After the Fact | Scientists at Work: Studying Volcanic Eruptions—When, How Big, and How Fast?

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TRANSCRIPT

[Cold Open]

Ben Andrews, director of the Smithsonian Institution's Global Volcanism Program: So I'm going to turn off the furnace … I'll grab a big glove, and I'll put on a safety-first shield, one that isn't going to be schmutzy. Yep, here we go.

[Intro music fades in]

Ben Andrews: So if you're standing right in there, that's a good—

Dan LeDuc, host: A good spot? OK.

Ben Andrews: Yeah.

[Ben's voice fades to the background]

Dan LeDuc (narrating): For The Pew Charitable Trusts, I'm Dan LeDuc and in this episode of After the Fact we're looking at volcanoes.

[Ben fades back in]

Ben Andrews: So we're able in these very small furnaces to make small batches of magma.

[Ben fades out]

Dan LeDuc (narrating): And that was Ben Andrews. A volcanologist and geologist. We started in his lab.

[Ben fades back in]

Ben Andrews: And so in these furnaces we can make very small batches of magma that let us understand what the magma's doing before it erupts.

Dan LeDuc: You had a piece of mineral in there and you'd see it like it was in the earth's crust before it came out?

Ben Andrews: Yeah, very much so or very similar to that. So if we look at Mount St. Helens is a good example, some of those rocks, on the morning of May 18, came up in the space of about five or six hours. Other rocks, later on that summer, came up in the space of weeks or months. And we can determine how fast they came up by looking at the minerals in those rocks and so if we do a series of experiments we can then start to look at the natural rocks, comparing them with experiments.

… So right now, I'm about to quench an experimental petrology sample. So quenching just means cool it fast enough that we preserve all the textures that are present at high temperature and high pressure. So I first blow on it with compressed air.

[Music fades in]

Ben LeDuc: That thing is just glowing.

[Sound of hissing] **Ben Andrews:** And then I plunge it into water—

[Sound of squealing and hissing] **Dan LeDuc (narrating):** And that's how it sounds when an igneous rock is formed …

[Squealing and hissing continues]

Dan LeDuc: Oh, that is amazing! It totally changes color when you plunge it in there.

Dan LeDuc (narrating): At least in a laboratory at the Smithsonian National Museum of Natural History. Scientists like Ben who study volcanoes have plenty to research. There are more than a thousand of them dotting the globe and learning how they erupt and perhaps, even more importantly, forecasting when they'll blow is important especially to the 800 million people around the world who live in the footprint of a volcano. That 800 million is our data point for this episode.

[Transition music]

Dan LeDuc: Ben Andrews, thanks so much for bringing us into the interior of this amazing museum. Let me first ask you about you. You grew up near Mount St. Helens?

Ben Andrews: That's right. I was born about six weeks after the big eruption in 1980 of Mount St. Helens. So I was born in July. And on May 18, St. Helens erupted in a big way in an eruption that was transformative for volcanology in the United States, and even worldwide. Because this was one of the first eruptions, maybe the first eruption, that was observed with modern geophysical instruments, modern satellites. And as a result, we learned all sorts of things.

Now, for me, I was a baby. Well, I wasn't even born yet. But once I was born, there were a series of additional eruptions that happened. And there's photos of me in my parents' arms with an ash column in the background. I know they took good care of me, but I probably breathed in a little bit of ash as a baby. And I've been in love with volcanoes ever since.

Dan LeDuc: So these volcanoes, what role do they play in the formation of the Earth?

Ben Andrews: Well, most of the planet, at one time or another, has been surfaced by volcanoes. So the entire seafloor, it might have a thin layer of scum and sediment and biology on it, but underneath that, it's all lava. So the seafloor, which is about two-thirds of the planet, is lava.

If we look at the continents, the continents have granites in them. Those are, essentially, magmas that did not erupt. They have volcanoes that are the erupting part and surfacing, covering large portions of the continents with lava and ash and other rocks. So they do a big job of resurfacing the planet. And ultimately, they often can do things like lead to soils.

So if you take an eruption like Mount St. Helens and dump a bunch of ash on the ground, initially, that ash is not very fertile. It kills things. But if you give that ash time to break down and to form other minerals and interact with water and the environment, ultimately, it can become very fertile soils.

Dan LeDuc: So we all know that volcanoes have these craters. There's magma down there. How far down does it go? I mean, we're not going to the center of the Earth, but it goes down pretty deep.

Ben Andrews: Sure. So if we think about where magmas are coming from, ultimately, all magmas are sourced in the mantle. So that's at the base of the crust or below the crust. So that's at a depth of 50 or even a hundred kilometers. So that's 30 to 60 miles.

Most magmas, though, before an eruption—most magmas don't come straight from the mantle to the surface. Instead, most magmas sit in the crust before they erupt. So if we look at St. Helens, its magma sits at about 7 to 10 kilometers. So that's about 5 to 6 miles below the surface.

In this instance, their plumbing system that connects to the mantle is important, but it's not the final pressure that they see before they erupt.

Dan LeDuc: If we're hiking around a volcano, near a volcano, we're basically walking about 3 miles above a really, really hot oven, but down below our feet.

Ben Andrews: What's interesting about volcanic systems is the magma body, the magma chamber, many of these magma bodies are not there all the time, or they're there, but they're not in an eruptible state. So you could have a mush of crystals. So it's magma, but it's not very fluid.

Dan LeDuc: It doesn't look like the glowing stuff we see in the movies?

Ben Andrews: If we could slice the Earth open, I'm sure it would glow, but it's so full of crystals that it doesn't really want to move. Now if we were to heat that magma up by 50 or 100 degrees many of those crystals would dissolve and at that point the magma can erupt. And so what we think about many volcanic systems is that their magma spend most of the time sitting as a mush I'll say low temperature. It's still hotter than a pizza oven, so it's still really hot, but just not hot enough to really move. And then, occasionally, they get heated up. And then, at that time, they might be able to erupt.

Dan LeDuc: So very basic question here: Why are there such things as volcanoes, right? Why are these points at hundreds of spots around the globe?

Ben Andrews: So I'll say that there are points at approximately 1,427 at last count.

Dan LeDuc: That's a lot of—

Ben Andrews: That's a lot of points. I say that to wear my global volcanism program hat. We track all the world's volcanoes and all the different features. And so there's even more than that, but we just don't know about all the ones in the bottom of the ocean. But the question about why there are volcanoes in certain spots and not everywhere relates to how magma is generated. And that is not every place in the mantle makes magma the same way or will make magma.

So above a subduction zone, there's more magma generated than sitting below Kansas, where there's not going to be much. Now, if we bring that magma up to the surface, once it starts to make a crack, or once it finds a crack and a pathway to the surface, that'll make it much easier for every subsequent magma to come up.

So as a result, we find that even though magma's generated in enormous areas, enormous regions, volcanism tends to focus at specific points. And if we look around the world, we see that there's tall stratovolcanoes like Mount St. Helens or Mount Fuji—big, tall cones that have seen repeated eruptions, one after another, coming up at about the same spot.

Dan LeDuc: And if there are more than a thousand volcanoes around the world, how many people are living near them, are affected by, or potentially going to be affected by, volcanoes?

Ben Andrews: Yeah. So that's a fantastic question and one that partly depends on how we define the footprint of a volcano. But I think one metric is within 60 or 100 kilometers of a volcano, and there's about 800 million people around the world who live within 50 or 100 kilometers of a volcano. So that's more than 10 percent of the world's population.

And if we look in the United States, Oregon and Washington, their population centers fall within that. Some of the California population centers fall within that. The nation of Indonesia, pretty much its entirety sits right next to volcanoes. Japan has lots of volcanoes. So large fractions of the world's population live next to a volcano.

Dan LeDuc: So how does one study volcanoes? You've shown us in the lab what you can do. But I mean, how do you know more about what you can't see?

Ben Andrews: Most obvious way, is as an eruption happens, you go, and you watch it and collect samples from it.

You could also study eruptions by looking at their rocks. So look at ancient eruptions. And ancient, in this instance, just means one that's not erupting as we speak. So we can study St. Helens by going and picking up a pumice that erupted on May 18. Or I can say the eruption in Kamchatka or Guatemala or many, many different places by looking at the rocks from those eruptions. We can also study eruptions by doing experiments in the laboratory or by doing computer simulations of the processes going on.

Now, the unfortunate thing is that eruptions can be very difficult to forecast or to forecast in a way that is most useful for the public and emergency managers. So we can look at a volcano and say it has a 1 percent probability of having a big eruption in the next 100 years. That means that it could erupt tomorrow, but it also might not erupt for 100 years. It might not erupt for 10,000 years. And so a lot goes into forecasts and thinking about how to make those useful for the public and so on.

Dan LeDuc: How many of these over 1,000 volcanoes around the globe are actively monitored?

Ben Andrews: Most around the world are, unfortunately, not adequately monitored on the ground. And that's just because we don't have resources, or we have not allocated resources to do that. That being said, we do have better and better satellite monitoring of volcanoes. And the challenge there is that satellites can give you a worldwide picture of what's going on. But then, you still have to have an idea of what's happening on the ground.

Dan LeDuc: You had mentioned that Mount St. Helens, because it happened to occur near where there was all of this modern technology that could monitor what was going on, was this sort of milestone. Since Mount St. Helens, or because of Mount St. Helens, what do you think are some of the biggest lessons that scientists like you have learned about how volcanoes work?

Ben Andrews: So St. Helens, because it happened near a major metropolitan area with modern geophysical instrumentation and satellite observations, we learned a lot about how volcanoes work. So that showed us 11 years later when Pinatubo erupted in the Philippines, scientists there were able to work together and do a very good job of forecasting that eruption. They were able to evacuate a lot of people, they evacuated a lot of assets out of the area. It was essentially a forecasting success. So that was in just 11 years.

The big lessons that we've learned are in order to understand what's happening at a volcano, we need to know what its background state is. We also need to know what that volcano has done in the past.

Now, the other thing that volcano scientists have learned in the last decade is the importance of communication and unified communication so that what we know about volcanoes and how they erupt and what we think about their forecasts make it into the hands of the appropriate civil authorities and then that that information is adequately communicated to the public. And some examples of where this can go right or it can go wrong are thinking about how to convey certain hazards.

If we look at a volcano, what people often think about is hot lava, red hot lava flowing down the side of the volcano, that that's the big thing to worry about. And for some volcanoes, that is. If we're at Hawaii, as evidenced a year and a half ago, lava flows can do a lot of damage.

But for many volcanoes, lava flows are not the concern. Instead, the thing that might be of concern, or the principal hazard, might be a lahar, which is to say a volcanic mud flow. So in 1985, Nevado Del Ruiz, a volcano in Colombia, had a relatively small eruption that, unfortunately, triggered a very large lahar that killed more than 20,000 people in the city of Armero. This was incredibly bad—very, very, very bad.

And so if we go to Rainier in the Seattle area, Mount Rainier has made big mud flows in the past. And if you look around Rainier, you'll find all of the drainages have lahar or mud flow warning hazards.

There's evacuation routes. There's a systematic effort to educate the public about what this volcano can do to get people out of the way. And again, people think a volcano is red hot lava. Well, maybe lava is not the thing to worry about.

Dan LeDuc: So after all this time of doing this, what don't you know that you want to know about volcanoes?

Ben Andrews: Well, a lot of my work comes to understanding—it's how fast, how big, and how an eruption is going to happen. And I hope my funding agencies are listening: These are really important questions for societal relevance. But understanding how fast an eruption happens, there's an intrinsic sort of cool factor that's like a little boy doing science, wanting to see stuff like how fast can the car go? How fast does eruption go?

But it's also important for understanding how fast does magma come up during an eruption, or how fast does a pyroclastic flow move across the ground? And how big—again, there's a little kid element—but it's also important because how big an eruption is dictates how high into the atmosphere the ash will go or how much area the deposit will cover. And so those are really important for reconstructing ancient eruptions and also forecasting and understanding what could happen in the future.

[Transition music fades in]

And then the last part, the what's it going to do, it's a basic question. So is this magma going to ooze, or is it going to blow up? And so a lot of my work looks at those different questions: the how big, how fast, and what's it going to do?

Dan LeDuc: We appreciate the hospitality of the folks at the Smithsonian who allowed us behind the scenes. To see pictures of our visit and learn more about volcanoes, please head over to pewtrusts.org/afterthefact.

Until next time, for The Pew Charitable Trusts, I'm Dan LeDuc.