handful of it and have forams, or [00:03:00] how do I get them out?

Brian Huber: Well forams, firstly, because they are tiny, a lot of them are less than a millimeter, even less than a half of a millimeter in size, many specimens occur in a small amount of sediment. When you go to a marine sediment, you can get something like chalk and you just put it in water and it'll disperse in water if there's not a lot of cement. Then you wash that through the sieve and that screen contains the sand sized material that concentrates the foraminifera. You dry that material, you pour [00:03:30] it into a tray. And then you can put it into a vial, and you label the vial with a sample number. Then you can use a dissecting needle, or a picking brush, to move the specimens around under a light microscope, and then put them on a little microscopic slide for study and identification.

Maggy Benson: Interesting. So, what are forams used to tell scientists about? As a paleobiologist, they must tell you something about life in the past.

Brian Huber: Well, benthic foraminifera have different distributions with depth in all kinds of environments, [00:04:00] like oxygen content of the ocean during the past. Planktic foraminifera tell you about the water environment. But both of them in their shells have a chemistry that allows you to reconstruct past temperatures.

Maggy Benson: So, do different forams occupy different temperature ranges in the ocean?

Brian Huber: Yeah. So some species occur only in the tropics. Other species only occur near the poles. And so the modern distribution tells us that planktic foraminifera are very temperature-sensitive. [00:04:30] And this is the case during the geologic past. You have restricted distributions that can tell you, sort of, where the climatic belts were located.

Maggy Benson: So forams are trapping temperature information in their tiny shells. But are they also telling you how old they are so that scientists can know how warm it was in the past (and) when?

Brian Huber: Well like any fossil, there is a time when that fossil species first appears in the geologic record, and then a time when it goes extinct. Planktic foraminifera are especially useful for telling [00:05:00] geologic time because some of their age ranges are really short. Some species only exist for about one-million years, others maybe fifteen-million years.

Maggy Benson: Is that what we are looking at right now?

Brian Huber: Yeah. If you measure any sequence of rock you can go up through time, basically, from the older sediments, in this case in the section that was measured at the bottom, and you'll see that at some point these species goes extinct. Other species appear, and sometimes they overlap. By comparing these assemblages, then you can reconstruct the kind of environment, or [00:05:30] it's kind of geologic time, and narrow it down based on studies worldwide.

Maggy Benson: Now you just said that one-million years is a short interval of time. One-million years seems like a long time to me.

Brian Huber: Yeah, in human time-scale it's just incredible to imagine a million years, let alone one-hundred million years. Remember that the earth is about 4.6 billion years. So four-thousand six-hundred million years. So forams, with their [00:06:00] record back to five-hundred and forty-million years are a pretty small part of that Earth history. One-million years is next to nothing.

Maggy Benson: So you've told us a little bit about forams and how they are used to understand Earth's temperature at a specific time throughout the foram history at least. But I'm really curious what this kind of information tells scientists. What do you say we ask our viewers?

Brian Huber: Yeah.

Maggy Benson: All right, viewers. Now's your chance to tell us what you think. You can respond [00:06:30] to this poll questions using the window that appears to the right of your video screen.

Maggy Benson: Tell us, what do forams tell scientists about?

Maggy Benson: Global climate change?

Maggy Benson: Evolutionary change?

Maggy Benson: Extinction events? or

Maggy Benson: Environmental conditions?

Maggy Benson: Take a moment to think about it and put your answer in the window to the right. And remember that this is the same place that you can post questions for Dr. Brian Huber to answer during our live broadcast today.

Maggy Benson: Brian, [00:07:30] the results are still coming in, but the majority, 71 percent of our viewers think that forams are telling scientists about extinction events. What do you think?

Brian Huber: They do tell about extinction events, but they also tell about the other things that were listed. So forams are very useful for all kinds of information [00:08:00] about the geologic past. Climate change, and so forth.

Maggy Benson: So extinction events - our viewers must be interested in them. Have you ever recognized an extinction event in the foram record?

Brian Huber: Yeah, actually this is something I studied quite a bit for the earlier part of my career here. The really fantastic thing about planktic forams is that they are so sensitive to these kinds of changes. Sixty-six million years ago, there was an asteroid impact that ended the dinosaur era, and this is something that everybody knows about.

Maggy Benson: [00:08:30] And there's global evidence of that?

Brian Huber: Yeah, this section is from Spain, and actually, I took that photograph between the Cretaceous Age, when the dinosaurs existed and the Paleogene, after the extinction of dinosaurs. The planktic foraminifera, in that section, suffered 90 percent extinction across that interval. Now remember that this is a chalk sequence on land, but we also have records from the deep ocean, worldwide, and even both, from pole to pole, that demonstrates this abrupt extinction of them.

Maggy Benson: Do [00:09:00] you have an example of that with us today?

Brian Huber: I do. This is a deep-sea core that came from off of northern Florida. At the bottom of the core is a sequence that has the cretaceous age foraminifera and these are completely different from the forams from just above the dark layer in the core.

Maggy Benson: What part is the bottom?

Brian Huber: Down here?

Maggy Benson: Okay.

Brian Huber: So this is the cretaceous age, and then this dark layer itself is full of little glassy balls called tektites; [00:09:30] that's material that was ejected from the impact bed. This ejected material shot through the atmosphere, and then fell from the sky, and then was deposited into the ocean bottom. At the top of that impact bed is a rusty colored layer which is the metal of the asteroid itself. That fine dust was the last to fall to the sea floor. Just above that are the sediments where tiny species, the few species that survived, can be found. So completely different assemblages.

Maggy Benson: How can you tell that they are different assemblages? [00:10:00] Do they look different? The ones before the asteroid impact and the ones after?

Brian Huber: Yeah, they are really different. Size wise, the ones before are quite a bit bigger.

Maggy Benson: Like the ones we are looking at now?

Brian Huber: Yeah, you can see the shells are quite different sizes. Some of those shells are very ornate, very pretty little keels. But there is a diversity there that's on the order of maybe thirty species. But when you go above this extinction level, you have very few species and they are much smaller. So only about two species [00:10:30] survived this event. And then, very quickly you see evolution of new species, right within a few millimeters after the impact bed.

Maggy Benson: Wow that's fascinating. Now you must have a collection of forams here at the Smithsonian's National Museum of Natural History to be able to really understand that those assemblages before, and after the impact are different.

Brian Huber: Yeah, my job is called curator. I oversee the largest collection of foraminifera in the world. We have hundreds of thousands of slides that are in our collection, and these slides go back to [00:11:00] the 1800s even. We have people coming worldwide to study these collections, because we want to be sure we identify these species correctly. So we have the original vouchers with identifications for these species that were first named.

Maggy Benson: Very cool. Well thanks for helping us better understand what forams are and how they help paleobiologist better understand life in the past.

Brian Huber: Yeah.

Maggy Benson: So I know that early in your career you studied in Antarctica. Why there?

Brian Huber: Well really it was luck. I got invited [00:11:30] to join an expedition to Antarctica to see if there were foraminifera in a section of a place called Seymour Island. It's on the Antarctic peninsula, at 65 degrees south. This island is not ice covered year round so it exposed sediments between seventy and fifty-million years old. By mapping that sequence then we could figure out what the ages of the sediments were. But the discovery that we made was that there was a very abrupt transition in the fossils there. In particular [00:12:00] we found that these things called ammonites, which are a type of cephalopod, shown here.

Maggy Benson: Right. This one right here?

Brian Huber: Yeah. So this is an ammonite. It's related to the nautilus, which survives today, but it's an extinct relative. These and things like this snail, called Amberlaya, and a bunch of other things went extinct very abruptly right across the island. You can map the level where these go extinct. They also went extinct the same level where mosasaurs and plesiosaurs, which are swimming reptiles, went extinct.

Brian Huber: So we knew it had an extinction [00:12:30] level. It was from the study of the planktic foraminifera that we knew this was the Cretaceous-Paleogene boundary extinction event.

Maggy Benson: Interesting, and I see something else large on this table that looks like wood. Is this from Antarctica?

Brian Huber: It is, and one of the things that left a lasting impression on me was working in Antarctica and freezing my fingers and my face and then seeing this evidence of warmer climate, and particularly, wood. We know that there were forests near this place where [00:13:00] the marine sediments were deposited because this wood was deposited with the marine sediments. We found fossil leaves along with the wood deposited in the marine sediments.

Brian Huber: So all this stuff washed off rivers and into this place where we were finding our marine fossils.

Maggy Benson: Wow. I'm super fascinated to know that there were trees, there were plants, and reptiles in Antarctica when we know now it's totally covered in ice.

Brian Huber: Yeah. It's amazing. Today, the only thing that grows there is moss, which blooms [00:13:30] once a year, maybe, and likens on rocks. No animals live there year round, so obviously, this is an environment that changed dramatically.

Maggy Benson: I wonder why Antarctica was so warm, and maybe we should ask our viewers. What do you think?

Brian Huber: Yeah.

Maggy Benson: All right. Viewers, here's another opportunity to participate in a live poll.

Maggy Benson: Tell us: Why were these species in Antarctica?

Maggy Benson: They drifted there on icebergs?

Maggy Benson: These organisms [00:14:00] used to be more cold-tolerant?

Maggy Benson: It used to be warmer in Antarctica?

Maggy Benson: Or Antarctica used to be in the tropics?

Maggy Benson: Take a moment to think about it and put your answer in the window that appears to the right of your video screen.

Maggy Benson: [00:14:30] Brian, the results are still coming in, but so far 81 percent of our viewers think the answer is C, that it used to be warmer in Antarctica. What did your foram research tell you?

Brian Huber: Well, actually, yeah. Just finding the fossils themselves clearly show that it was warmer at that time. But we could study the shells of foraminifera, measure the chemistry of those shells, and determine what the water temperature [00:15:00] was. And what we found was (that) the planktic foraminifera (were) living in the surface ocean, at around the order of 10 to 12 degrees centigrade at this time 66 to 70 million years ago.

Maggy Benson: And how warm is it there today?

Brian Huber: Today, it's freezing. I mean, we have sea ice that covers Antarctica, so we've dropped considerably since that time in terms of temperature.

Maggy Benson: So I see a key here. It's Cretaceous warmhouse. Is that the period that they call this time of warming in Antarctica?

Brian Huber: Yeah. This is a time where there was [00:15:30] actually no ice in any of Antarctica. And no ice, also, in the North Pole. So we know that both poles were warm, and in fact, the whole Earth was warm. An so this Cretaceous age we call a warmhouse.

Maggy Benson: Interesting. So we have a video question for you. Are you ready to take it?

Brian Huber: Sure.

Maggy Benson: All right. Let's see.

Austin: Hi. My name is Austin. I'm from Dandridge Elementary, and I would like to know from Dr. Huber if forams had a partner and prey relationship. Thank you.

Brian Huber: Austin, that's a great question. [00:16:00] Yeah, in fact, the major prey of forams today is fish. Fish will just suck in the plankton and then they'll use their gills to filter out the plankton, and so that's their lunch.

Maggy Benson: Great question. So we have another question here. This one comes from Patrisio at Indian Atlantic Elementary: "What type of fossil is the most common that you discovered in Antarctica?"

Brian Huber: Very good question, Patrisio. On the surface [00:16:30] of these sediments in the Cretaceous age, this ammonites, actually, were scattered quite continuously throughout the sequence. But the most common thing, weirdly enough, is a strange calcareous worm. It's a worm tube with a calcareous or limey shell, and these things were like pavements in some parts of that sequence.

Maggy Benson: Great question. So this question comes from Wolfgang and Jonah. Are underwater fossils related to underwater animals we find today?

Brian Huber: [00:17:00] Wolfgang and Jonah, yes indeed. We have a lot of living relatives of the fossils that we find. But remember we are dealing with something, in Seymour Island for example, that is as much as 70 million years old. And so there's really no species that exist today that have such an ancient fossil record. But we have similar kinds of organisms, in terms of we know whether there's a snail, or whether it's a clam, or whether it's a nautilus.

Maggy Benson: So I'm seeing pictures of extinct marine [00:17:30] reptiles here. Do we have anything like that today?

Brian Huber: All of those things in that illustration are extinct. That's a mosasaur, and that mosasaur is feeding on ammonites. All of those were victims of the asteroid impact.

Maggy Benson: All right, we have another video question. Are you ready to take it?

Brian Huber: Oh, yeah.

Maggy Benson: All right.

Speaker 5: Hi my name is K.J. from Dutch Ridge Elementary School and I would like to ask Dr. Huber how scientists found the KT boundary line.

Brian Huber: [00:18:00] So how did we find the KT boundary line?

Maggy Benson: Yes.

Brian Huber: Well it's a very distinct change in the fact the color change as well as the composition and texture of the sediment in a lot of places changes abruptly because it turns, right after the impact. There's a clay layer which marks the impact layer. So in the photograph shown there's a line that I drew on that photograph which is a distinct clay layer where the impact fallout [00:18:30] is preserved.

Maggy Benson: And that KT boundary line, that's basically another way to say that impact bed where there's evidence of that asteroid impact.

Brian Huber: Yeah, that is a distinct mark of a very brief, what we call, a bad day in earth history.

Maggy Benson: Absolutely.

Maggy Benson: So we have another question, and this one comes from the students watching in the Q?rious lab here at the Smithsonian.

Brian Huber: All right.

Maggy Benson: And they want to know why forams go extinct so often.

Brian Huber: [00:19:00] It's a great question actually, because throughout geological history species appear, they evolve, and they go extinct. Often times we try to find a mechanism to explain those extinctions. But many times we are completely mystified as to why they went extinct. You have competition between organisms, but also you have environmental change. So whether it's climate change, or change in the chemistry of the ocean, there are many factors that could contribute to the extinction of organisms. Sometimes we just don't have the information in the geologic [00:19:30] record to tease apart the story that actually would tell you that answer.

Maggy Benson: Great. Great questions. So Brian, I know that you did research in Antarctica early in your career, but you also did research on deep sea drilling ships. Can you tell us about that?

Brian Huber: Yeah, the deep sea drilling ship is actually out there for science, to drill ocean cores in the ocean floor. So you can drill down, deeper and deeper, [00:20:00] and get an older and older record of climate change, environmental change of the ocean. And in the sediments, foraminifera are often extremely abundant, so those things are the story tellers. You can tease apart those sediments, analyze the foraminifera, and then better understand what happened in the past.

Maggy Benson: And what we were looking at before from the KT boundary is actually a core. This is what's extracted from those ships?

Brian Huber: Yes, in fact I was on the drilling ship when this particular core was drilled. This is from off of Northern Florida, as [00:20:30] I mentioned. It was drilled in two-thousand two-hundred meters water depth. The core itself came from about 130 meters below the sea floor.

Brian Huber: Now we knew what age this was by knowing the foraminifera in the sediments from the core. We could anticipate how soon the core would come up when the Cretaceous Paleogene boundary was drilled.

Maggy Benson: So you were drilling into deeper sediments on the deep sea drilling ship. Did you find any different evidence than you found in Antarctica?

Brian Huber: The extinction [00:21:00] story is the same worldwide. We have many deep sea drilling sites that show this impact bed. The impact bed gets smaller the further away you get from the crater where the impact occurred, but that's a global story.

Maggy Benson: Did you find any evidence in your research there that the earth was warmer?

Brian Huber: Well, the other thing that you could do with the ocean drilling ship, of course, is look for sediments of different ages. And the further back in time you go in the Cretaceous, we [00:21:30] find from the analysis of the chemistry of foram shells, that we had an even warmer earth than during the time of the asteroid impact. The graph that's on the screen shows a temperature curve that was put together from analysis of the shells' chemistry, using benthic foraminifera from the deep ocean. Probably greater than a thousand meters water depth. And you can see from the present day that we have freezing temperatures, but you go back in time and you see lots of wiggles. There's time where it was warmer, and times where it got cooler. Go [00:22:00] back further in time, you look at 55 million years ago it was very warm; there was no ice at either pole. But then you keep going back in time and you look between about 94 to 89 million years ago, and we have extremely warm temperatures, some reaching up to 20 degrees centigrade. And this time is called the Cretaceous hothouse. The Cretaceous greenhouse, whatever you want to say.

Brian Huber: This was an earth that was extremely warm.

Maggy Benson: So even warmer than the conditions that you found in Antarctica?

Brian Huber: Yeah. The deep sea today at 1,000 meters water depth water temperature [00:22:30] is about one degree centigrade. So to have 20 degrees centigrade in the deep, deep ocean, is amazing. We also know by drilling near Antarctica, that the polar regions were extremely warm.

Maggy Benson: So on that graph, it showed a shaded box, and I understand that's where you're trying to fill gaps in the climate record. You've traveled to do some of your research in Tanzania. Were you looking to fill gaps in that record, there?

Brian Huber: Right. We were looking to fill gaps in the age interval that was missing for putting together this record. But also because [00:23:00] Tanzania was in tropical latitudes, we wanted to understand what were temperatures like that were near the tropics. And there's very few places where you can get good preservation to do this, but Tanzania sediments that used to be under the ocean bottom yield beautifully preserved foraminifera. And by analyzing those shells, we could reconstruct the temperature history through quite a long time interval.

Maggy Benson: We see that you collected cores from the marine sediment on land there. So what did the data that you found in Tanzania [00:23:30] tell you about warming on Earth?

Brian Huber: Well, we couldn't have had it better. Our prediction was that based on the climate models, if this is a CO_2, greenhouse Earth, the tropics should also be warmer than present day. And sure enough, these really well preserved foraminifera showed that the tropical regions in Tanzania were much warmer than today on the order of 34, 35 degrees centigrade. Present day tropics typically are about 28 degrees centigrade.

Maggy Benson: So it's very warm, and you mentioned that's because of rich [00:24:00] CO2. How is the CO2 contributing to a warmer atmosphere?

Brian Huber: CO2 and methane are types of greenhouse gases. And those greenhouse gases sort of form a blanket around the world atmosphere, and they trap heat energy so it doesn't escape outside of our atmosphere. And so the more CO2 and methane you have, the more greenhouse warming you're going to have.

Maggy Benson: And I just saw a map of the world from 94 million years ago. With the increased amount of CO2 in the atmosphere and the way [00:24:30] the world and the continents were arranged then, does that have something to do with the Earth heating up?

Brian Huber: Yeah. If you look at this map, you'll see that Australia is up against Antarctica, the Atlantic was much smaller. And there's a seaway going through the North American continents as well as all through western Europe. So these factors contributed to the warming. The fact that sea level is much higher also tells us that we had much faster sea floor spreading as a result of the kind of continental drift that occurred. [00:25:00] This caused much greater volcanism in the deep ocean floor, and so these submarine volcanoes pumped out a lot more CO2 because of the faster spreading rates during this time.

Maggy Benson: So it was much warmer 90 or so million years ago. But today I know that the poles are covered in ice. I mean, Antarctica, your original study site, is ice covered today.

Brian Huber: That's right. Well, one of the things that's happened in the last couple of decades is a huge loss of the shelf ice near [00:25:30] Antarctica. And in one case, the Larsen Ice Shelf that was just shown in the photograph there, broke up very abruptly. A size of ice shelf, the size of Rhode Island, floated away and melted. And this is happening in Greenland, where there's deglaciation from melting of the base of the ice shelf. And also in Antarctica, the ice is moving faster. So we have a lot of loss of ice in the polar regions.

Maggy Benson: So it's really global evidence of warming [00:26:00] after the poles glaciated.

Brian Huber: That's right. In the Arctic, we know that these Arctic sea ice is shrinking. We also see from Alpine glaciers, like Mount Kilimanjaro, the amount of ice is shrinking. This is a global phenomenon. It's happening quite fast, very abruptly.

Maggy Benson: So what's in store for our future?

Brian Huber: Well, when you consider that this ice that's been trapped on land for tens of thousands, hundreds of thousands of years is going to sea, we [00:26:30] know the sea level's rising. And the prediction is, we may have several meters of sea level rise in the next century or so. So cities that are near sea level, within a couple of meters, are going to be flooded.

Maggy Benson: So the projection that we're seeing here, is that the melting of the Arctic?

Brian Huber: Yeah, this is based on the prediction for climate warming over the next century. And based on that, we know that the ocean temperature warms. That's going to melt the sea ice, and what's going to happen is within a century [00:27:00] we'll have shifting lanes going from the Atlantic Ocean to the Pacific Ocean through the Arctic. And considering how frozen that is today, it's very hard to imagine this happening within just a century.

Maggy Benson: So whatever warming does occur, is that going to be tracked in the foram record?

Brian Huber: Forams are great archives for climate change. And so we know that forams that were living in the last century and then forams living today and then forams living in the next centuries are gonna record this whole transition, [00:27:30] from the pre-greenhouse world to the greenhouse world as a result of all the greenhouse warming from CO2 resulting from the industrial age.

Maggy Benson: Wow. So thank you so much, Brian. We're actually all out of time, but thank you for helping us better understand forams and how they are nature's natural data loggers.

Brian Huber: Forams are really cool. I'm really glad to have talked about it.

Maggy Benson: Wonderful, and can you tell our viewers now where they can learn a little bit more about your work?

Brian Huber: Well, I'm in the Department of Paleobiology [00:28:00] at the Natural History Museum Smithsonian. And we have a website that has links to story about the blast from the past, about the Cretaceous Paleogene boundary. There's a link to what forams are, and there's links to lots of other fun stories about fossils and geologic time.

Maggy Benson: Awesome. Thank you so much, Brian. Thank you so much for joining us. The archive will be available later this evening on qrius.si.edu. See you next time on Smithsonian Science How?

Announcer: [00:28:30] Thanks for watching. You can explore more Smithsonian Science How? shows on our website, qrius.si.edu. We hope you'll join us again on Thursday, March 12, for a conversation with geologist Cara Santelli, where we'll explore the role that microbes play in the mineral cycle and their practical applications to pollution clean up. [00:29:00] Register now at qrius.si.edu.