Sidedoor (S10E02) – Cellphones Rock

Lizzie Peabody: This is Sidedoor, a podcast from the Smithsonian with support from PRX. I'm Lizzie Peabody.

Lizzie: *I'm looking at my phone.*

Josh Bell: *Yeah.*

Lizzie: *Um, it's a little dirty. Let me just scrub the screen off a little. This is embarrassing.*

Josh Bell: *[laughs]*

Lizzie: *Okay, I'm looking at my phone ...*

Lizzie: All right. Is your cell phone handy? Maybe you're listening to my voice on your phone right now. Take it out for a second—I'll wait. Take a look at it. Feel the weight of it in your hand. Now touch the screen. See how the phone responds to your finger on the glass?

Josh Bell: *The thing that makes that possible is this incredible element known as indium.*

Lizzie: Indium. Yeah. I'd never heard of it before. But Josh Bell is all about it. He's a cultural anthropologist at the Smithsonian's National Museum of Natural History.

Lizzie: *What is indium?*

Josh Bell: *Well, it's number 49 on the atomic weight.*

Lizzie: *That means nothing to me, Josh. Tell me something else.*

Josh Bell: *Okay, so indium is this particular element that was discovered by two Germans in 1863.*

Lizzie: This was long before the invention of the telephone. And the German guys who discovered indium in the 1860s had no idea that one day, this soft, silvery metal would make it possible for me—and you—to touch an image on glass and make it move. And that's exactly what indium does. But how? Well, the screen of your phone isn't just glass. It's coated in something called "indium-tin oxide," or ITO. It's translucent, and it conducts energy.

Josh Bell: *So when you touch it, you're changing the electric flow on the screen, which the ITO, the indium-tin oxide screen registers. And then that sends signals to the microprocessors, the motherboard, and it says, "Hey. This human, my human, Lizzie, is touching me. I need to respond."*

Lizzie: *[laughs]*

Josh Bell: *And so then, voila, it opens up.*

Lizzie: Voila! And it's okay if you don't understand exactly how your touchscreen works. The point is it wouldn't work without this rare, precious element called indium. In fact, the average cell phone has at least 65 different elements all working in harmony so you can play Wordle. And order dinner. And call your mom. And scope out your friends' pictures on Instagram, and all the other things you do on your phone.

Lizzie: We think of cell phones as connecting us to each other, but they also connect us to the natural world.

Josh Bell: *It's a technology that relies on the earth. Most people don't tend to think of it. You know, they might be like, "Oh, the front is glass of some sort." The outside casing, you know, with older devices, they could have been metal, or it's plastic. But all of that is from the earth and then processed.*

Lizzie: So much of our lives are happening online in some digital, ephemeral space every day. But we still rely on good, old-fashioned hardware to get us there. And arguably the most widespread tool connecting us to that virtual space is the cell phone. But we don't spend a lot of time thinking about what it takes to put all that power at our fingertips.

Josh Bell: *Where does it come from? How is this made? Who makes it? How does it connect us to people around the world?*

Lizzie: That's why Josh has led the creation of a new exhibition at the National Museum of Natural History called "Cell Phone: Unseen Connections."

Josh Bell: *It's telling a global human story through this device in nearly everyone's pocket on the planet. And so it allows us to tell a very natural history story through an unusual object.*

Lizzie: So this time on Sidedoor, cell phones rock! And they're full of rocks. We're busting open the cell phone to better understand how cutting edge technology is cut from stone—some of them millions of years old and incredibly rare. That's coming up after the break. Okay, you're allowed to put your phone down now.

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Lizzie: To sit down in Mike Wise's office is to literally find yourself between a rock and a hard place.

Lizzie: *Wow, this is so cool! There's so many minerals in here.*

Mike Wise: *Oh, you have—like I say, you have no idea.*

Lizzie: *Whoa, what's this thing?*

Lizzie: Mike is a mineralogist. I'm at his office at the Smithsonian's National Museum of Natural History, which he calls his own little mine shaft. Because well, it's full of rocks.

Lizzie: *Every surface is covered with some different rock, but rocks of all sizes.*

Lizzie: From chunky quartzes to sparkling gemstones to dark, slate-y looking minerals, perched on top of filing cabinets, packed into drawers. And Mike says hard core rockers like himself have a saying ...

Mike Wise: *If it can't be grown, it has to be mined.*

Lizzie: Just think about that for a second—everything is either grown or mined.

Mike Wise: *Most people have no idea that everything they use requires mining.*

Lizzie: *Well, hang on. Not everything else you use in life. Like, not this chair.*

Mike Wise: *Really? You want me to play that game?*

Lizzie: *Okay.*

Mike Wise: *Okay. So chairs come from?*

Lizzie: *Wood.*

Mike Wise: *Wood comes from?*

Lizzie: *Trees.*

Mike Wise: *Trees grow in?*

Lizzie: *Forests. The ground.*

Mike Wise: *The ground is made up of?*

Lizzie: *Uh ...*

Mike Wise: *Soil.*

Lizzie: *Soil.*

Mike Wise: *Soil comes from?*

Lizzie: *Hmm, eroded ...*

Mike Wise: *Rocks.*

Lizzie: *Really?*

Mike Wise: *Yes.*

Lizzie: *Oh. [laughs]*

Mike Wise: *See the connection now?*

Lizzie: *Yeah. Yeah, I do. But you didn't have to mine those rocks in order to get trees to grow.*

Mike Wise: *No, but my point is geology plays a much, much larger role in everyday life than you can possibly imagine.*

Lizzie: Like, the saw that cut the tree is made of metal that was mined. And the hammer that drove the nails? Also mined. So I do see Mike's point. But of all the rocks in our lives, I want to focus on one in particular.

Mike Wise: *It's hard to not collect big rocks.*

Lizzie: *[laughs] Whoa!*

Mike Wise: *This is ...*

Lizzie: Mike heaves a bowling-ball sized rock onto the table. Part of it is dark gray. It almost looks like coal. This rock is full of something called Tantalum. Chances are you've never heard of tantalum, but chances are, you'd be lost without it.

Lizzie: *What would the world without tantalum look like?*

Mike Wise: *Well, we probably wouldn't have a lot of the electronics that we use every day.*

Lizzie: *Like?*

Mike Wise: *Computers.*

Lizzie: Video game consoles, televisions, and of course ...

Mike Wise: *Cell phones.*

Lizzie: You're using tantalum right now to listen to this podcast. It's a metal, and it's used to make a little piece inside your phone called a capacitor.

Josh Bell: *So your battery is the main source of electricity, but the capacitor kind of is a midway point.*

Lizzie: Curator Josh Bell again. He says what makes tantalum great for capacitors is that it's resistant to corrosion and it's really dense, so it can hold a big electrical charge in a tiny package.

Josh Bell: *And so it holds that charge so that, you know, in the case of you touching your screen, you've got the energy there to activate whatever you need to do. So think of it as like a weigh station, where basically energy is just sitting there saying, "What does Lizzie need us to do? We are ready." [laughs]*

Lizzie: But here's the thing: like anything found in nature ...

Josh Bell: *This stuff is not infinite.*

Lizzie: ... there's a finite amount of tantalum in the world. How much? Well ...

Mike Wise: *If we were to take the crust, the Earth's crust which we live on, and we were able to take a representative sample, grind it up, analyze it for all the different elements, scientists have estimated that tantalum is about two parts per million of the crust. So it's really, really rare.*

Lizzie: So why is tantalum so hard to come by, and where do you find it? That story begins underground. Deep underground. It's geology time.

Mike Wise: *Deep in the Earth's crust, you know, several kilometers down, it is so hot and the pressures are so high, you actually can melt rock. And that creates magma.*

Lizzie: Picture the red hot lava that oozes from volcanoes.

Mike Wise: *If it stays underground, we refer to it as magma. Essentially it's the same thing.*

Lizzie: This magma is made up of melted rocks, so it's swirling with an alphabet soup of elements that were in those rocks.

Mike Wise: *So if you melted, let's say, some sedimentary rock, whatever that sedimentary rock was made up of, once it melts, those elements are in that magma.*

Lizzie: *In that soup.*

Mike Wise: *In that soup. Right.*

Lizzie: Some of those elements are common ones like sodium and iron. Others are rarer like lithium and tantalum. And this molten magma full of elements is moving around underground all the time.

Mike Wise: *It's buoyant, so it'll rise. And at some point it'll reach an equilibrium state and start to cool.*

Lizzie: And as it cools, some of the elements crystallize into the minerals that make up granite. You know granite rock. It's everywhere, it's one of the most plentiful rocks on Earth.

Mike Wise: *As the granite crystallizes, solidifies, taking out more and more of the major elements.*

Lizzie: *The common ones.*

Mike Wise: *The common ones, yeah.*

Lizzie: These elements get pulled out of the liquid magma to become solid granite rock. Think of it like this: you know when you're playing baseball as a kid in gym class, and the team captains get to pick their players? Imagine instead of a rock made up of elements, granite were a baseball team made up of players. To make a strong team, granite's gonna say, "I pick aluminum, sodium, magnesium, iron" and a bunch of other major elements first because they make great players on its team, leaving all the weirder—or less common misfit elements to the end.

Mike Wise: *The rare elements become more and more concentrated in the leftover stuff, what I like to call the goodies.*

Lizzie: The goodies being elements like tantalum, but also rare metals like lithium and beryllium.

Mike Wise: *And the tantalum and the lithium and the beryllium continues to concentrate even more so to the point where at some stage they actually begin to form their own mineral species.*

Lizzie: Meaning they combine with other elements to form different minerals. And those minerals ...

Mike Wise: *Will then cool and crystallize and form its own rock type which is called pegmatite. And then that's when the magic happens.*

Lizzie: Now Mike has a soft spot for pegmatites because he's studied them his whole career. And they're pretty cool rocks. Pegmatites form at the last stage of granite crystallization, with all those leftover goodies. They're similar to granite, except they often contain large crystals of these rare minerals.

Mike Wise: *So you get minerals that are rich in tantalum like tantalite, or rich in lithium like spodumene, or rich in beryllium like beryl.*

Lizzie: And those are the ores.

Mike Wise: *And those ultimately become the ore that the miners are looking for to extract those elements.*

Lizzie: Over millions of years, erosion wears away at the surface of the Earth until these mineral-rich pegmatites are exposed for mineralogists like Mike to find.

Mike Wise: *In a cluster, just sitting there happy as can be, minding their own business.*

Lizzie: *Mining their own business?*

Mike Wise: *Minding their own business. [laughs]*

Lizzie: *Sorry, I thought you were making a pun.*

Mike Wise: *No, no, no.*

Lizzie: But let's run with the pun, because that's exactly what happens next: mining. Once you find a pegmatite with the stuff you need ...

Mike Wise: *You have to extract it from the ground, and that requires in many cases, drilling and blasting. We're talking about hard rock mining here.*

Lizzie: This mining can happen anywhere in the world because tantalum is found all over the world. But ...

Josh Bell: *A large majority of the world's supply is in the Democratic Republic of Congo, so Central Africa, neighboring Rwanda.*

Lizzie: Both countries that have experienced political instability in recent years. And militant groups have used tantalum mines to finance armed conflicts—sometimes through forced labor, leading tantalum to be labeled a "conflict mineral."

Mike Wise: *You have situations where the tantalum ore gets mined from a conflict area, and it's smuggled across that particular country's border into another country. They'll mix it up with legal tantalite, and then it gets shipped off, and so you don't know if it's—all of that tantalite's been illegally mined or legally mined.*

Lizzie: *Hmm, so it's very hard to trace.*

Mike Wise: *Yeah.*

Josh Bell: *The issue then is how you create traceability programs, and how do you create ethical sourcing of these minerals?*

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Lizzie: We don't yet have reliable traceability programs to guarantee 100 percent ethical mining, so yes, there's a chance that some of the tantalum in your phone right now could have come from an illegal mine in a conflict zone. It's hard to know for sure. And no matter where it happens, mining comes with an environmental cost as well.

Mike Wise: *We don't have the technology yet to mine in a way that won't disrupt our environment. It's just not gonna happen.*

Lizzie: *Hmm. So some level of environmental disruption is necessary in order to have the technology we've grown used to.*

Mike Wise: *Yeah. And I think people have to accept that.*

Lizzie: No matter which way you cut it, mining is the bedrock of electronics production. The United States has long outsourced most of this rare metal mining to other countries. In fact, the US has imported all of its tantalum since the 1950s.

Lizzie: Now in your phone there are about 40 grams of tantalum. That's like 40 grains of salt, which is not a whole lot. But it adds up. By the most conservative estimate—which doesn't count the tantalum inside electronics manufactured abroad—the US imports at least 1,300 tons per year. That's 260 Asian elephants. Or seven Boeing 747s. Or 100 elephants riding on four 747s.

Lizzie: Anyway, tantalum is just one of an estimated 65 elements in your cell phone. There's silicon from Russia, indium from Japan, gold from Australia, lithium from Argentina and Bolivia, copper from Peru and Chile. Each element is mined, transported and refined as part of a global network.

Josh Bell: *So you have the materials coming from different areas of the world to factories, their different components are made around the world, put together by different companies and their suppliers, et cetera, and then brought to the store and then sold to you.*

Lizzie: The phone in my hand, I've had it for years now. But the screen is cracked, the battery needs a lunchtime charge to get through the day. The camera cannot compare to the new ones on the market. And someday pretty soon, it's gonna conk out.

Josh Bell: *But then what happens when you're done?*

Lizzie: Roses are red, violets are blue, your phone's eligible for an upgrade, what do you do? We'll have more on that after the break.

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Lizzie: The first ever cell phone was roughly the size of a large shoe, and weighed about as much as a pineapple. 50 years later, our power-packed phones are sleek enough to tuck into our pockets. And they're packed with rare elements and minerals—mined, refined, manufactured and engineered into a compact computer. But let's say you're like me and you've had your phone for a few years. You've gotten the screen and battery fixed a few times, it's finally time to upgrade. What do you do with this hunk of junk phone that's too beat up to donate?

Lizzie: Technically, yes, you can recycle that old phone. But it's not so simple.

Josh Lepawsky: *That combination of characteristics, the number of minerals packed in there, and then the tiny spaces that it's all packed into, makes recycling of cell phones a real challenge.*

Lizzie: This is Josh Lepawsky.

Josh Lepawsky: *I am a professor of geography at Memorial University of Newfoundland.*

Lizzie: *Oh, it's Newfound*land*?*

Josh Lepawsky: *Yes.*

Lizzie: *I always heard* New*foundland.*

Josh Lepawsky: *Yes. Well, if you say that here, you will be corrected. I am not from here originally, but this is years of trauma of being corrected by students in class. [laughs]*

Lizzie: *Got it. Okay.*

Lizzie: Josh has spent a lot of time loitering around dumps—for research purposes. One of the things he studies is e-waste, and how electronics get recycled. He walks me through the basics of how one of these recycling plants can look.

Josh Lepawsky: *Imagine a factory that is built for taking things apart.*

Lizzie: Trucks bring in loads of old computers, TVs, printers, fax machines, cables and cords galore—all of which has to be sorted first.

Josh Lepawsky: *I remember walking around in one where there was a giant—what I would call a dumpster, with handwritten across it in chalk. 'This is not garbage.'*

Lizzie: *[laughs]*

Josh Lepawsky: *And it was full of recovered modems, like, for—you know, if you have internet at home. These were being pulled out of the scrap stream. So there's an initial sorting that goes on, that's gonna pull stuff out that can be reused and resold.*

Lizzie: Once the usable, resellable stuff has been separated out, workers at the recycling plant have to separate out dangerous materials like lithium-ion batteries. That's because they have this eensy-weensy problem ...

Josh Lepawsky: *When they get exposed to air, they catch fire. So you can't—shredding them is not actually ...*

Lizzie: *Advisable?*

Josh Lepawsky: *The way to process. Advisable. Yes, exactly! [laughs]*

Lizzie: Lithium-ion batteries have to be removed from any portable electronic device—sometimes by hand—before the rest of it can be shredded.

Josh Lepawsky: *Once that kind of hand dismantling is done, scrap then moves into a more automated process that essentially is a set of conveyor belts. That material goes up, you know, a big conveyor belt, kind of like the beginning of a roller coaster.*

Lizzie: The conveyor belt will carry the e-waste up, and then drop it into some sort of industrial scale shredding equipment.

Josh Lepawsky: *That can be like giant steel teeth, kind of like, you know, some sort of terrible horror movie, slow motion kind of stuff.*

Lizzie: *[laughs] Uh-huh.*

Josh Lepawsky: *You know, some of those machines are designed to swallow, you know, like, whole photocopiers, and you just hear crunching and grinding.*

Lizzie: Sometimes the shredder looks like a giant cylinder.

Josh Lepawsky: *With a bunch of chains inside it, whipping around at some ridiculous set of revolutions, and just smashing things to pieces.*

Lizzie: *Oh goodness! Wow!*

Lizzie: It's just like sticking a log into a wood chipper and making mulch. The phone gets pulverized into smaller and smaller pieces. But ...

Josh Lepawsky: *The problem of so many different minerals packed into a very tiny package, and what the shredding ends up doing, of course, is mixing all of those together.*

Lizzie: *Mm-hmm.*

Josh Lepawsky: *It's then a matter of sorting out those tiny, tiny pieces into, as the industry would say, as pure fractions as possible.*

Lizzie: Imagine if you put peanuts, Tic Tacs and peppercorns into your coffee grinder and turned it on. I mean, each of these things has value, as a breath freshener, piquante seasoning or a protein-rich snack, but blended together, they're definitely not useful or delicious. So how do you re-separate these materials back out?

Lizzie: Well, recycling plants have a whole series of ingenious-sounding methods to sort tiny shards of material into like-categories. Like, conveyor belts run through magnetized chambers to pull iron-rich materials from the rest. Drop particles into water to see what floats or settles at different rates. Or even ...

Josh Lepawsky: *Essentially puffs of air.*

Lizzie: *Really?*

Josh Lepawsky: *Yeah, because different metals have different weights and densities.*

Lizzie: *Oh!*

Josh Lepawsky: *And so you can get—you know, they're just moving along a conveyor belt, and as they drop off the end of one, there will be a ...*

Lizzie: *A puff of air?*

Josh Lepawsky: *A puff of air at a known pressure. And that will sort—you know, the finest particles will—I'm using quotes here—will "float" further before they land on the next conveyor belt, whereas the heavier ones drop sooner.*

Lizzie: *Whoa!*

Lizzie: The whole operation looks like a Rube Goldberg machine for sorting.

Josh Lepawsky: *I mean, you can think of it like sifting.*

Lizzie: *Yeah.*

Josh Lepawsky: *This process of refining and refining and refining the material streams to as pure as possible, and then where there are markets for the materials that are recovered, selling those back into the manufacturing sector.*

Lizzie: *How possible is it to get back to, like, the pure elements that went into the phone?*

Josh Lepawsky: *Yeah, so that's a really important question. One of the things that make electronics really challenging from a technical recycling point of view is that they are made up of so many different types of materials.*

Lizzie: And those materials can be bonded in ways that make it hard to pull them back apart into their component pieces.

Josh Lepawsky: *It's like a baked cake. You can't un-bake it. You can shred a cake, but that doesn't mean you're gonna get the flour and the baking soda and the butter back out.*

Lizzie: *Yeah, you're not gonna get a whole egg with its shell from a cake that you disassemble.*

Josh Lepawsky: *Exactly. That's right.*

Lizzie: Remember how your phone's capacitor uses tantalum? Well, think of the capacitor as a cake, and the tantalum as the eggs in that cake.

Josh Lepawsky: *So the tantalum is in there, but un-baking it is not something that can be done yet.*

Lizzie: *Hmm.*

Lizzie: Josh says, when it comes to what we *can* do ...

Josh Lepawsky: *From an individual consumer point of view, the best thing you can do is use the device you have for as long as possible. That's the most environmentally friendly thing to do because all of the embodied energy materials, all of the pollution waste that has happened from mining and manufacturing has already happened.*

Lizzie: We can't put the minerals back in the ground, and it's really hard to recycle them into a new phone. But we can think twice before ditching a basically-fine phone for a newer model. In fact, if everyone in the country used their phone one year longer on average, it would be the same as taking 636,000 gasoline-powered cars off the road. We can preserve precious materials by getting our phones repaired when possible, and making them last as long as we can.

Josh Lepawsky: *I completely empathize with the sense of individual responsibility that, you know, lots of us want to know, like, what can I do personally? And we can be racked with guilt about what to do as individuals. And to that I would say, "I'm with you. Feel those feelings and let them go." Because the individual action that you can take that actually has, you know, any sort of tangible effect is very limited.*

Lizzie: Like many things, a simple awareness of where our things come from—and where they go when we're done with them— is a big step in the right direction. Josh Bell says that's really what the cell phone exhibition is all about.

Josh Bell: *I think we take for granted where stuff comes from. And so understanding where stuff comes from, I think one, helps us to see ourselves as part of this closed system that is the planet, but I would hope that it also helps us to understand that we can be better users and kind of take more care.*

Lizzie: Thinking about the effort, mineral resources and energy it takes to make a single cell phone has made me look at my own phone a little differently. To think about everything my phone can do: videos, calls with people across the world, GPS tracking of my location—much of this made possible by minerals found in rocks that originated 20 million years ago underground, that's pretty darn cool!

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Lizzie: You can go check out the exhibition "Cell Phone: Unseen Connections" yourself at the Smithsonian's National Museum of Natural History. There's so much to see in there—including all the minerals we talked about in this episode. We'll include more information in the Sidedoor newsletter. You can subscribe at SI.EDU/SIDEDOOR.

Lizzie: Special thanks this episode to Josh Bell, Mike Wise, Josh Lepawksy, Jim Wood, and Tina Tennessen, who ha,- after many years at the Smithsonian, moved on to other opportunities and we already miss her *so* much!

Lizzie: The podcast is produced by James Morrison and me, Lizzie Peabody. Our associate producer is Nathalie Boyd. Executive producer is Ann Conanan. Our editorial team is Jess Sadeq and Sharon Bryant. Tami O'Neill writes our newsletter. Episode artwork is by Dave Leonard. Extra support comes from PRX.

Lizzie: Sidedoor show is mixed by Tarek Fouda. Our theme song and episode music are by Breakmaster Cylinder.

Lizzie: If you want to sponsor the show, please email sponsorship (@) prx.org.

Lizzie: I'm your host, Lizzie Peabody. Thanks for listening!