Video Transcript – How Bones Fossilize or Don't

Maggy Benson: Hello, welcome everyone. Thank you so much for joining us here on Smithsonian Science How, a program that connects you with the scientists and the research that happens here at the Smithsonian's National Museum of Natural History.

Maggy Benson: Before we begin our show today, I want to invite you to participate in the poll, and tell us how you would describe a fossil in just one word. That is the subject of our show today, fossils. And out of all the life on earth that has ever lived, only a tiny fraction has escaped being recycled into new life to become a fossil. To help us unpack why that is, we have today with us curator and paleontologist, Dr. Kay Behrensmeyer. Kay, thank you so much for joining us here today.

Kay Behrensmeyer: Thank you Maggy. I'm a paleontologist and that means I study fossils of all kinds, and I also study how things become fossils. That's one of my big interests.

Maggy Benson: Today we are surrounded by a wonderful collection that you shared with us and even the objects behind us, part of the collection here at the Smithsonian's National Museum of Natural History,

Kay Behrensmeyer: Right. We have a just a treasure trove of wonderful things here. 145 million different objects of all kinds, plants and insects. And of those 40 million are fossils. So it's a great place to be interested in fossils and study them.

Maggy Benson: And today we're going to understand a little bit more about how things fossilize or don't. But before we go there, we want to understand what a fossil is. Some of our viewers have weighed in. And the most popular answer right now is the one word that comes to mind, dinosaur, old. Some of the other words include history, petrified, paleontology, mineral, bones. These all seem to be tracking on the right path.

Kay Behrensmeyer: Right, yes. That's taking us down the path to finding out more. Sometimes what is a fossil can be tricky.

Maggy Benson: You're actually going to lead us in a little exercise where we can decide if some of the objects you show us are fossils or not. Viewers, to follow along, we're going to put a new poll up and Kay is going to walk through a couple of objects. You can decide if you think each one is a fossil or not. You can select as many options as you'd like. Again, you can participate here. It appears in the poll section to the right of your video player. So Kay, where should we begin?

Kay Behrensmeyer: Okay. We have right here, this is a bone piece of a leg bone. You can see it's got sandstone on it. It's mineralized. It's heavy. So that's one. It's one and a half million years old. Then, we have something that is a complete skeleton of a ground squirrel. That's only about 30 years old. Then over here we have a very amazing specimen, which is a piece of mammoth hide with orange fur from an actual mammoth. It's 10,000 years old. Then, we have a piece of wood, which if you count the rings when it died, it was about 50 years old. Then we have something that looks almost exactly like what you'd expect. It's poop.

Maggy Benson: It does look like poop.

Kay Behrensmeyer: It's old poop. It's about 15 to 20 million years old. Finally, we have a lump of coal, and that is about 300 million years old.

Maggy Benson: Well, what an amazing collection that this right here is. So viewers, we're going to give you another couple moments to think about which of these objects are fossils. Kay has shared with us a mineralized bone, a skeleton, mammoth fur, a piece of wood, a piece of poop, and a piece of coal. How old each item is is on the screen.

Maggy Benson: So we're going to leave that poll up for you. If you didn't get a chance to answer it yet, you can still do so. But right now, Kay the responses are coming in. Most of our viewers think that the mineralized bone is a fossil. Second up is the poop, but also the tree trunk has some votes. Everything actually has a vote. But by far and large, the mineralized bone.

Kay Behrensmeyer: Okay, well that makes a lot of sense because we generally think of fossils as hard, as well as old and preserved. But, in fact, some things that are old, very old, are not mineralized or not changed. That I can show you, as an example, is a piece of leaf that is from rocks that are 56 million years old. These leaves were preserved and pressed into the rock and they're still flexible. You can peel them off.

Maggy Benson: Yeah, that leaf is actually peeling off of the rock.

Kay Behrensmeyer: And you can put them in water and you can shake them up like recent leaves, and they're soft. Scientists can actually study the cell structure, but these are so old. So you can't just think of fossils as only hard mineralized things. In special circumstances, they can be almost like modern leaves like this.

Maggy Benson: And like a woolly mammoth, which certainly isn't around today and is still very old. But we can see the fur from here.

Kay Behrensmeyer: Right. That mammoth was preserved in frozen ground and then nothing happened to it. It's very much the way it was just after the mammoth died.

Maggy Benson: So we have a student video question that is related to this conversation about fossils. So let's take a look.

Ethan: Hi, my name is Ethan and I was wondering how long do fossils normally last?

Kay Behrensmeyer: Well, thank you for the question, Ethan. That's a good one. It all depends on whether they're buried, and where they're buried, and how long it takes for them to get mineralized. I'm going to talk about how that happens. So they can be 10,000 years. They can be millions. If they get really well mineralized, then, they can last indefinitely.

Maggy Benson: So this mineralization process that must be a key to lasting a really long time. Can you help us understand a basic overview of the fossilization process?

Kay Behrensmeyer: Yes, and I'll do it mainly for bones because that's what I study. The leaves, of course, we've got pressed into rock. But for most things like bones, you take the mineral that's already in the bone, but that's not enough to make it last effectively. There are many, many little spaces.

Maggy Benson: It looks very spongy.

Kay Behrensmeyer: It's very spongy because-

Maggy Benson: There's air in there.

Kay Behrensmeyer: There's air, there's space, and it's very fragile actually. When a animal's alive, this is filled with organic material, it decays, and then this can be crushed very easily. But if it's underground, and there are minerals added to it, those go into the spaces. That's something we call permineralization, which means added minerals.

Maggy Benson: Do you have an example of a permineralized bone here today to share with us?

Kay Behrensmeyer: Well, I just happened to have these two. I would like you to pick one up and then pick the other up carefully.

Maggy Benson: All right. So I'll pick this one up. It's a little further away. This is a very large bone. Not that heavy. But this one is smaller and much, much heavier. It also is kind of cold to the touch. It feels a lot like a rock.

Kay Behrensmeyer: Yes.

Maggy Benson: And it's very rigid.

Kay Behrensmeyer: Right. Well, that is a 10 million year old rhinoceros bone from Pakistan. And it's the same bone as in the body. It is a limb bone as this one, which is from a modern horse. But this one just has the original minerals from the horse in it. This one has added minerals, the permineralization, which went into the pore spaces. So it's about 30% heavier, even more than that original.

Maggy Benson: Why is it this color?

Kay Behrensmeyer: The color, too, shows that it's had some iron minerals seeping into it that were contributing to this permineralization.

Maggy Benson: So this bone right here, from a 10 million year old rhino, is it all mineral or some of the original bone material, like we see here, actually still present in this?

Kay Behrensmeyer: Well, that's a wonderful thing is that you'd think this is petrified, which would mean it's turned to stone. But it isn't completely because the original mineral that was in that bone has been retained. But then new minerals have been added in the pore spaces. If we see the micrograph of this, where we cut some section of it and looked, that will show us that it's got these minerals. There we go. It's purple because of the way the microscope shows the light. But the little round circles are the interior of the bone and they're very much like they would have been 10 million years ago. But you can see with the arrows, there's added mineral in the center of these circles and then around the edges of them.

Maggy Benson: Because we know that fossils are really rare. Why are they so rare?

Kay Behrensmeyer: Well, that's a very interesting story that's central to my research. First of all, they have to go through the process of not being recycled, which in this diagram, most things that are dead and out on the landscape or even underwater, other organisms want their nutrients. So you have to escape this recycling, a natural recycling and then be buried, permanently buried underground. And then be stabilized by permineralization so you don't get dissolved later on.

Maggy Benson: What is this branch of science? You actually study fossilization. What's this branch of paleontology called?

Kay Behrensmeyer: It's called taphonomy. Taphos means burial. So it's the science or study of the processes of burial. And it's not only how things become fossilized, but what they represent of the ancient world, the ancient ecosystems, the parts of the animals. So there's a lot missing and we have to understand what we do have.

Maggy Benson: How did you get interested in this branch of paleontology?

Kay Behrensmeyer: I started out as a geologist. I love to be outdoors solving puzzles. Then I learned other fields like paleontology, ecology and biology. I like being interdisciplinary, so pulling these different things together. That led to my ability to solve puzzles of taphonomy where I wanted so much to be able to read the fossils, read the record, and understand the worlds of the past. So that was the driving curiosity is to use these methods to find out more that people had never found out before.

Maggy Benson: Do you have an example here to help us understand how taphonomy can help you better put fossils into context?

Kay Behrensmeyer: I like to use this little ground squirrel as an example of a beautiful skeleton. If it were preserved, it would give us lots of information. But if I hadn't brought it back from Wyoming, it would have just disintegrated, been trampled, and maybe only the teeth would have survived. They're very hard. But then if it's only the teeth that get buried and survived, then it's not going to give you a lot of information about the whole animal. So it's just a very small part of that information that you get. The same goes for whole ecosystems that existed in the past. We only get a few species, sometimes very few and sometimes more. But we have to use taphonomy to try to figure out how those few that were lucky enough to get preserved actually can tell us about the whole system.

Maggy Benson: Thank you for helping us understand how fossilization works and more about the branch of taphonomy. We have a couple student questions. This first one is a question about our poop specimen. They want to know why is poop black? Maybe what is the proper term for a fossilized poop?

Kay Behrensmeyer: The term is coprolite. It's a trace fossil, meaning it isn't really the fossil animal itself, but there had to be a fossil animal there for there to be poop. We think that this one might be from a marine crocodile.

Maggy Benson: Oh wow! That must've been a very large crocodile.

Kay Behrensmeyer: Yes, indeed. We're lucky they're not around today.

Maggy Benson: This one is from Sienna. How can we tell about the invertebrates from fossils?

Kay Behrensmeyer: There are so many invertebrate fossils. There's shells. There's coral. That's much more common. In fact, our fossil collections here have mainly invertebrate fossils. The vertebrate fossils are less common. Partly because they mostly come from on land. And if you're underwater, it's easier to become fossilized. So many of the shells are already underwater.

Maggy Benson: This one's from Grayson. Can a fossil unfossilize?

Kay Behrensmeyer: I love that question, Grayson. Thank you. Yes, in a way it can. It can be underground and already mineralized. But then if the soil is the wrong chemistry, then it can be dissolved even after it's fossilized.

Maggy Benson: All right. Let's take one more question for now and this one comes in by video.

Izzy: Hi, I'm Izzy. I was wondering if is it easier for fossils to form in warm or cold climate?

Kay Behrensmeyer: That's a great question, Izzy. And it's actually something that we're still working on and trying to discover. It's usually hard for things in tropical climates to become fossilized because the warmth and all the organisms that live there just disintegrate the bones very quickly. It's easier, and they last longer and colder climates. But we don't really know yet where are the best places are in terms of climate for fossilization to occur for bones at least.

Maggy Benson: Great question. Kay, moving on to understanding a little bit more about how taphonomy can help us understand ancient ecosystems, can you help us understand why it's important to study what gets fossilized and what doesn't? And do you have an example that you can share with us?

Kay Behrensmeyer: Well as I said, there's not much in the fossil record in terms of the amount of information. We have to go looking for the rare examples of where we have good preservation. One of those is actually a quarry, a bone bed, that we have a picture of here. This is a block that is called the Agate Fossil Beds Quarry block. Then we have it here in the museum. It's just a piece of a very, very large bone bed. And you can see all the bones, there're ribs, there're limb bones. They're different sizes and they're all mixed up.

Maggy Benson: They're all mixed together.

Kay Behrensmeyer: They're all mixed up together, but they're all packed into this huge bone bed. So that gives us a puzzle, a question. How did this form and what does it represent? There are only two species in this. One of them is an extinct, small rhinoceros. Here you have some pictures of it. And then the other is a bigger animal called a Chalicothere, which is also extinct and was like a giant sloth sort of. So, why with all these bones do you only have two species represented in this block? Now that's a real mystery.

Maggy Benson: That's like the million dollar question. So as a taphonomist, where do you begin to start chipping away at this mystery?

Kay Behrensmeyer: What I did was when I encountered things like this, I wanted to understand in the modern world what happens to bones. How do they get destroyed and recycled and how much of them get preserved or buried? So you can't really go back in time and do that in Nebraska where the bone bed is. I was able to do a study in East Africa of a modern ecosystem. It's called Amboseli Park. It's in Southern Kenya. It has wonderful habitats, big swamps and forests, woodlands, plains, bushlands. It has lots of different kinds of animals. I have had many different expeditions there. This was the latest one with my Kenyan colleagues and my American and European colleagues.

Kay Behrensmeyer: We all would just go out and do a sampling of the bones that we could find. Here I am with an elephant skeleton. Then we would talk about what would happen to these bones when they were lasting on the landscape or getting buried, and could you ever form something like the Agate Bone Bed?

Maggy Benson: That's really fascinating. You're looking at modern animal bones, not fossils, to be able to solve a mystery from 19 million years ago. So you mentioned that there are three steps in that fossilization process, well three main steps. That first one is the death and the avoiding getting recycled. How does that play out in our bone bed mystery?

Kay Behrensmeyer: Well, there are lots of reasons for getting recycled. One of them is that there are many scavengers. There are scavengers in Amboseli. There were scavengers in all the different time periods that would eat up the remains. In Amboseli, we looked at all the animals and the dead ones that we found. We made these graphs, or diagrams, of what happened. So if you take a thousand wildebeest and 250 of them or so die every year and then you follow them along.

Maggy Benson: So in the fossil record, that was also the case. There were scavengers and there were predators that were consuming bones not leaving anything for the fossil record.

Kay Behrensmeyer: That's right.

Maggy Benson: So in the case of the bone bed mystery, was there any evidence on any of those bones that they had been scavenged or preyed upon?

Kay Behrensmeyer: Very, very little. It looks like if there were scavengers around, they were just overwhelmed by having too much to eat. And they didn't do any damage to speak of to the bone bed. There are a few tooth marks, but no. It didn't happen the way it does in Amboseli.

Maggy Benson: So the next stage of our fossilization process is burial. When you have a fossil, is it possible, as a paleontologist, to understand the conditions in which it was buried just by that fossil?

Kay Behrensmeyer: If you look at the surface of the fossils in the quarry on the bone bed, they're very fresh surfaces. If you look at the bones in Amboseli, many of them, after they've been out for a few years, they look like this. They're weathered. They're fragmenting. They're getting broken.

Maggy Benson: Looks like it's chipping paint or wood.

Kay Behrensmeyer: It's the wear and tear of being on the surface in the hot sun and the rain. So most of the bones, if they're not scavenged, they just weather away over a number of years. But they start showing evidence of that very quickly.

Maggy Benson: And so the bones in the bone bed, do they have evidence of that wear and tear and weathering?

Kay Behrensmeyer: They don't actually. That's another big clue because if they'd been out for anytime at all exposed to sun and rain, they would start showing that evidence. So that implies that there was very quick burial. But it couldn't have been before all the skeletons decayed, that is the soft tissues. So the bones fell apart and then they were kind of all mixed up.

Maggy Benson: What about the geology of where these animals lived before they died and were buried? Is there any way to reconstruct that system of what Nebraska looked like 19 million years ago?

Kay Behrensmeyer: Geology is one of the big lines of evidence that you really need to figure out this mystery. The geologists that work there came up with the idea that there was a big river ecosystem. They made this reconstruction. And how did they do that? They looked at the sediments that the bones were buried in. They looked at the structures. It was mainly sand and some silt. And you could tell there had been currents flowing around the bones and depositing sediment to bury them.

Maggy Benson: So with all the clues that you've put together from the actual fossil bone bed block and together with the geology, are you able to form a hypothesis to understand what happened to these animals?

Kay Behrensmeyer: We have a hypothesis.

Maggy Benson: But before you share-

Kay Behrensmeyer: Before we share it, let's see what the students say.

Maggy Benson: I think that's a great idea. Students were going to ask you to weigh in on this fossil bone bed mystery. Considering all of the clues that Kay shared about the fossils and the geology of the area. Tell us, how did all of these animals die? Were they poisoned, trapped in mud? Was it predation? Was it a drought and then a flood, or a snowstorm? Let us know what you think by putting your response in the window that appears to the right of your video screen.

Maggy Benson: Kay and I can see all of your results coming in. We'll leave the poll open so you can continue to vote if you haven't done so yet. But we have a tie for first. Well, it's changing quickly. So we have responses on most of them, but predation seems to be the top pick. What do you think?

Kay Behrensmeyer: Well, if it had been predation, we would expect there to be more tooth marks and evidence that these animals had been killed by predators, like this bone right here that has tooth marks on it.

Maggy Benson: Oh wow! And there wasn't any evidence of tooth marks on the other bones.

Kay Behrensmeyer: We don't really see that. So that's probably not what could have killed all the animals, hundreds of them that ended up in this bone bed.

Maggy Benson: What about trapped in mud? That's the second most popular answer right now.

Kay Behrensmeyer: Everybody thinks that's the way to become a fossil, and it's possible. It's possible at least some of these animals were trapped in mud. But we don't find their feet kind of sticking down into the bottom of the sediment, which you'd expect some of those feet to have been preserved that way.

Kay Behrensmeyer: So I'll tell you the favored hypothesis right now, taking all the evidence into account, that first of all, these animals congregated around remaining water in a river bed that had dried up during a big drought. They were dying around the waterhole and more came and more died. Then they had eaten everything in the vicinity. So there was nothing left. So it just accumulated into this vast field of dead animals. Then the drought broke after the bodies had decayed some. Rains came and the floods came down the river and buried all the mixed up bones in a big deposit. Then underground, those bones became permineralized over some time and survive today, 19 million years later, for us to find.

Maggy Benson: It's really fascinating to hear how all of your observations in research in Amboseli Park, Kenya, about watching animals and looking at bones can help you interpret this mystery from 19 million years ago.

Kay Behrensmeyer: Right. And that's the wonderful thing about it. Amboseli is a laboratory where I can ask questions based on fossil records. Then even when I don't find something like the fossil record, it tells me how special that one instance might be of this bone bed. We don't have very many bone beds like this. It's very lucky that we do.

Maggy Benson: Wonderful. Thank you so much for being here today and helping us understand more about fossils, taphonomy and solving the Agate Bone Bed mystery alongside you.

Kay Behrensmeyer: Thank you. It's been great.

Maggy Benson: Viewers, thank you so much for tuning in today and viewing this episode of Smithsonian Science How. If you want to learn more about fossilization and Kay's work, you can visit the Q?rius website at qrius.si.edu. On that page is where this program will be archived later this evening. We hope you can tune into our next Smithsonian Science How Broadcast. We will be live next Tuesday, October 2nd in a program live from Belize. I'll be interviewing several scientists that are stationed at the Smithsonian, Carrie Bow Cay field station in Belize. We hope you can join us then. For now, we're signing off. Thank you so much for joining us here on Smithsonian Science How.