Video Transcript – Paleobotany – Climate Change Past and Present

Maggy Benson: [00:00:30] Most people have heard of global climate change. Today, we're concerned with hotter summers, colder winters, stronger storms, and melting polar ice, but what would you picture if someone asked you to think about climate change over millions of years? Some paleontologists take a long view of climate change, reading the fossil record to look back through time to understand how life on earth responded to the warming and cooling of our planet.

Maggy Benson: [00:01:00] Today, we'll meet Smithsonian Paleontologist, Dr. Scott Wing, to learn about how a warming event 56 million years ago might help us better understand our changing climate today. Hi. Thanks for joining us. I'm Maggy Benson, host of Live From Q?rius, Smithsonian Science How? We have a really great show for you today, but before we start, I want to ask you a question. You can respond using the poll that appears to the right of your video screen.

Maggy Benson: Has the earth ever been [00:01:30] as warm as it is now? A, for sure, B, no way, or C, don't know. Take a moment to think about it and put your answer in the window to the right.

Maggy Benson: While the results are coming in, we're going to go to our special guest. Today we have with us Dr. Scott Wing, paleobotanist here at the Smithsonian National Museum of Natural History. Thanks [00:02:00] for joining us, Scott.

Scott Wing: I'm delighted to be here.

Maggy Benson: So what does a paleobotanist do?

Scott Wing: Well, a paleobotanist is just somebody who studies fossil plants and fossil plants. Plants have been living on this planet on the surface of the continents for more than 400 million years. So there's a lot to study. And of course, the planet goes back farther than that, back to 3.6 billion years ago.

Maggy Benson: Wow. So do you study fossil plants for that whole time period [00:02:30] or do you focus on any time specifically?

Scott Wing: I am very focused right now on a particular period of time about 56 million years ago when the Earth's climate warmed very rapidly and stayed warm for about 100,000 years.

Maggy Benson: Interesting. So I see on this map that 56 million years ago wasn't actually that long ago in earth's history.

Scott Wing: Yeah, a lot of people, there's a lot of teasing and paleobotany about, [00:03:00] oh, you study those young things that are only 56 million years ago, but I'm serious. I study things that are much older than that. So yeah, this is 56 million years ago. It's 10 million years after the dinosaurs went extinct, a lot of mammals running around. So it's relatively recent in earth history even though it seems like a long time to us.

Maggy Benson: Interesting. So the results of our poll are in, and our viewers think, 100 percent of them actually, that the earth has been this warm before. [00:03:30] What do you say?

Scott Wing: I say the viewers are right, 100 percent correct. The earth has indeed been much warmer in the past. There've been times when there was no ice at the poles. There have been times when there were palm trees growing in Alaska. So it's definitely cool overall now compared to what it has been for much of the history of the planet, but we're also in a glacial age, so it's sort of been going up [00:04:00] and down. The last 2 million years, the ice has come, the ice has gone.

Maggy Benson: And is this what it may have looked like back during that time period?

Scott Wing: During the 56 million year ago warm period, we call it the Paleocene Eocene thermal maximum, lots of words there. We think that it was very warm, and that reconstruction's from Wyoming. And I assure you, it doesn't look like a dry tropical forest in Wyoming today.

Maggy Benson: No. So tell us about this time period, this Paleo [00:04:30] Eocene thermal maximum, you called it?

Scott Wing: Yeah.

Maggy Benson: What is that?

Scott Wing: It's a geologically short period, and during that period, starting about 56 million years ago, the climate warmed by something like five, six degrees Celsius, which would be a 10 degrees Fahrenheit, 11 degrees Fahrenheit in a period of just a few thousand years. And then it stayed warm for probably about 100,000 to 120,000 [00:05:00] years following that.

Scott Wing: And then it dropped back down to the temperature it had been before that, but of course, this is all during a time period when it's already quite warm. So it's basically a short, really warm interval in the middle of a much longer also very warm interval.

Maggy Benson: So we already have a student question, are you ready to take it?

Scott Wing: Sure.

Maggy Benson: All right. This one comes from Beryl from Arlington. Was the earth really cold right before that PETM happened?

Scott Wing: [00:05:30] No, Beryl. It was actually warm even before. So we're talking about a time there are palm trees growing in Wyoming before this event starts. Then it gets much warmer than that and it gets even hotter, of course, everywhere. So this is a warm period that's inside a longer warm period. It's very dramatically warm.

Maggy Benson: Great question. So this [00:06:00] PETM, how do people, how do scientists have the evidence? I mean, what kind of evidence do they have to know that this actually happened?

Scott Wing: Well, the event was first discovered by taking cores in the deep ocean, which is kind of interesting that these white dots you can see on your screen are places all over the world where deep sea drilling vessels have drilled holes in the bottom of the ocean, pulled out sediment cores, and much of the sediment in the deep [00:06:30] ocean is composed of the shells of tiny little organisms.

Scott Wing: These are relatives of amoeba that make a little shell out of limestone; you can see one of the shells on the screen. Those shells, the chemistry of those shells actually tells us the temperature of the ocean water at the time the shell was made when the organism was alive. And there are millions of those little shells in the cores.

Maggy Benson: And that has been looked at globally.

Scott Wing: And that's been looked at all over the world [00:07:00] now. And we find at this period of time, 56 million years ago, temperatures rose everywhere.

Maggy Benson: Interesting. So I know that you do work in Wyoming. So what kind of things do you look at in Wyoming to learn about this period of warming 56 million years?

Scott Wing: Well, because I'm a paleobotanist, I like to look at fossil plants, and one of the reasons I'm interested in fossil plants is because they are very sensitive. Plants are very sensitive to climate. So I go out to [00:07:30] Wyoming and walk around in the Badlands looking for fossil plants. You can see some of what the Badlands look like here, very well exposed rocks. It's easy to see. It's dry today, lots of erosion. So we can see the strata and we can see the fossils that come weathering out sometimes.

Maggy Benson: So what makes this location unique for finding fossils?

Scott Wing: Well, it's in the Rocky Mountains, and [00:08:00] we can use our little tool here, our demonstration device. So during this period of time between say 66 and 50 million years ago, the Rocky Mountains were bending up and you can see that as the crust bends and these layers of sediment get raised higher. Then these erode off because these are the tops of the mountains and the sediment that erodes off there ends up in the base and over here.

Scott Wing: [00:08:30] And so during this time period, sediment was piling up in the Bighorn Basin, where I'm working, and in some places, it's thousands of meters thick of sediment that were deposited during this period of time.

Maggy Benson: And in that sediment, you're finding fossils?

Scott Wing: That's the beauty of a place where there's lots of deposition, is that it traps the fossils. So we go around and collect them.

Maggy Benson: [00:09:00] Cool. So we have another student question, and this one comes from Elizabeth from the Fort Worth Museum of Natural History. How do you measure temperatures from so long ago?

Scott Wing: Well Elizabeth, there are a couple of different ways, and one of them involves the chemistry of those little shells I talked about from the deep ocean, but we also can use leaves to tell us something about temperature. [00:09:30] And the feature that's really most helpful, has to do just simply with the edge or the margin of the leaf. And I think you can see on some of these leaves, for instance here, this leaf has what I would call a smooth margin or an entire margin. And this leaf over here has a toothed margin, a jagged margin.

Scott Wing: And if you go look at forests today, you can see that in places where the climate [00:10:00] is very warm, that these tooth margins are relatively rare, and if you go to a place where the climate's cold, like Canada, you see lots of species with these toothed margins. So we can actually use the shapes of the leaves themselves to tell us something about the climate.

Maggy Benson: Yeah, great question. So you go to Bighorn Basin in Wyoming and you look at all of these fossils, but when did people figure out that that was a great place to find [00:10:30] them?

Scott Wing: I think the first geologists or paleontologist who ever walked into the Bighorn Basin probably thought, that is a place I need to spend a lot of time.

Maggy Benson: When was that?

Scott Wing: That was like 1880, the first scientific expedition to the Bighorn Basin. So ever since then, paleontologists have been going out there. The first guys were working on horseback, of course, and it took weeks and weeks to get there, but they are doing pretty much the same thing that we're doing. They were [00:11:00] wandering around in the Badlands looking for fossils and making very careful notes about what they saw. It may have been a long time ago, but they were very keen observers.

Maggy Benson: So what kind of modern tools do you have now that gives you an advantage over these expeditions 100 years ago?

Scott Wing: Well, we have things like GPS devices. A lot of people have these for hiking, but we use a very similar kind of equipment that helps us, [00:11:30] of course, position ourselves. We also use some somewhat old-fashioned equipment. This is a Brunton compass that we use for determining whether the strata are dipping or whether they're horizontal to measure what that dip is.

Maggy Benson: And when you say strata, that means the actual layers that you're looking at in the rock?

Scott Wing: The layers of rock that are, sometimes they've been pushed up since they were deposited, and so they're not flat anymore. You need to be able to account for that. [00:12:00] We also use maps, old fashioned maps like this. Sometimes we use geology hammers to break open the rocks to find the fossils.

Scott Wing: And really, my favorite is this hand lens. This is a 10-power hand lens, nothing fancy about it. You can get one very inexpensively online or at a supply store, and this just magnifies the image of the fossil and you can [00:12:30] see much more about it. So it's kind of a mix of tools we use today, some of them old-fashioned and a lot of them fairly high tech.

Maggy Benson: So are there any new discoveries? I mean, if paleontologists have been here for over 100 years, are you finding anything new?

Scott Wing: What's new is the questions that we ask. So 100 years ago, people didn't know how to correlate events that were happening in the ocean and the events that were happening on land. And so just knowing that, for instance, this period I study [00:13:00] that the climate warmed globally makes you ask different questions than you would have asked if you didn't know that this was a global event. So we look for different things and we ask different questions than our predecessors did, but we proceed in many of the same ways. We have advantages they didn't have, put it that way.

Maggy Benson: So you said that the questions are different. What kind of major questions have you had that you've [00:13:30] been investigating in Wyoming?

Scott Wing: Well, because I knew that this warming period at 56 million years ago happened, I made a sort of prediction that the plants should change very radically. Because if you warm the climate by five or six degrees Celsius, that should mean a lot to the plants and that different kinds of plants should show up. So that was my idea that I was trying to gather data to test.

Maggy Benson: [00:14:00] Did you find any plants to represent that period? Actually, we're looking at them.

Scott Wing: Yeah. You can see this period of time represented right in this slide. The stripes that you see are fossil soil horizons. So those are periods during which there was no deposition on the ancient flood plains, and a soil would form, and it would oxidize the iron. You get a little red stripe and then deposition starts up again. So those layers, [00:14:30] you can actually follow around. That's actually a big help when you're trying to do the geology in the field.

Maggy Benson: So you actually know how to read those layers.

Scott Wing: Yeah, and that's just a matter of going and going, and looking over and over again, and making drawings, and taking photographs, and measuring the rocks. It's a time consuming process of getting to know the country, in a way. But yeah. So there was a long period of time, 11 years or so, when I [00:15:00] was looking for fossils from this warming interval and not finding them.

Scott Wing: And one day in 2005, I think it was the second day of the field season, I was out with my field assistant, a college student who was in the field for the first day ever of his life. It had gotten kind of late in the afternoon, and it was over 100 degrees, and we were out of water, and we were quite a long ways from the field vehicle. [00:15:30] And we went over a hill and I thought "Oh, I just really need to check that place over there. It looks like it might be promising."

Maggy Benson: Just one more site.

Scott Wing: "Just one more place." And so I dug in with the shovel and I saw a fossil. The first thing I thought was "This is different." This is different from anything I've ever seen." And so I got on my knees and I was really digging away as fast as I could and more fossils were coming out. I just started to laugh. It made [00:16:00] me laugh because I thought "it's exactly what I ... It looks completely different. These are different plants." And I was so happy that my laughter turned into tears. I was kneeling on the ground in the middle of nowhere laughing and crying and digging. Okay. And then I remembered that I had a field assistant with me and I thought, oh, he must be really worried.

Maggy Benson: He wasn't crying?

Scott Wing: No. Well, if he was crying, it was because he was worried about [00:16:30] whether he was going to get back to the car. Anyway, it was a very exciting moment.

Maggy Benson: It sounds thrilling.

Scott Wing: Yeah, it was.

Maggy Benson: Those 11 years that you spent looking for these fossils, did you feel like they were wasted in any way?

Scott Wing: No, they were actually essential. I'm not sure I would've known what to think if I had found these key fossils before I understood the question. So I went out with a question in mind, and it was because I knew the plants [00:17:00] that occurred before the event and after the event that I was able to recognize that they were different. So it's kind of a preparation as to how I think of it.

Maggy Benson: This one comes from Dixon, from Altoona. What happens to plants when it gets much warmer?

Scott Wing: Well Dixon, when it gets warm, a plant can't move. So it either dies or it manages to survive. So the way they do move is through generations, [00:17:30] through seeds and dispersal of those seeds. And that's what we think happened during this warming event 56 million years ago, is that it took many generations for plants that were better adapted to the warmer drier conditions to move into the area of Wyoming that we're studying. And during that time, the populations of plants that didn't do so well died off in that area.

Maggy Benson: And I understand that some of these [00:18:00] collections here today might represent that period of warming.

Scott Wing: Yeah, absolutely. We have on this side of the table, a bunch of plant fossils that come from the warm period and over here, fossils that come from cool period before, or cooler period, still warm.

Maggy Benson: How did you tell the difference between them?

Scott Wing: Well, a lot of my life involves just trying to sort fossils. So you find leaves, [00:18:30] many of them are incomplete, and you have to learn to pay attention to the features that help you distinguish different species. And so a lot of the characters are in the venation of the leaf.

Maggy Benson: And that's what?

Scott Wing: Those are the ... They show up a little darker in most of these fossils. They are the fine lines, and that's the tissue that carries the water to the leaf and it helps the leaf resist being torn by the wind. [00:19:00] And those veins form really intricate patterns that you can see even with just a hand lens, but you can see them better under a low powered microscope. And they are quite distinctive.

Scott Wing: So leaves of different species look different in detail when you really zoom in and look at those veins carefully. And then there are also features of the edge of the leaf, like I mentioned, the smooth leaves and the toothed leaves. Those features can be really [00:19:30] informative as well.

Maggy Benson: So you must spend a lot of time sorting your leaves after you go out into the field and collect them all.

Scott Wing: That's what I spend much of my winters doing, is just trying to figure out how many kinds I have. It's really one of the simplest ideas in science, is how many kinds of things are here? But it's not very easy to do.

Maggy Benson: And I know that you've prepared a poll question for our viewers, actually, so that they can test their sorting abilities.

Scott Wing: Yeah. [00:20:00] This is our Sesame Street "one of these things is not like the other" activity.

Maggy Benson: So perfect. Ready for another poll? It's up on your screen now. Which fossil leaf is not like the others? Take a moment to think about it and put your answer in the window to the right. All right, Scott. Can you give us a hint?

Scott Wing: Well, the secret with this quiz is not the edge of the leaf, not the margin, but the venation. And it has to do with the major veins [00:20:30] in the leaf. So those are the thickest veins, not the fine veins that you might be able to see. So it has to do with how many. How many of those major veins are there?

Maggy Benson: All right. So we're looking at the veins.

Scott Wing: Right.

Maggy Benson: The structure that carries the water.

Scott Wing: Yeah. The structures that carry the water and they tend to be a little bit darker in these fossils than the rest of the leaf.

Maggy Benson: So our viewers are thinking that it's C. What does your evidence tell you?

Scott Wing: My evidence is that the viewers [00:21:00] are correct. It is C. And the reason that it's C is that leaf C has just one primary vein. So it just has one vein going up the middle of the leaf and the other two had three major veins, one going up the middle and two from the base going up the sides of the leaf. So that's the difference.

Maggy Benson: So you spend your time sorting based on these things, an exercise like this that you do over and over again.

Scott Wing: [00:21:30] Right. And I actually ... This is not a dead easy one because leaf C, the one that was different, didn't have the base preserved so you couldn't see all the way to the bottom of the leaf. And that is the most common problem I have, is that when you're collecting leaves, they don't come out perfect. Many of them were broken before they were ever deposited, or you don't collect them quite right and the rock breaks. And so you're missing a part, and you still have to see if you can figure out what it is.

Maggy Benson: Interesting.

Scott Wing: [00:22:00] Yeah.

Maggy Benson: So you've spent enough time sorting to know that the ones in the warmer area have smoother leaf edges, the margins. Why did it get warmer during this period 56 million years ago?

Scott Wing: Well, the reason why it got warmer is one of the most interesting parts of the story, and the evidence for that comes from the chemistry of carbon. And this is something, again, we can see both in the ocean cores and also in the Bighorn Basin and in other places. There are two kinds of [00:22:30] carbon that are stable, carbon 12 and carbon 13, they're called isotopes. And carbon 12 is a little bit lighter and plants and animals like to use carbon 12 if they can because it's more reactive.

Scott Wing: And what we see in both the ocean and on land is a sudden increase in the amount of carbon 12 in rocks and in fossils. And what that tells us is that there was a huge amount of carbon released, in fact, about the same amount of carbon that's contained in [00:23:00] modern fossil fuel reservoirs. So thousands of billions of tons of carbon, and that's what changed the climate.

Maggy Benson: And I see a graph on the screen right now, and this looks like current time. Is that carbon release similar to the carbon release that we're experiencing today?

Scott Wing: That's exactly right. So what we're seeing here in the graph is our measurements of carbon made over the last decades. You can see that it's increasing. Here it is, 2006, and it's above 380 [00:23:30] parts per million. This past month, just for the first time probably in a couple of million years at least, the amount of carbon and the carbon dioxide in the atmosphere was over 400 parts per million. So we're raising the amount of carbon dioxide in the atmosphere, and it's exactly the same thing that happened 56 million years ago, except we're doing it much faster.

Maggy Benson: Interesting. So we have another student question, and this one comes from Jake. What [00:24:00] was the first fossil you discovered?

Scott Wing: Jake, I'm not sure I remember the first fossil I discovered. Oh wait. It was probably a fossil mammal tooth, and it was probably in Wyoming, and it probably wasn't all that far from where I work today because that was the experience that really got me excited about paleontology. It was right after I graduated from high school. Somebody took me out to Wyoming and said, "You can collect fossils for me," so I [00:24:30] did.

Maggy Benson: So people should go on fossil hunting trips if they get the opportunity.

Scott Wing: It is absolutely one of the most amazing things you can do. It's just the joy of discovery is in it and also the opportunity to walk around in beautiful places.

Maggy Benson: Absolutely. So I want to get back a little bit to the climate change. The climate change that we're experiencing now, I mean, what have we learned about what's happening now compared to the evidence that you're gathering from 56 million years ago?

Scott Wing: Well, the reason that I'm so [00:25:00] interested in this warming period 56 million years ago is because it is a lot like what's happening today. The big difference is 56 million years ago, the warming probably took several thousand years. Today, the warming is happening in hundreds of years or even less than that. So what we're doing is much faster than what was happening then.

Scott Wing: But the big points that come out of studying this past event [00:25:30] are, first of all, if you add a lot of carbon to the atmosphere and ocean system, you get warming. Secondly, that warming doesn't go away. It stays in the system for a long time, so the carbon that was released isn't taken up very quickly, and that's why it stayed warm for 100,000 years during this warming event. And the third thing is it makes the plants and animals have to adjust. So we see these big changes in the flora and [00:26:00] in the fauna that go along with the warming.

Maggy Benson: And we're experiencing that same carbon emission right now.

Scott Wing: Yeah. We're seeing many of the same kinds of things except at a much increased rate, maybe 10 times faster than it happened during this ancient event.

Maggy Benson: This one comes from Matthew. Besides locating fossils, what is the biggest challenge you face in the field?

Scott Wing: Probably the biggest challenge is just getting around, [00:26:30] Matthew. It's pretty rough country, and you often end up having to walk a long ways to get where you're going because there's no road that goes there. Also, sometimes we get stuck in our field vehicles and you can spend hours digging yourself out of a mud hole. There's a fine balance between driving there, which is faster if you don't get stuck, and walking, which is 100 percent sure to get you there but can take [00:27:00] a lot longer.

Maggy Benson: This one comes from Jackson. How do you date the plant fossils?

Scott Wing: The plant fossils that I find are mostly dated through a process of looking at other fossils that are around them. So you can date rocks by ... You can date volcanic rocks, rocks that have been heated up, by looking at their radiogenic isotopes. So it's basically like there are little clocks [00:27:30] in the rock. You have elements that are decaying from one state to another and you know how fast that happens. And if the rock was heated up, you can use those to tell you the age of the rock.

Scott Wing: But most rocks are not coming out of volcanoes. So we have to sort of use the fossils to ... We have a layer in one place where we actually have a radiometric date, and then we have fossils above and below that, and we find the fossils somewhere else and use the date from over [00:28:00] in the other place to tell us the age of the fossil. So it's actually a two-step process.

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

Scott Wing: There's a website at the museum here for the Evolution of Terrestrial Ecosystems Program, and you can see the web address on the screen. ETE is the short way to say it and a lot less of a mouthful. I also recommend realclimate.org. It's a place where climate scientists get on to comment about the latest discoveries [00:28:30] that have been made in climate science.

Maggy Benson: Wonderful. Thank you so much, Scott.

Scott Wing: Yep. It's been a pleasure.

Maggy Benson: And thank you so much for tuning in. This show will be archived on qrius.si.edu later this evening, if you missed part of it. And thank you so much for joining us for our very first season of Smithsonian Science How?

*(**Editor's Note:** The Evolution of Terrestrial Ecosystems Program's web page is now located here, https://naturalhistory.si.edu/research/paleobiology/research/evolution-terrestrial-ecosystems-program.)*