Outro (00:01):

Welcome to Earthly, a Clemson University podcast discussing issues of agriculture, horticulture, nature, and design, impacting the world nation, state of South Carolina and even your home. Here's your host, Jonathan Veit.

Jonathan (00:17):

There has been a flurry of geological activity in South Carolina lately, particularly around the Midlands and upstate. In fact, the most recent was a 1.6 magnitude earthquake recorded April 4th, near the town of Cross Anchor in Spartanburg County. Today on Earthly, I talked to Clemson assistant Professor Brady Flinchem about South Carolina earthquakes. And if all the little quakes we've been having mean there's a big one headed our way. Flinchem, studies how near surface geophysical measurements can improve our understanding of what's happening beneath earth's surface.

Jonathan (00:49):

Thanks for joining me on Earthly Today. Brady, if you don't mind, start by telling us what causes earthquakes and what's happening below the surface of the earth while the ground is shaking.

Brady (00:59):

Yeah, sure. So fundamentally what an earthquake is, is it's, it's, it's comes down to play tetectonic. So, you know, the general structure of the earth is, it's got four layers. We've got the inter core, the outer core, and then the mantle. And then on floating on top of this really hot mantle, we've got the crust. And these crusts really brittle rock, and they tend to kind of float around and mantle processes, whether that's heat or probably more complex processes kind of push on these plates, right? And so they'll push, they'll slide, they'll move along one another. So what an earthquake is, is it's actually the result of stresses that build up usually along plate boundaries or along faults. And then for whatever reason that stress overcomes the strength of the rock. And then it goes right, it, it, it blasts away. It moves.

Brady (01:44):

There's different kinds of earthquakes. They can move laterally for strike slips. This is kind of like the situation we have in California. They can move in normal. So you can have one that drops underneath the other in, in terms of regional extension. If those forces on the crust are pulling away that would be like the great basin in Northern Nevada. And then the earthquakes that we tend to have here on the east coast are, are either thrust or reverts faults because we're in compression. So the forces are pushing those plates together and one plate kind of slips up or below. Now this is all happening well below the surface, usually kilometers down, right? So we can't really see that. But what you're feeling in the earthquake is that abrupt failure of the rock, right? And then as that rock fails and rubs up against the other side, along that fault plane, it produces elastic or you know, seismic energy that you can feel at the surface, right? And this energy will travel around the world depending on how big it is.

Jonathan (02:37):

Is there a difference between the way an earthquake feels if the two plates are pushing together or if they're moving away from each other?

Brady (02:44):

Probably not to you and me, but if you have multiple seismic sensors out, you can certainly tell the difference. And this is actually and you know, we'll talk about it a little bit later, but how do we know, how do we define the size and what kind of fault it is? So actually that question, if it's moving away from each other and you have a sensor on one side, you can actually see the ground move toward the sensor, and then on the other side it'll move away from the sensor. Now to you and me, you probably won't feel that, but we have instrumentations. Those, those seismometers are sense enough to literally see that. And so yes, if you have, you know, three or four of these in a circle, you would actually see the ground displaced in different directions.

Jonathan (03:20):

Talk a little about the technology. We use this seismometers. Is that the term you used? How, what they are, how they work.

Brady (03:28):

So seismometers are fantastic instruments. They're, they're crazy sensitive, right? So for my research, I use what we call a geophone, which is like a super cheap seismometer. My geophones usually have like a spike on them, and they go on the ground and, and they record. They're, they're considered not very sensitive, but I'll tell you, I can put them in the ground, put them a football field away and basically jump on the ground and see that on my geophone. So the seismometers that we're using to monitor earthquakes around the world are even more sensitive than that. And fundamentally what a seismometer does is you put it on the ground, you basically couple it to the surface, and there's a couple of different types of them, but fundamentally they're recording ground motion. So they'll either record physical displacement of the ground as a function of time, which usually is velocity. But the really fancy ones to get really deep earthquakes, cause they typically have lower frequency energy are accelerometers. So they actually will measure the acceleration of the ground. And they'll do this in all three directions. So you can measure, they're usually set. So they're set so that we know which way is north, south, which way is East Wests, and then you get the vertical component as well.

Jonathan (04:30):

My understanding is we're measuring the depth of an earthquake too. How do we do that? And why is it important to know the depth?

Brady (04:36):

Yeah, so the, the depth, you can't necessarily get the depth of an earthquake from one single station, right? So maybe many of the listeners are listeners are familiar with the idea of GPS, right? So the idea, we have a satellite that goes around and your phone pings a satellite and you have to have at least three satellites to kind of triangulate, right? The same idea for earthquakes. So if you have more than, you know, at least three seismometers out there, you can basically pick the arrival time of when that earthquake on-set happens at the three differ-nt stations around the world for many, many years. We have a pretty good idea of the velocity or how fast these energy, the, the, the waves travel through the subsurface. So you can basically triangulate the location of the earthquake using multiple seismometers.

Jonathan (05:20):

The U.S. Geological Survey says we typically have between, you know, six to 10 earthquakes per year, the state of South Carolina, but there have been 108 recorded in the state since January 18th, 2021. That's a lot. That's way, way above the normal average. Do we have any idea why this is happening?

Brady (05:44):

No, not necessarily. I mean, earthquakes, they're, they're fairly unpredictable. I got on the U.S.G.S catalog prior to the interview and just kind of did a search, right? And it didn't look like anything abnormal to me. These, the earthquakes, they tend to happen in clusters. So if you have a bigger one, you have what they call aftershocks. And if, again, I, I would encourage you all to go to, to Google type U.S.G.S earthquake catalog. You can then go to like, draw a little box and draw a box around South Carolina, put in your dates and you'll see can sort 'em by magnitude, so their size, and then you can also sort them by date. And you'll see usually if there's a bigger one, like a three or four, then there'll be a bunch of clusters around the little one.

Brady (06:24):

So actually, I think it was last year, I recall there was a bigger one, like a 3.6 near Elkin, South Carolina. So part of that, what you see in those statistics recently might still be small aftershocks from that much larger one. But it doesn't look super abnormal, right? These things are kind of statistically right. We, we statistically have a significantly larger number of small earthquakes with a few larger ones put in. I wanna, I don't know what the average is off the top of my head, but I wanna say we have five or six, seven or eights every year usually along big plate boundaries. But I did want to add that here in South Carolina, earthquakes are a little bit strange, right? So most earthquakes, they occur on those plate boundaries, right? That we had mentioned earlier that are floating on the mantle. All of the earthquakes in South Carolina are interplate earthquakes, right?

Brady (07:11):

And these are kind of a little bit of a mystery to scientists for, I guess lack of a better word, I guess I I should say, not necessarily a mystery. We know probably a lot about how they slip and what they slip and the stress state. They're much more unpredictable than the ones that are on the boundaries in South Carolina. We've got the mid-Atlantic Ridge and the Atlantic that's kind of pushing, you know, for lack of a better word, in the Piedmont. And if you've ever walked around the Piedmont, you see all these rocks and they've got all these curves and you know, they're really deformed. And that's because they've been pushed together. And so some of that stress, some of that residual stress is still built up in the rocks. So what some of those smaller earthquakes are, are those rocks kind of readjusting to that stress state or kind of slipping. These small ones are pretty common. Part of that might be the instrumentation is getting better as well, right? These seismometers are getting more sensitive, I believe the U.S.G.S records anything over a 1.5. But if you think about how we do things as scientists, we build statistics over years. You know, if you look at the back at the statistics, they probably didn't have that instrumentation. So, you know, the average is kind of moving around. But I wouldn't really be too concerned about anything else like that.

Jonathan (08:13):

The U.S.G.S doesn't record anything below 1.5. I'm wondering how large, for lack of a better term, does an earthquake have to be for us to feel it? I I would imagine there are earthquakes that are happening, tremors that are happening that we don't even know about, right?

Brady (08:29):

Oh yes. So actually, if you were to go to a fancy a really expensive seismometer, we would probably be seeing seismic waves from earthquakes around the world, right? But you and I, we, we can't feel that. I guess to answer your question of like what you would feel like, I want to talk a little bit about how they're measured, right? So I've already thrown this idea of magnitude out and you know, as a, as a new professor and, and teaching and even talking with uothers, the idea of a logarithmic scale is something that's really kind of hard to grasp. And when we say a magnitude one or magnitude two or magnitude three, these are logarithmic scales. So to give you an example, the magnitude 1.6 that just happened in cross anger, I think it was a 1.6. So if you were to go to a 2.6, you would have to, basically the energy required to move that amount of rock, right...

Brady (09:18):

The energy released would be 30 times that of the 1.6.So if you think about the best way to think about, it's like an earthquake, right? It's like brittle rock. So if we went to the store and we grabbed a spaghetti noodle, right? And it's an uncooked spaghetti noodle, and think about how much force it would take. So if you grab that spaghetti noodle with your two hands and you start to bend it, right, it'll start to bend. It'll start to bend. That's that stress buildup. And at some point that noodle will snap in half, right? And you can kind of feel it. So the Cross Anchor earthquake that's a 1.6 is one noodle. If you were to up this to 2.6, you would need 30 noodles, right? That's probably about a quarter of a package. Now you gotta grab it with your hands and you gotta start bending and you'll still hear it, you'll hear 'em start to kind of crack and crumble, and those are all those little 1.6 s and then all of a sudden that string of noodles will go boom, right?

Brady (10:06):

To go above that, if you're getting to a 3.6, which is the one that happened in Elgan last year, you now need 30 times 30, you need now need 900 noodles. You can't even grab that with your hands, right? You're, you're gonna stretch, squeezing that and just think about even just from a human point of view, 900 noodles, maybe a strong man might be able to do that, but right. It's the amount of energy. So think about, you know, we keep upping this, we keep upping this. So a a 4.6 would be 900 times 30, right? And a 5.6 would be 900 times 30 times 30. So you're looking at I had done some math, right? The, the February, 2023 earthquakes that just happened in Turkey that have been all over the news, they've been absolutely devastating. That was a 7.8. So put this in perspective, that would take 729 million pasta noodles, right?

Brady (10:55):

To break that for scale. So I I, you know, to get back to your original question, like what would you feel? It's a good question. And it ranges, and this is that whole idea of differences between how do we quantify the scale and the energy release from like a scientific point of view, which is this moment magnitude and the intensity, right? But that Cross Anchor earthquake, you might have felt it if you were sitting right near the location. Now that Elkin earthquake, that 3.6 actually people in Greenville felt that, right? So you, you know, it kind of varies a little bit, but it's the amount of energy required that really shakes the ground. I hope that helps put that in perspective. So it's like, eh, you know, if you're right over it, you could probably feel a 1.6. I grew up on the west coast in Reno, Nevada, you know, very close to California. If you've ever been to California and you ever go over bridge, you'll see all of the earthquake engineered stuff. I would feel commonly three or fours all the time and nobody even bats their eye, right? But if you have, if you feel a three or four on the East coast where we're not used to to feeling earthquakes, it is freaky, right? So it's also that scale of what you're used to.

Jonathan (11:57):

That's wild. . So speaking of growing up on the, on the West Coast, South Carolina isn't really thought of as an earthquake zone. We have some pretty tall buildings in the state, especially in Columbia and Greenville down around the coast, like Myrtle Beach, areas like that. Do you know if buildings in South Carolina are required to meet some kind of minimum standard for earthquake resilience?

Brady ([12:19]()):

Most definitely. So I've started working with a couple folks in the civil engineering department, and actually this is a really, really big deal. And surprisingly there was a big earthquake, I wanna say it was in the 1800s in Charleston, that that was that big and it destroyed everything, right? And then there was another follow up one I wanna say near Columbia. And these were magnitudes based on damage. They didn't have seismic recordings out. So I think based on intensity they were probably around a five or a six. I do know that most buildings in South Carolina are designed to withstand above that, right? Just in case that ever happens again. So there is very stringent codes, there is a lot of research that goes into this. So we talked about the energy and what you need to feel it. This is where my research comes in a little bit more to play, but also where you're sitting matters as well.

Brady ([13:04]()):

So if you're in Myrtle Beach or you're in Charleston, the rocks underneath you can make a huge difference in the amount of shaking that you feel, right? So up here in the Piedmont, we usually have, we're sitting on weathered kind of crystal and rock and then bedrock underneath us. So even if a, a fairly large earthquake were to happen in Clemson, we probably wouldn't shake too bad. But if you get out past Columbia down that fall line and you get onto all those really loose sediments and then you start getting that shaking, it'll essentially be amplified. So this is very well known, this is very well studied. I actually just went to a Ph.D. Defense where they actually spent his, he spent his entire four or five years trying to understand what the site response would've been in the valleys in and around the midlands, right? So we look at seismic stations, they'll go put seismic stations out, they look and they use catalogs of past earthquakes, they amplify them statistically, and then they model that ground shaking. And all of the tall buildings, bridges, infrastructure are all designed to, to take that.

Jonathan ([13:59]()):

You may have already answered this, but I want to answer it more explicitly. So these multiple small earthquakes we're having, could they be a harbinger of a stronger earthquake or a stronger geological activity to come?

Brady ([14:12]()):

My gut tells me that if you're having a bunch of smaller ones, you're probably less likely to have a big one, right? So if you think back to the, the noodle example, right? One noodle, you start to bend it and it'll snap, but you start adding, you know, if you take a whole package of spaghetti noodles, put 'em in your hands and start to bend it, and you put your ear to that spaghetti, you'll start to hear those subtle cracks, right? Those are all of that, that's all that stress being released as you go. So, you know, if you could somehow manage to kind of snap each one of those noodles one by one, you would never end up with the big one, right? During my undergraduate, I had done an internship looking at what they call slow slip earthquakes. So in the Cascadia subduction zone, they have sensitive enough seismometers to actually see the plates creep really, really slow.

Brady ([14:56]()):

And actually one of the big findings coming out 10 years ago was that where they had these slow slip earthquakes, they were actually much less likely to get the big one because that stress from the mantle, whatever these plates are pushing along, is actually being taken care of from a, like a flow point of view. So it's not building up, building up and snapping like a rubber band. It's actually allowed to move. And whenever the plates move in the earth or in the ground, it's gonna make elastic energy. And our, our seismometers are amazing and we can pick that up.

Jonathan ([15:24](#)):

Where's the Cascadia subbduction zone?

Brady ([15:25](#)):

Oh yeah, sorry. The, the Cascadia subduction zone is the, it's the plate kind of off the coast of Oregon and Washington. All of those volcanoes are coming cuz it's usually along that big subduction zone. So as that plate, as the oceanic place goes down, it gets compressed, it gets heated up, and then hotter things usually rise. It's a buoyancy thing. And that's why you get these back arc volcanoes. And this is why there's, there's volcanoes, you know, in Japan along the coast of the, you know, the Alucian Islands up in Alaska, right? This is what's known as that ring of fire. Those are all those subduction zones and they're usually very active seismically as well. South Carolina, we're probably not gonna feel too large of one, but there is, there's something that goes on every October called the Great Shakeout and it's kind of what to do in an earthquake.

Brady ([16:07](#)):

So if you're in an earthquake, what you should do is you should drop down, cover your head and get under something sturdy, right? Because the, the ground shaking, your building that you're in is probably gonna be fine. It's been designed to take this, but I can almost guarantee you if you're like my house, we have loose dishes, we have things on the, on the on the counter. We have things hanging, you know, light fixtures hanging on the roof. That's usually what's gonna cause human harm in an earthquake. So if you feel that you want to get under a solid table, cover your head and hold on. The other thing that I want to point out is that I've been in earthquakes, it's kind of hard to tell if you're on the west coast, A three or four is probably not gonna cause that much damage.

Brady ([16:47](#)):

But usually in an earthquake there's a couple of different wave forms. You get this, this first arrival P-wave and if you've been in a bigger one, it sounds like somebody kind of knocking on your wall. So you'll hear it, you might be sitting there watching TV and you'll just kind of hear this big bang right? And you kind of jump up, there's not really a lot of shaking. And then all of a sudden, depending on how far away you are from the source, then you start to get the shaking. And what damages in earthquakes are those surface waves and they travel at different speeds. So I guess my other advice is if you are ever, you know, if you feel a big bang and you kind of see some shaking, then it's time to get down and drop and cover. And again, this, the, the separation can actually be quite large.

Brady ([17:23](#)):

I think one of my graduate student friends he was studying at uh UC San Diego and they were talking about putting an early warning system in. If the San Andrea's fault ruptures down in Los Angeles, they'll actually have two or three minutes of warning before it gets to San Francisco, right? And that's that P-wave. So they can feel that P-wave and the damaging S waves aren't gonna come in until that time. So I guess that's, that's the thing. My other thing with, with earthquakes is, is be curious, i I, you know, if you feel one, one of the biggest feedbacks, particularly for scientists is did you feel it? And so if you go to that U.S.G.S catalog, even now, if you're, if you're a listener and you felt that Cross Anchor earthquake, you can go look it up in the catalog and mark that you felt it, right?

Brady ([18:06](#)):

So this gets back to your original question, like how do we, you know, how big does it have to be to feel? Well we don't know. And actually as scientists, as the U S G S, we depend on the public to do that. And so if you, if you go in their catalog, you can look at the shake map or the intensity map and they have a, did you feel it map? And they will mark who felt things and where they felt them. So I encourage you be curious, there's all kinds of resources about earthquakes. This has been happening since the dawn of time, right? I think one of the original seismometers that's always shown to me is a Chinese seismometer. It had like a little dragon with a little ball in its mouth. So if the ground moved, the ball would drop.

Brady ([18:40](#)):

And you know, your question of if it, if it moved away or moved towards you, the dragon had like four directions so they could actually tell which direction the quake was coming from. So we've been studying earthquakes for a long time. There is amazing amount of resources out there. And if you've ever experienced one, it's one of those things that I feel like the science can kind of, kind of get close to you cuz you've, you felt it, you've experienced it, you have those questions, right? And not only that, earthquakes, statistically the large ones happen quite often, right? And earthquakes are amazing things. They can tell us so much about what's underneath our feet, right? Earthquakes are how we know about the structure of the earth. And actually, I just saw an article come out in nature. They put a seismometer on Mars, right? And they, they basically literally just learned about the interior of another planet because of a Marsquake, right? Coming from the other side of the planet. So when you take basic geology or if you've ever taken basic geology and you see the cut-through of the earth, right? How do we know there's a mantle? How do we know there's an outer and inner core that all comes from earthquakes. So if you feel it, mark it and follow up.

Jonathan ([19:46](#)):

We'll have a link to the U.S.G.S website on the additional resources for this episode of the podcast. So this has been great. Tell us more about your research. What are you doing here at Clemson?

Brady ([19:56](#)):

Yeah, so my main area of study is what we call the critical zone. So earth's critical zone. I like to think of it as this is the, the part of earth that we as humans all get to interact with, right? This is the part where rock, soil and life basically coalesce in this nice dance, right? And, and if you think about rock, if you've ever picked up a solid piece of rock, right? There's not really a ton of life in that, right? But you go to your grocery store and every piece of fruit, piece of meat, whatever you have in that grocery store is grown from the soil. So my research really tries to focus on understanding the processes that take that underlying rock and basically transform it into soil. And, you know, a key variable that links all of these processes is water.

Brady ([20:38](#)):

So my other area of research is basically understanding how does water that falls as rain or snow basically move through or, or get stored in this, this region that we call a critical zone. So my area of focus is usually no more than a hundred meters deep. So maybe about a football field length. There's all kinds of interdisciplinary research in this area, right? We have, we have biologists studying specific plants and processes, and then we have remote sensing scientists who are looking at this stuff from space. We have people who go out and take the rocks and do all the geochemistry. And so my niche in this particular area is really imaging, right? Like, so how do we see that if we go drill a borehole? And we can get so much information about that right in one place. But the key question is, if you moved over 10 feet, would you see the same thing? That's where I come in. So I use what we call seismic refraction. So basically I am the earthquake, right? Very small earthquake, but I go through and I'll hit the ground with a sledgehammer and we will record all of that sound or vibration along a string of geophones or small seismometers. And basically how fast and the path that that energy takes will tell us a lot about the properties of that subsurface, right?

Jonathan (21:53):

Why is it important for us to know that?

Brady (21:55):

Yeah, so it's, it's really critical. Again, one of the resources that we're going through right now is soil, right? So if we, if you think about going and tilling a field every time you till up the field, a lot of that dirt gets, gets removed, right? And so one thing that we, that we often take for granted, right? We often think of oil and gas as a limited resource, we're gonna run out of it eventually. Soil is in that case, right? So how do we, how do we preserve those, those natural resources that we have? The other thing is with the climate changing, we need to know how are these things going to respond, right? If you have a landscape that you know is traditionally only getting X amount of water and all of a sudden you're now getting a ton of water, how is it gonna react?

Brady (22:35):

Are we gonna get landslides? Are we gonna get excess runoff? Uso, so it has a lot of implications ranging from basically how we as humans use and manage the land to really understanding the evolution on other planets. So I always, I always find this just completely fascinating, like on Mars they have dust, right? Where did that dust come from? Right? It had to come from the rock originally. And you see the images, you see the, the, the little twisters and, and things like that. So, you know, using earth as a proxy and the processes that convert that rock into soil helps us also understand basically the origins of other planets as well. So it has, it has so many implications.

Jonathan (23:13):

What are some of the tools you're using to, to do your research?

Brady (23:15):

Yeah, so I, I love this, this is, I love fancy toys. But my, like I said, my main toy is seismic refraction. And so just like, you know, today I was talking about earthquakes, I use a geophone. And so we'll set out 96 of these things, and then what we'll do is we'll hit the ground with the sledgehammer at multiple points and when we record those vibrations. So that's my main tool and what that gives us is the sound speed or the seismic velocity of the top a hundred meters over, say two or three football fields. So the, the power of this method is we can cover, you know, two to three football fields in a single day with a group of a couple people. The other method I use is ground penetrating radar. So if you've ever seen surveyors out, you'll usually, if you've ever seen somebody in like a, a suit pushing a little cart, you know, that's usually a ground penetrating radar.

Brady (24:01):

They're usually searching for utility lines or buried pipes. I use it to study the thickness of the soil. I had a master students do a, a whole project of actually mapping individual tree roots, right? How do we, how do these individual large trees, you know, how do they root into the critical zone? What's holding them up? How are they getting their water? Where are they getting their water from? I have a, a down-hole nuclear magnetic resonance device. So this is an NMR device, it's a, it's a really cool device. It looks like a, a large pencil. We drill a hole and as you drop this thing down there uses a magnet, a strong magnetic field, and it basically gives the earth an mri. So if you've ever been an MRI, MRI stands for Magnetic Resonant Imaging. Yeah, I'm using nuclear magnetic resonance.

Brady (24:42):

This is kind of the, it's kind of like an mri, but really, really poor tool, right? When you get an mri, you get to go in the whole tube, right? I get one location, but what's really unique about this measurement is basically if there's any water in the poor space, I will get a signal and if there's no water, I won't get a signal. So it's, so we can use that to map shallow water where the plants are getting it, how much of it is moving through, you know, it tells us about the size of the pores as well. And then I've also used DC electrical resistivity, which is basically the, how well does the ground conduct electricity. And so the combination of all of this really allows us to see spatially. So the reason that I use all these tools is we want to try and link sound speed. How well does the earth conduct electricity to, is there water to, you know, different changes in dielectric permittivity, right? These are all the pro physical properties that I measure to really understand the question of like, you know, how does that rock turn into soil? Where does the poor space begin? What are the fundamental variables that we need to be aware of to adjust for changing climate or to go in and correctly manage a system or what formed the dust on Mars? Right? Some stuff, stuff like that.

Jonathan (25:49):

Are you doing this in South Carolina, and if so, what part of South Carolina?

Brady (25:52):

Yeah, so we have, so I'm part of a five year NSF grant called the Critical Zone Exploration Network. And we're in one of the, the networks that's called the, we call ourselves Team Bedrock, but our fundamental question is really trying to understand the connections between geology and bedrock and the near surface, right? So we have sites all over the Continental U.S. So we've, we have a key site here in the Piedmont of South Carolina, not exactly, but quite near the Cross A nchor earthquake. We have, we've collected data up in Maryland, in the Piedmont and Maryland. We've collected data on the crystal and rock in Piedmont in Georgia. We have data in the Rocky Mountains near Boulder, not quite at Boulder, but kind of up in that area. And then we, we just got back this last summer from a 10 week trip through Southern California.

Brady (26:43):

So we were in the San Jacinto range, the San Gabriel ranges up through the Southern Sierra Nevadas. And like I said, we're just now starting, we're about three years in, so we're now just now starting to synthesize all this data, right? So the key is looking for processes and variables. So we went to all of these sites holding, you know, some of these variables constant so that we can kind of explore what these responses are. So this last summer we just finished collecting data. So we're at this point where we're starting to kind of synthesize, we have a, a few more things to do, like drill and confirm and validate some of the geophysical measurements. But yeah, we're, we're starting to really do some, some really cool synthesis. Yeah.

Jonathan (27:20):

Well, Brady, this has been great. You've been really helpful in helping us understand earthquakes, understand your research, and here's a promise to you and a promise to our listeners down the road when you've got some results and you want to talk about 'em, come back on Earthly and we'll do it.

Brady (27:32):

It sounds great. That's fantastic. This has been really fun.

Outtro (27:40):

Earthly is a production of Clemson University and can be found wherever you get your podcasts. Listeners can find archived episodes of earthly transcripts and learn more about our guests by visiting clemson.edu/earthly.