Video Transcript: How Volcanic Eruptions Send Materials Up and Out

Maggy Benson: Wow.

Maggy Benson: Hey everyone. Thank you so much for joining us here on Smithsonian Science How. We have a really awesome program today about volcanoes. We are joined by geologist, Dr. Ben Andrews from the Smithsonian's National Museum of Natural History. Ben, thank you so much for being here with us today.

Ben Andrews: Thanks. It's a great pleasure to be here.

Maggy Benson: So you're a geologist here at the Smithsonian.

Ben Andrews: Mm-hmm (affirmative).

Maggy Benson: And you specialize in volcanoes, but what specifically?

Ben Andrews: That's right. I study volcanoes, and I look at volcanic eruptions. I look at how volcanoes erupt, beginning with magma storage deep in the crust, maybe five or six or 10 kilometers below our feet, then magma coming up to the surface, and then how does that magma erupt. Does it come out as a lava flow or is it explosive eruption of pumice and ash like we see in this picture of Mount St. Helens?

Maggy Benson: So that is characterized as an explosive eruption.

Ben Andrews: That's right. This next picture is also of Mount St. Helens, and these are both explosive eruptions where we have great big clouds of pumice, and ash, and gas, that are coming out and ultimately can cause a lot of hazards.

Maggy Benson: So you have a demonstration here for us today, to help explain the difference between an explosive eruption like we just saw, and something else, like a lava flow that comes down the side of a volcano.

Ben Andrews: That's right. If we want to think about why volcanoes explode, it all comes down to dissolved gas. We have right here ... You know what comes next.

Maggy Benson: A bottle of soda.

Ben Andrews: That's right. You've seen this.

Maggy Benson: Or is this a model?

Ben Andrews: This is a model. This is not a volcano. It's a bottle of soda, but we can use this model to understand how real volcanoes work. Real volcanoes explode because there's gas that's dissolved inside of that magma, and if the gas is able to escape very slowly, we have an eruption of lava, but if the gas doesn't escape, and instead comes out really fast, and comes out with the magma, we have an explosive eruption. So if I were to take this and open it up real fast, what would happen?

Maggy Benson: You'd have one less friend.

Ben Andrews: I'd be in a lot of trouble.

Maggy Benson: And I'd get really wet.

Ben Andrews: That's right. So we're not going to do that, but instead, if I let the gas out very slowly, we'll hear a hiss ...

Maggy Benson: There it is.

Ben Andrews: And we can now see that the gas is escaping without exploding. This is what allows lava to erupt rather than in an explosive eruption.

Maggy Benson: So going back to what is kind of coming out, here we see (on the right) the fast bubbles; this is the explosive eruption.

Ben Andrews: That's right. If the bubbles come out of solution very quickly, that is, they exsolve. They form just like we saw the bubbles form in the soda, if those bubbles come out very quickly, and they don't have time to escape or to get away from the liquid, then they explode that liquid out with them. They carry it out with them, and that's what happens in an explosive eruption.

Maggy Benson: So let's talk a little bit about the differences between what is coming out of the volcano then.

Ben Andrews: Sure.

Maggy Benson: Because if you have that slow kind of the gas is escaping, then the lava comes out, versus and explosive eruption, what is that ash made of? Is it the same material?

Ben Andrews: Well, chemically, it's the same. The difference between a lava and a pumice and a piece of ash has nothing to do with the chemistry or the composition, but it does have a lot to do with whether or not there are bubbles. So right here, I have a bag of pumice and ash that were erupted in the 1980 eruption of Mount St. Helens. I'm going to pour some of this out.

Maggy Benson: I see clouds of ash coming out right now-

Ben Andrews: That's right. There are clouds of ash.

Maggy Benson: ... even on our table.

Ben Andrews: Even on our table. And right here, we can see that this pile right here, there's some big pieces of pumice, right here. This is a piece of frozen magma foam. And then there are smaller pieces. Ultimately, there are little tiny things that are smaller than grains of sand. Those little pieces are bits of frozen magma foam, little bits of glassy foam. It's sharp. It's full of bubbles. That's what's in an explosive eruption. We have gas coming out, and ash, which is little pieces of rock, and pumice, which are bigger pieces of rock.

Maggy Benson: And all of that is very sharp and very dangerous.

Ben Andrews: That's right. You would not want to breathe this in, or you wouldn't want to have it get into your airplane engine, or even if you had a bunch of this land on the roof of your house, that would also cause a problem.

Ben Andrews: This right here is a picture of Mayon Volcano in the Philippines, and we can see a great big cloud of ash and gas, coming down the side of the volcano. This is a microscope view of what that ash looks like. This is a piece of ... It looks like a piece of foam, because it is. It's glass, and it's full of little tiny bubbles, and the size there ... That's about as big as three human hairs. One human hair is generally about 30 microns across. That scale bar was 30 microns. So we can see that ash is very small, full of very tiny, very, very tiny bubbles.

Maggy Benson: Now, help us understand the difference between this ash and lava that we might be more familiar with.

Ben Andrews: Sure. We'll come back to our little magma, our eruption simulator here. If we take our magma, pour it in here, the foamy bit that should come up on top, that's essentially like pumice. Well, not so foamy today, but the pumice would be the magma foam, and the black part here, where there's no more bubbles, that's like lava. We have examples of that here on the table, where we have a piece of obsidian lava right here. This is almost no bubbles at all. This is essentially a great big piece of volcanic glass. Right next to it, in white, we have a pumice that's also a piece of volcanic glass. This piece of volcanic glass was full of bubbles. This is about 75 percent bubbles. But, if you were to grind this up, and grind this one up, the pumice and the obsidian would look exactly the same. They're the same composition, the same flavor of magma. One has bubbles and exploded, that's the pumice. One flowed out without any bubbles, and that's the obsidian.

Maggy Benson: And when this was flowing out, that's a much different occurrence than when ash is exploding out of a volcano. Isn't that right?

Ben Andrews: That's right. When these lavas ooze like we see in this movie right here, they don't move ... Generally they don't move very fast at all. This is a time-lapse movie showing one hour of a lava flow in Hawaii, happening in one minute. So, it doesn't move very fast at all. We might even see some people run around in the background.

Maggy Benson: There they are.

Ben Andrews: You can see that this thing doesn't move quickly at all. It's moving much less than a meter per second. You could walk away from that no trouble. It's very, very slow. A pyroclastic flow, on the other hand, moves very, very quickly. Pyroclastic flows oftentimes move at speeds of 30, or 50, or even 100 meters per second. Now to put that in perspective, that's three or even 10 times faster than the fastest human has ever run.

Maggy Benson: Wow. That's incredible.

Ben Andrews: It is.

Maggy Benson: And kind of scary-

Ben Andrews: It is. That's right.

Maggy Benson: ... knowing what it's all made up of.

Ben Andrews: Mm-hmm (affirmative). That's right. These clouds look fluffy, but they're not. They're full of sharp pieces of glass and rock.

Maggy Benson: We've seen a couple pictures of these explosive eruptions, and they look like they extend way higher than the actual volcano, that mountain that it's coming out of. How is that behavior happening?

Ben Andrews: As these pyroclastic flows move, like we see in this picture right here, it's moving down the side of the mountain, down the side of the volcano, but as they move, they mix air in. Because they mix air in, they can become buoyant, and they can start to rise like a hot air balloon. If you take air and you heat it up, it expands; that lets these clouds rise up, like we see again in these pictures of pyroclastic flows from Mayon Volcano in the Philippines. You have all these people right here that are at a safe distance, watching some pretty spectacular and pretty terrifying eruptions of pyroclastic flows.

Ben Andrews: Now in this movie right here, we can see an eruption from Calbuco Volcano in Chile, and this is showing us what happens when a volcanic eruption entrains enough air, or mixes in enough air, that it rises from the beginning. So this ash and gas is coming out, it mixes, it rises up to 10 kilometers up in the air, and spreads buoyantly, whereas in this one here, we have a small eruption of Mount St. Helens that didn't mix in enough air, and so it collapsed as a pyroclastic flow.

Maggy Benson: And you used the word entrain, what does that word mean?

Ben Andrews: Entrain is just another way of saying mix.

Maggy Benson: Got it. So it's mixing with that air, and it's rising up.

Ben Andrews: That's right.

Maggy Benson: Well then, you've laid some great groundwork for what a pyroclastic flow is, and what a lava flow is, and how they're a little bit different. Let's check in with our visitors and see-

Ben Andrews: Sounds great.

Maggy Benson: ... and give them an opportunity to participate in a live poll. Viewers, here's an opportunity to participate in a live poll with us. Tell us what you think by responding to the poll that appears to the right of your video screen. Tell us, compared to lava flows, pyroclastic flows, the things that Ben studies, are hotter, faster, denser, safer, or predictable? Put your answer in the window that appears to the right of your video screen, and remember that this is the same place where you can post questions for Dr. Ben Andrews to answer on air today, or volcanologist Ed Venzke in the chat window, will respond to you in the chat.

Maggy Benson: Ben and I are watching your results come in, and 89 percent of you think that pyroclastic flows are faster. So, recapping a little bit about speed.

Ben Andrews: That's right. That's right. Pyroclastic flows move at very high speed. They might move at 30, 50, or even 100 meters per second, which is three or even 10 times faster than a person can run ... the fastest person can run ... whereas lava flows are much slower. They oftentimes move at less than a meter per second. They're something that you could walk away from, whereas a pyroclastic flow is something that even a car might not be able to make it away from.

Maggy Benson: So let's revisit some of those other poll answers that were up there. How about temperature? How do pyroclastic flows compare to lava flows?

Ben Andrews: Pyroclastic flows are just about always going to be colder than a lava flow. That's because pyroclastic flows mix in air, which has the effect of cooling them down. We have a demo that we can do right there, if that's okay with you.

Maggy Benson: Yeah. Absolutely.

Ben Andrews: All right. So, I see you're a coffee drinker.

Maggy Benson: Of course.

Ben Andrews: If we take these two cups of coffee right here, and we take their temperature, we should see that they're pretty warm.

Maggy Benson: Here's your thermometer. This is not the one I have in my kitchen.

Ben Andrews: No, this is actually the type of thermometer ... We could stab this into lava and get its temperature.

Maggy Benson: Very cool. But we have coffee today instead.

Ben Andrews: We have coffee. So we look right here, we can see that this cup of coffee has a temperature of 43 degrees Celsius ... 44 maybe. This cup here is also 44, which is good. They were the same temperature. Now, if we were to mix in some cream into here, this cream has a lower temperature of 21 degrees. So what's going to happen to the temperature of the coffee if I add some cream to it?

Maggy Benson: My hypothesis is that it will get colder.

Ben Andrews: That's right. Let's see. If we have this guy here, and we add some cream ... This was at 44 degrees. If we add cream into there, we see that we've just cooled this off by about four degrees. Now, what we've done here, we've cooled it off, we've add new material. We've added cream to this, but we haven't changed the amount of coffee that was in there. There's still the same amount of coffee. This is what's happening in a pyroclastic flow. It starts out hot, but it mixes in cold air that has the effect of cooling down the pyroclastic flow.

Maggy Benson: Well, and here we see the difference here, between this red-hot magma, and the pyroclastic flow.

Ben Andrews: That's right. This red-hot lava on the right is glowing, which means that it's at least 600 or 700 degrees Celsius. That's hotter than a pizza oven. Whereas on the pyroclastic eruption to the left, we can see it's not glowing, and we also have this mixed in air. This is going to be much cooler. It's still hot for you and me, but it's much cooler than that lava.

Maggy Benson: So what about one of those other options, density? How dense is a pyroclastic flow compared to lava?

Ben Andrews: Let's start with the lava. A lava is essentially ... Or it is, solid molten rock. That means that this is, like this lava here, this has a density that's about a thousand times ...Sorry, about two and a half times the density of water, or about 2,000 times the density of air. This is a solid rock. Now, if we look at a pyroclastic flow, it has some rocks in it, but it also has a whole lot of gas. The density of a pyroclastic flow is about eight or ten times the density of air, or about a hundred times less than the density of water. So we can see then, that the difference in their densities is huge.

Ben Andrews: We also see differences in their deposits. This picture here is showing us a series of volcanic eruption deposits in Kamchatka, Russia. Those brown layers, the brown and sort of orange layers are soils. In between them, there's all these layers of gray and white, and sort of yellowy-white speckledy pumice falls and ash layers, and those are all from explosive eruptions. Those layers are composed of lots of individual little rocks, just setting down, one on top of another.

Ben Andrews: That's very different from this picture of a big cliff of lava in Hawaii. This is that red-hot lava flowing down the side is an eruption from Mauna Ulu, and it's flowing into the Makaopuhi Pit Crater. That's a crater that looks like at least 100 meters deep, and all of those horizontal layers there are previous lava flows.

Maggy Benson: Wow.

Ben Andrews: So, it's just layer upon layer of solid rock. We see that again here, where this is a lava flow in Oregon. That's a different type of lava, but the front of this lava flow is made up of really big pieces of rock, maybe the size of a refrigerator or the size of a car, but the interior is just solid rock.

Maggy Benson: Interesting. Now you've kind of laid the foundation for what a pyroclastic flow is. It's pretty hot, but not as hot as lava.

Ben Andrews: That's right.

Maggy Benson: It's not as dense as lava, but it's very fast.

Ben Andrews: Yes.

Maggy Benson: And very dangerous.

Ben Andrews: Yes.

Maggy Benson: Now, does that pose any kind of air hazard for aviation or even people?

Ben Andrews: Yep. Absolutely. Pyroclastic flows are one of the biggest hazards that a volcano can pose to people and to property, and that's because they move very quickly. The first thing we'll talk about is their aviation hazards. In all of these pictures, where we've seen of pyroclastic flows, there's a current going across the ground, but there's also ash that's lifting up into the air to make a plume. We see that here in this picture of Redoubt Volcano, erupting in 1989, and there's a ... the mountain is that ... that volcano looking mountain on the left side, but the big ash plume is not rising from the top of the mountain. Instead, it's rising from a pyroclastic flow that erupted a few minutes before this picture was taken.

Ben Andrews: All of the ash from that eruption ... or a lot of that ash ... has lifted off to form a plume that ultimately went up to 8 or 10 kilometers altitude, which happens to be about how high airplanes fly. Now, you might remember about seven years ago, there was an eruption in Iceland of Eyjafjallajökull Volcano, and we see a picture of that here from a satellite. That big brown stripe going down the middle of the frame is the ash plume from this eruption. It wasn't a very big eruption, but it shut down air traffic over all of Europe for about two and a half weeks, and caused several billion dollars' worth of economic damage.

Maggy Benson: Wow. That's catastrophic for the economy.

Ben Andrews: It was very big. Yeah. It's a big deal.

Maggy Benson: And especially from not that large of an eruption, as you just said.

Ben Andrews: That's right. It wasn't a very big eruption. It didn't hurt anyone, which is very good, but it caused a whole lot of economic damage.

Maggy Benson: Now, what about the ground hazard? What happens when this flow comes down the side of the mountain, what happens if you're in its path?

Ben Andrews: These pyroclastic flows, they often look like a big fluffy cloud, but they're a big fluffy cloud that's full of pieces of broken glass, big rocks, hot rocks. It's more like a big super-heated sandblasting cloud, and it destroys almost everything in its path. We see evidence of that right here. This is a picture of all that remains of a wall of a structure in the El Chichon eruption in Mexico. This happened in 1982, and a pyroclastic flow erupted from this volcano, and it knocked down almost everything. We can see the remains of the forest in the background, and all that remains of this building is a little piece of the wall, and the rebar that used to hold part of that wall up, or help hold that concrete wall up, has been bent and twisted off to the left.

Maggy Benson: Wow. That's really powerful.

Ben Andrews: It's incredibly powerful and terrifying. We see another evidence here from an eruption at Montserrat in the West Indies. Right here, all of the ... The green is grass and plants, but all that's been covered by pyroclastic flow deposits, which are in the grayish-brown color. You can see some buildings there that were largely destroyed by this eruption. Again, this was not a particularly big eruption.

Maggy Benson: So, as somebody who studies pyroclastic flows, you must have the most dangerous job on Earth. Do you ever actually get to go out into the field to study these?

Ben Andrews: I do get to go into the field. We like to say, though, that it's only dangerous if I'm doing the job wrong. So, the ways that we study these volcanoes, one way is to go into the field, and we can look in an active eruption like this one here. This is showing Santiaguito Volcano in Guatemala. We're sitting on the top of Santa María Volcano, looking down at this. This is one of the few places in the world where you can safely watch an explosive eruption, because we're about two and a half kilometers away, and a kilometer above it.

Ben Andrews: When we're at these volcanoes, we use various cameras and other instruments to get close-up views. We can see that with this camera right here. We can use video cameras. We can use temperature cameras like this thermal IR video showing us the lava lake at Kīlauea. That's about three football fields across right there and full of liquid lava. We can also study volcanoes using geophysical techniques like seismology. To do that, we listen for the earthquakes, and by locating those earthquakes, and looking at how those earthquakes sound, we can then see where the magma is, is the magma moving, what are the rocks doing, and we can ultimately get a great handle on what's happening below the ground.

Maggy Benson: So, can you use these different streams of data to be able to model volcanoes?

Ben Andrews: Absolutely. One way that we can do that is that we can combine our field observations into numerical models. We see a picture of that right here, where we have a numerical simulation, or a computer model, showing the eruption of Mount Vesuvius in Italy. We have the eruption column come up, and then it starts to collapse and make pyroclastic flows. We can see right here, that this particular model would let us understand where pyroclastic flows might go, how far they might extend into the surrounding city. We can also do tabletop experiments, or analog experiments sort of like this one here, where we have a volcano made out of clay. A lot of my work, we do this. We aren't making volcanoes out of clay; we're playing with some other things we'll see in a few minutes. But, by doing these experiments, we can understand how natural systems work in a very controlled and safe manner.

Maggy Benson: We want to check back in with our viewers to give you a chance to tell us what you think in a live poll. So, tell us, to model a pyroclastic flow, you will need to build a small volcano, make 1,000 degree gas erupt, make ash spew out, make a mixture of gas and ash, or make big chunks fly out. Take a moment to think about it and put your response in the window that appears to the right of your video screen.

Maggy Benson: We're watching all of your responses come in. Most of, 60 percent of you say, build a small volcano. What do you think, Ben?

Ben Andrews: Well, that was actually a bit of a trick question that we offered them, because it turns out all of those answers are correct, depending on what question we're asking. If we were asking a question about how might lava flows or pyroclastic flows behave at a particular volcano, where might they go, we might want to build a model of that volcano. And so, that would be a great answer like 60 percent of you said. If, on the other hand, we wanted to study how hot lava, or how ash, interacts with the ground, and what it does when it lands in a swamp, and makes the swamp explode, or when it hits a building, we might then want to make very hot ash. If, on the other hand, you're doing what I study, which is to understand how far and how fast pyroclastic flows go, for that we would use a mixture of ash and gas.

Maggy Benson: So that's your big research question.

Ben Andrews: That's right. I generally try and study how fast do pyroclastic flows go, how far do they go, and ultimately, when and where do they lift off to make a buoyant plume.

Maggy Benson: So you're going to show us in a video clip in a moment, how you do that in your lab.

Ben Andrews: Mm-hmm (affirmative).

Maggy Benson: But first, can you explain to us a little bit more about how that pyroclastic flow can lift up?

Ben Andrews: Sure. So if we think about a pyroclastic flow, we can also call it a pyroclastic density current. We can break that name apart. Pyroclastic, so this would mean, fire and broken, or fire rock. That's pretty simple. It's volcanic rock. And then density current, so the density part means that it's moving, because it's denser than the air. This means that pyroclastic flows, or pyroclastic density currents, start out very similar to an avalanche, that is, they're both moving because they're denser than the air. In our little cartoon here, we could see the snow avalanche goes down the side of the mountain because it's a big loud of ice and snow. It's denser than the air, so it moves across the ground. The same thing happens in a pyroclastic flow, but in the case of a pyroclastic flow, because it's hot, any air that it mixes in, it heats up and expands. As we've talked about earlier, buoyant things rise. And so, if we take this pyroclastic flow, we add volume to it, and we lower its density, pretty soon it's no longer denser than the air, and now it can lift off and rise like a hot air balloon.

Maggy Benson: Well, let's take a look at how you model that in your experimental space, here at the Smithsonian. We have a video to see.

Ben Andrews: Welcome to the Experimental Volcanology Laboratory. This is a great big box that we built, inside of which we can make small volcanic eruptions. Volcanic eruptions are often very, very large, and very dangerous. But this is a facility that we can use to make very small eruptions that aren't dangerous at all. A natural volcanic eruption might have a cloud of ash that's moving at 100 miles per hour, and it might be 500 degrees Celsius. Now, that's super dangerous, but this thing behind us makes little currents that move at able one meter per second, and they're also only about two degrees warmer than the room, so that's not very hot at all.

Ben Andrews: This is a great big box that's 28 feet long and 20 feet across, and from the floor up to the ceiling, it's eight and a half feet tall. This is built on top of a commercial stage, and it's framed with two by fours, plastic sheeting, and then again, we have plexiglass that lets' us see inside of the tank. Inside of there we have temperature sensors, which outside of the tank make this crazy mess of yellow wires.

Ben Andrews: Part of the way that we watch our experiments is using lasers. We use the laser to make a great big sheet of light that allows us to see one slice of the experiment. Of course, in this case, we're using three different colors, a red laser, a green laser, and a blue laser, so we get to see three different slices of the experiment all at the same time. Now, the lasers that we use are about a hundred times more powerful than the laser pointer in a classroom. When I go inside of the tank to either clean the experiments, or if I have to adjust the lasers, then I have to wear laser safety glasses. These glasses right here block the laser light and prevent it from coming in and hurting me.

Maggy Benson: So we got an awesome view there. Thank you Ben so much for inviting us out there.

Ben Andrews: Thanks for coming out.

Maggy Benson: I mean, we saw how you're basically replicating that big fluffy part, which isn't actually fluffy at all.

Ben Andrews: That's right. It looks fluffy, but it's not.

Maggy Benson: And you're using laser beams.

Ben Andrews: That's right.

Maggy Benson: And we have a fun new addition here on our set, and you're going to show us exactly how you use these laser beams in your experiments.

Ben Andrews: That's right. First, I'm going to hand you some laser safety glasses.

Maggy Benson: All right.

Ben Andrews: We use lasers because we want to see inside of our experiment. We want to be able to slice and dice that pyroclastic flow and see what's happening inside of it. We can use lasers essentially to make a sheet of light that goes right down the middle of the experiment, or wherever we want to put it. That's what I brought here today is a laser and a lens, and we're going to see how that works.

Maggy Benson: These are to keep our eyes safe?

Ben Andrews: That's right. The beauty of these laser glasses is they keep the laser radiation from hurting our eyes. This is good. The downside is we can't actually see the laser, so that's the funny part about laser safety glasses. So, I'm going to turn this laser on right here.

Maggy Benson: So, we're going to depend on our camera crew here to tell us if you can actually see the laser. We can't see it.

Ben Andrews: All right.

Maggy Benson: All right. Here you see it.

Ben Andrews: So right here, we can see this amazing laser beam right there. Oh ... we have to shift a little bit. There we go.

Maggy Benson: All right.

Ben Andrews: Now, if I were to put a lens there in front of this, we can turn this beam into a sheet. So right there, we've not turned this beam into now a horizontal sheet. We can do this is in the lab. We can use a whole bunch of different lasers, and so we can have great big sheets that are illuminating the entire experiment.

Maggy Benson: So you're slicing and dicing using laser beams and lenses, which are these glass rods.

Ben Andrews: That's right. That's right. I'm going to turn this off.

Maggy Benson: So cool. So you mentioned that you use three different colored lasers.

Ben Andrews: Mm-hmm (affirmative). That's right. I use red lasers, and green lasers, and blue lasers, and that's because our cameras have pixels that are sensitive to red and green and blue. We can take our video data that we collect in an experiment, and we can separate that into a red, a green, and a blue, and therefore, we can get independent planes that give us different views of what's going on in our current, like we see in the cartoon there, where we have a horizontal plane in blue, a vertical plane in green, and another vertical plane in red.

Maggy Benson: So when you're in the lab, it looks really fun. You get to simulate these volcanic eruptions. Do you do it all day long until your camera footage runs out and you're-

Ben Andrews: Well yes and no. We certainly run out of memory cards a lot, and we run out of camera batteries a lot, but for every experiment that lasts maybe 100 seconds, I spend about a half hour cleaning the tank.

Maggy Benson: All right. So, can you tell us how you're visualizing these results to be able to better understand pyroclastic flows?

Ben Andrews: Sure. Well, one of the big questions that I'm looking at is how do these pyroclastic flows mix air, and to do that, we want to understand how the volume of the current changes, and also how its surface area changes. We can do that using our lasers and a high speed camera, and we can make 3D measurements of these model pyroclastic flows. In the bottom picture here, we have a cold current, or an ambient temperature current, and this would be like a snow avalanche. Even though it mixes in air, it never becomes buoyant, and it just flows out across the floor of the tank. The difference in the upper current is that it's a hot one, so when it mixes in there, it lifts off because it becomes less dense than the air, and it rises buoyantly.

Maggy Benson: So how do these experiments compare, in scale, to a real volcanic eruption?

Ben Andrews: Well, if we remember a real volcanic eruption, it might be 500 degrees Celsius, moving at 100 meters per second, and it's like 200 meters thick.

Maggy Benson: Totally deadly.

Ben Andrews: Deadly and terrifying. My experiments are about 100 times smaller in all ways. They're like one meter per second, two degrees warmer than the room, and less than a meter thick. My experiments also differ in the deposits they leave. That previous picture was showing Mount St. Helens, and that was about a 10- or 20-meter thick deposit from one afternoon of pyroclastic flows. My currents leave deposits that are like a tenth of a millimeter thick. So not very thick at all.

Maggy Benson: You could sneeze those away.

Ben Andrews: You can and you do.

Maggy Benson: Ben, thank you so much for helping us better understand pyroclastic flows, and how you found these really innovative and creative ways to model them in the safety of your lab.

Ben Andrews: Sure. Thank you very much.

Maggy Benson: So Ben, we are unfortunately all out of time. Thank you viewers for all of your wonderful questions. We're sorry we can't get to all of them. Ben, where can our viewers learn more about volcanoes?

Ben Andrews: One great resource is the Global Volcanism Program, and our website is volcano.si.edu. If you go to our website and look at the Learn tab, you can find all sorts of resources, including image galleries, showing photos of volcanoes and different types of volcanic processes. We have the eruptions, earthquakes, and emissions app, which is an animation showing the last almost 60 years of eruptions, earthquakes, and volcanic emissions that have happened around the world. And we also have profile pages for all of the world's 1,449 active volcanoes.

Maggy Benson: Wow. It's a pretty great resource.

Ben Andrews: It's a pretty great resource.

Maggy Benson: Ben, thank you so much for being here with us.

Ben Andrews: Thank you.

Maggy Benson: ... and introducing us to pyroclastic flows.

Ben Andrews: Thanks.

Maggy Benson: And viewers, thank you so much for tuning in today and sending in all of your wonderful questions. We're sorry we didn't get to all of them. If you want to see this broadcast again, it'll be archived later this evening at qrius.si.edu, which is the same place where you can find resources about volcanoes and Ben's work. Thank you so much for joining us today and we hope to see you next time on Smithsonian Science How.