Astrogeology – Meteorites and Spacecraft Missions

Announcer: (Music) Meteorites are pieces of rock or metal that hurtle to Earth from outer space. How can scientists use these space rocks to better understand the origins of our solar system? Scientists are analyzing the structure and chemistry of meteorites, prompting the launch of spacecraft missions to learn more about the larger objects they come from. Join us now for a conversation with geologist Tim McCoy to see how meteorites spark our desire to probe the cosmos. Now, here's your host, Maggy Benson.

Maggy: Hi, welcome everyone. [00:00:30] Thanks for joining us for another episode of Live from Q?rius, Smithsonian Science How? I'm Maggy Benson. We have a really awesome show today. With us now is geologist from the Smithsonian's National Museum of Natural History, Dr. Tim McCoy.

Tim: [00:01:00] Hi, great to be here today. Thanks for having me.

Maggy: We're so happy to have you here. So Tim, you are a geologist, but specifically, you are a meteoriticist.

Tim: Right. I study rocks that came from outer space, meteorites. So we're the modern day space explorers. Like the people who traveled across the oceans or across the continents hundreds of years ago, we explore the solar system today. Sometimes we do that in our labs with rocks that fell from space, and sometimes we go out into space and explore the solar system.

Maggy: Very cool. [00:01:30] We're going to kick off our show today with a great student question, so let's take a look.

Tim: Okay, great.

Coby: Hi, I'm Colby from the Winthrop School. How do you tell that a rock is a meteorite, not something else?

Tim: That's a great question Colby. That's one we get about 100 times a year from people who send us samples they think are meteorites. So one of the best ways is to tell what the rocks around you are supposed to look like and find something that looks different. When you're looking for something different, (there are) a couple of things to look for. So, this is a [00:02:00] meteorite, and you can see it has this black outer crust. We call this the fusion crust. That's the part that melted when it came through the atmosphere of our planet.

Tim: And it looks quite different from the inside. The outside is this black fusion crust, (but) the inside, you can see, looks very different. You can see the reflection in there from all that. That's iron nickel metal. That's extremely uncommon in rocks on Earth, but very common in meteorites. So if you find something that the outside looks different than the inside, [00:02:30] that has flakes of metal and has this fusion crust, you might well have found yourself a meteorite.

Maggy: Do they all look like that?

Tim: No, they don't. They look like a variety of different kinds. Just to show you another example, we'll talk about this a little bit more. This is a meteorite called Cape York. This is an iron meteorite that fell in Greenland and you can see it looks very different from the chondrite here on the front. Here, we have almost all metal, and just a couple of other things. We have a little bit of troilite in here, but this is almost 100 percent metal. And again, metal is one of the keys when you go looking for a meteorite.

Maggy: [00:03:00] Wow, that's crazy. It looks really heavy.

Tim: It is. It's about three times as dense as a regular rock. So the big ones, you know, we do curls in the meteorite collection. (Laughter) you really get your exercise working out on that trying to move those around.

Maggy: So do meteorites ever strike people from space? I mean that would really cause them damage.

Tim: It would. You wouldn't want to be hit by a meteorite because these things . . For example, this is a meteorite that fell not very far from us, about five miles away in Lorton, Virginia. Just across the Potomac River. [00:03:28] And you can see. It fell in here, it broke into several pieces. So this is one piece. But this - ...

Maggy: I see its fusion crust.

Tim: It is. This is the fusion crust, but this thing actually fell through a doctor's office about 5:45 in the evening. This is the ceiling tile it fell through. So here is the hole that it actually went through (laughter) at the time that it fell to the earth.

Maggy: Did it hit the patient?

Tim: It did not. Everyone was out of the office at the end of the day. But these things, even though they're slowed down by the atmosphere, this is still falling at, say, 300 miles an hour. So this would really hurt if you got hit by it. But I wouldn't worry [00:04:00] too much, because the truth is, 20 people in the U.S. Last year were killed by cows and no one was killed by a meteorite. So I wouldn't spend a lot of time worrying you're going to be hit by a meteorite.

Maggy: So a couple of years ago, I remember seeing all these videos on the internet about meteors falling to Earth in Russia.

Tim: Right.

Maggy: Is that a rare occurrence?

Tim: It was rare that it was recorded. I didn't know there were so many dashboard cameras. I think we have some video that can show this. So here we see the start of the fireball that's coming across and it's going to get suddenly very, very bright. [00:04:30] And that's where the big meteorite broke up into a lot of small pieces. This is one of those small pieces.

Tim: So this is a piece of Chelyabinsk. There were literally hundreds of stones that fell to Earth. You can see again that fusion crust where it melted. And this is the interior of the rock. But a lot of people rushed to windows to see this light that came in. And then, they were hurt by the sonic boom. Remember, light travels faster than sound and so that sonic boom broke a lot of windows. Fortunately, no one was killed, [00:05:00] but several people were injured by the flying glass from the windows.

Maggy: So that fireball that we saw flying through the air, I mean that kind of looks like a shooting star. Is that the same thing as a meteorite falling to Earth?

Tim: No, not exactly. So when you think of a shooting star, a lot of people think of meteor showers. So you're looking at something like the Geminids or the Perseids. Those are typically tiny little dust grains from the tail of a comet. The earth passes through where that tail was and you see these shooting stars. Those don't survive passage to the ground. But if something does manage to make it all the way to the ground, [00:05:30] then we can pick it up, which is a rare event. We call those meteorites. So meteors and meteorites are related, but they're really two different things.

Maggy: So a meteor is really just the light that is generated from something passing through our atmosphere.

Tim: Right. Right.

Maggy: So where are these meteorites actually coming from? We know they're from outer space, but from where?

Tim: Well, that's a really good question, you know. we have a lot of them, so we know it must be some place where there's a lot of stuff. Maybe we should ask the audience what they think.

Maggy: I think that's a great idea.

Tim: Okay, let's take a poll. [00:06:00]

Maggy: So viewers, here's an opportunity to take a live poll with us, tell us. (Music) A meteorite comes from: a Planet? The Moon? A Star? An Asteroid? or an Object outside of our solar system? You can respond using the poll window that appears to the right of your video screen. Remember that this is the same place that you can post questions for Dr. Tim McCoy and Devin Schrader today. [00:06:38] So Tim we're watching the results come in and we can see that the top pick right now at 55 percent is an asteroid.

Tim: Well, you obviously have a very smart audience. So most meteorites do, in fact, come from asteroids. So these are the things that orbit the sun. They're 100 kilometers in size. They orbit the sun between Mars and Jupiter, and then form the asteroid belt. [00:07:00] And so, I think we might have a, a graphic here of the asteroid belt -

Maggy: And that's in our solar system.

Tim: That's in our solar system. That's right. So hundreds of objects. So here you can see between Mars and Jupiter, we have the asteroid belt. And so these things are coming from there, but I'll tell you a little bit later, they come from other places as well. So some of the other answers are not as far off as you think. So for example, here, we have, uh, [00:07:30] a piece of a rock. You can see it's got these little white bits in it. Here and here. Those are, um, anorthosite. Now, if you think, "Well, where do I see some white rock up in the sky at night?"

Maggy: The moon?

Tim: The moon, that's, that's right. This is actually a piece of the moon.

Maggy: Right here?

Tim: Right here on your hand. So this is an anorthositic regolith breccias. These are the white bits from the man in the moon. So actually are seeing a lunar meteor right there. Just like the Apollo astronauts held moon rocks, I can hold the moon rock here because it fell to Earth.

Maggy: So how did a piece of the moon [00:08:00] actually break off of the larger planet and come to our Earth in the first place?

Tim: Yeah, that's a really great question. How do they get here? Well, they're knocked off when things run together. So another meteorite will strike the moon or strike an asteroid and knock pieces off. And those pieces will then go into orbit around the sun, sometimes for millions or tens of millions of years until eventually they get to near the earth. And (then) the gravity well of the earth captures them and brings them to Earth [00:08:30] and they fall evenly over the entire surface of the earth.

Maggy: So these are really impacts. Are there any evidence of these impacts on planets that are out there now?

Tim: Yeah, we see a lot of them. We see craters on a lot of the planets including here on Earth, if you've ever seen a meteor crater. And in some of the rocks like Chelyabinsk, you can see these little black veins that run through the rock and those are actually impact melts. So a place where the shock wave melted part of the rock. So we see both direct evidence from the rocks and from when we look at planets.

Maggy: [00:09:00] So is this evidence right here of impact?

Tim: That's right. Those are all impacts. So Tycho crater, you can see Tycho is really spectacular. It's got these long rays and you can imagine at the end of one of those rays, some of that material didn't quite make it back and you end up with a lunar meteorite in your collection.

Maggy: So you mentioned the asteroid belt earlier. Are all these meteorites that are coming from asteroids, not necessarily the moon, coming from this location?

Tim: Yeah, they're coming from the asteroid belt, but there are different kinds of asteroids there. [00:09:26] So for example, this one I've been showing you, fairly frequently, here we can see where all the asteroids are today. This is actually taken from this morning and so this is the location. The big green belt is the asteroid belt. The blue blobs are the Trojans that lean and follow Jupiter. And all those red things are what we call near-Earth asteroids. Things that can actually come closer to the earth.

Tim: And one of those green blobs in the middle, I don't know which one, (laughter) actually has a name: 4259 McCoy. So that was named after me by ...

Maggy: I see it right here.

Tim: Yeah, by a former post-doc. I bet you don't have an asteroid named after you.

Maggy: So is that you? Are you out in [00:10:00] outer space right now?

Tim: Well, no. Not exactly, but I can watch my asteroid orbit around the sun. And so this is one of my favorite fun things to do. And you can actually study different kinds of asteroids. These are different sizes. Many of them are asteroids that I worked on. So 4 Vesta was visited by the Dawn Mission. I worked on that. 433 Eros was visited by the NEAR Mission. And so that was the first spacecraft mission I worked on.

Tim: So all of these are asteroids have been visited by spacecraft. But as I said, there are different kinds [00:10:30] of meteorites that come from different kinds of asteroids. So here we have a chondrite and if you look, there's this little round bit right there, okay?

Maggy: Mm-hmm.

Tim: I can tell you that round bit just looks like a circle here, but it's actually a little sphere. Those are called chondrules and I have a jar of them here. This is from a meteorite called Bjurbole. Let's see if I can roll that around to see the ...

Maggy: They look like little pebbles.

Tim: They do. They look like little balls that roll around in there. And I can pick a few up and I got a couple here laying on the table, put them in my hand [00:11:00] and you can see they're just little round . . . Let's see if I can get that so the camera can see them without them rolling off. Little round spheres there . . .

Maggy: There we go.

Tim: They're kind of rolling around. These were free floating molten droplets in the solar nebula, the cloud of gas and dust our solar system formed from. So, you know, before there were asteroids or comets or planets or, or even the sun, there were these little chondrules. And so you're looking at the earliest stuff from our solar system.

Maggy: Wow, that's incredible.

Tim: Okay, and we'll come back and talk a little bit about chondrules in a little bit. [00:11:30] But some of these asteroids, you can see if we go back to the chondrite, if I get the light just right, you can see there are little bits of shiny stuff. And now let's see if I can get this so you can see it. Yes, see the shining stuff in there?

Maggy: Ah, there it is.

Tim: There's the shiny stuff. That's iron, nickel, metal. We talked about metal being something that's common in meteorites. Well, imagine if I heated that and melted it and made a layered world like our Earth is layered. It has a core, a mantle and a crust. But the core, for example, we've never seen the core of the earth. It's about 3,000 kilometers below the surface [00:12:00] of our feet. And yet, we think we know what it's made of, and that's because of meteorites.

Tim: So this is a meteorite, this one, we looked at before. This is, again, Cape York from Greenland. Almost all metal. There's a few other little things in here. These little brassy bits are called troilite - this is iron sulfide. And just like if you've ever had oil spilled on your driveway and it rains, you get little blobs of oil in the water.

Maggy: Mm-hmm.

Tim: That's a miscibility. So here, we have a miscible troilite and metal and then ...

Maggy: That didn't mix in?

Tim: That didn't mix in and then the metal, as it cooled, [00:12:30] formed these long bars. And to make that pattern, you have to cool this at a few degrees every million years. So that's how we know these are the cores of asteroids. And they're very dense. They're very heavy, so it make sense that it is the core of an asteroid. So this part is probably as close as we get to holding the core of our own planet.

Maggy: So we know that this is from a core of an asteroid.

Tim: That's right.

Maggy: And it might be similar to what is here on Earth.

Tim: That's right. And if we want to move up just a layer, you can see where the core ... Oh, we actually have pieces of these. So this is a, a very cool asteroid. So this is what we call the dog bone. [00:13:01].Its name is (laughter) Cleopatras of Sirius. So if Sirius is the dog star, I guess this is its bone. And you wouldn't think it but that's actually metallic asteroid. That's the core of an asteroid just floating on space. All the silicate has been stripped off. And you can actually go visit these sorts of things.

Tim: But if we want to study the surface of that core, we'd probably get to a meteorite like this. This is a pallasite. If any of you are born in August, anyone out there born in August? Probably. Your birthstone is peridot. That's the gem name for the mineral olivine. [00:13:30] So here we have green olivine set in metal. If I tip this up just a little bit, you can probably see the metal in there.

Maggy: Oh you can see the metal and ...

Tim: Yeah.

Maggy: ... the crystals.

Tim: And the crystals. And the crystals of olivine.

Maggy: It's beautiful.

Tim: Just like a raft sinks down in water, hat mantle of olivine, that thick layer of olivine sinks down into the core and you get these pallasites, probably our prettiest meteorites.

Maggy: So these meteorites are actually giving you an opportunity to study core material and mantle material.

Tim: Right.

Maggy: Um, without actually having to [00:14:00] explore the earth.

Tim: Right, because the deepest hole we've ever drilled on Earth is only about 16 kilometers deep. Remember ...

Maggy: You could never get deep enough.

Tim: No, no. You can never drill the 3,000 kilometers. And so how are you going to do that? You're going to study meteorites. But you noticed, there's a layer we haven't talked about on the earth which is the crust. Now, some of you have seen the crust. Most of you have walked on the crust. I hope you've all walked on the crust. But if you've ever been to a place like New Mexico or to Hawaii, you've seen lava rocks. We call them basalts as geologists. [00:14:30] And basalts form from volcanoes. You probably had people on your show talking about volcanoes in the past.

Maggy: We have.

Tim: Well, imagine there were volcanoes on asteroids, okay? So this is actually a basalt from an asteroid, except instead of being new like the rocks from Hawaii, this is four and a half billion years old.

Maggy: Wow.

Tim: So we went all the way from this jar of chondrules to this basalt on the surface of an asteroid in something like 50 million years - I mean really quick processes. And you can actually hold these in your hand. [00:15:00] You can actually see the crust of an asteroid.

Maggy: So Tim we have a student question. You want to take it?

Tim: Yeah, sure.

Maggy: All right. This question comes from Molly, John, Michael and Emily. "How many meteorites do you find each year?"

Tim: Oh, that's a good question Molly, John, Michael and Emily. (Laughter) One of the best places to go look for meteorites is actually in Antarctica. And the Smithsonian, along with NASA and the National Science Foundation, sends people to Antarctica each year to collect meteorites. [00:15:30] We collect between 600 and 800 meteorites a year.

Tim: We've collected more meteorites in Antarctica over the last 35 years than have been collected over the entire surface of the earth in the previous 500. But ones that fall to Earth like Lorton . . . Probably, a hundred or a couple hundred a year fall to Earth. Most of them fall into the oceans, but maybe 10 or 12 this type, freshly fallen meteorites are actually collected from the surface of the earth each year.

Maggy: So we have another question.

Tim: Okay.

Maggy: This one comes from Susan who's watching with our friends over at the National Air and [00:16:00] Space Museum.

Tim: Oh, hey.

Maggy: Susan wonders: could meteorites ever originate from Earth.

Tim: That's a really great question Susan. And it's one of those things that we actually think . . . Remember, meteorites are really old, like four and a half billion years old. We'll come back and talk about that. The oldest rock on Earth is only about four billion years old. So there's a half a billion years of the solar system's history that we don't have recorded in rocks from Earth. But we think that meteorites from Earth could have wound up on the moon [00:16:30] and if we sorted through enough lunar soil, we might find some of those earliest Earth rocks.

Maggy: Wow.

Tim: So, probably not things that go up now that come back to Earth, but we could look for Earth meteorites on the moon.

Maggy: Wow, that's really cool. We have another question, but this one comes in by video.

Tim: Okay. Let's take a look.

Izzy: Hi. I'm Izzy from the Winthrop School. And I want to know how often is it that meteorites come to Earth.

Tim: Hi, Izzy, a great question. And again, probably a few hundred times a year, [00:17:00] but remember, the earth is covered three quarters by water. So most of them fall to the bottom of the oceans. Probably not a good idea to go looking for them there. But, you know, most of the ones that we see fall, it's actually when someone sees them fall or oftentimes they go out. I mean I worked on a meteorite that someone went out to mow their yard one week and the previous week, there wasn't a rock there and that week there was and so they found a new meteorite. It happens all the time.

Maggy: It's very cool. Thanks for all the awesome questions. And thanks for teaching us a thing or two about meteorites.

Tim: Sure.

Maggy: [00:17:30] So Tim, is there one meteorite that has been studied more than the rest?

Tim: Yeah. So this is a meteorite called Allende. By now, a lot of you are thinking, "Well, the meteorites don't fall as these like flat plates like this."

Maggy: That look . . .

Tim: Do you really? I mean that's kind of weird looking.

Maggy: A little like Texas.

Tim: Right? Yeah, this one looks a (laughter) . . . Hi to anyone out there in Texas. So, but, no, we cut them into these shapes. So this is a meteorite called Allende. It fell in Mexico in February of 1969. Now, do you remember what famous thing happened in planetary science in 1969?

Maggy: No. I wasn't born yet, but I do think that that was [00:18:00] the man on the moon.

Tim: That's right. July 20th, 1969. They landed on the moon. So by February, they had built all the laboratories that were going to study the rocks, but they didn't really have much to work on. And then this fell in 1969. This is a really special meteorite. It has chondrules in it again. These little round things that we talked about before, but it has things even older than the chondrules.

Tim: So if we flip this around, you can see this little white thing here, right there. This is called a calcium aluminum inclusion. [00:18:30] And if chondrules were little melted drops in the solar nebula, these were like your little dust bunnies. (Laughter) Some of them were never melted, so little dust bunnies of the solar system. And these are 4.567 billion years old.

Maggy: Wow.

Tim: Billion with a B, so ...

Maggy: This is probably the oldest thing that I am ever going to encounter ...

Tim: This is the oldest thing ...

Maggy: ... in my life.

Tim: ... in the Smithsonian. The oldest thing you'll ever hold. The oldest thing you'll ever see. And it forms when these little chondrules started sticking together. So you can see here, this is a process we called accretion. [00:19:00] And so things get swept up and stick together. Now, 4.567 billion years ago, this is like a time machine. So if you like the DeLorean from Back To The Future or the Hot Tub Time Machine (laughter) or maybe the H. G. Wells Time Machine from the Big Bang Theory,

Tim: you know, you can actually see them, and collisions start to break these apart. But some of these survived. And what's really cool is you can actually take a little bit of this rock. If I break a little piece off of there, I could actually dissolve that up in a strong acid and be left with diamonds, [00:19:30] tiny little diamonds, only a few hundred carbon atoms. One scientist described them as if amoebas gave each other engagement rings, (Laughter) those would be the perfect diamonds.

Tim: But those diamonds didn't even form in the solar system. They formed during the violent deaths of other stars. So when stars exploded, went supernova and red giant, they created those diamonds. So you might be holding pieces of 50 different stars that were light years apart, a billion years before our own solar system, right here in this one rock.

Maggy: So this one rock is ... can you say that this one rock, it holds all of the elements necessary for life [00:20:00] and anything else that we know on Earth?

Tim: It does. So if you think of the elements that make up life, we need carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur. Those are the life forming elements. All of those are found in this rock and found ... In fact, all of the elements that everything you've ever known are found in here.

Tim: So if you took everything you've ever known. Your favorite place to go like maybe like going to the Grand Canyon, your house, your pet, you know, everything you've ever eaten, your car and you put it on a big blender and you went, "whiiiiiiieeee," (laughter) and grounded all up and then you dried it out and made a rock. [00:20:30] All of that stuff would be in here. So there's gold in here and platinum and all those elements that form life.

Tim: And so our directors have been quoted as saying that if the museum were burning down and you could only save one thing, this may be the thing you want to save, because this rock is really the stuff that made up our planet.

Maggy: Wow. So this holds the recipe. So this rock is extremely important. So has it inspired scientists to study the cosmos?

Tim: It has, because we wanted to know what the composition of the solar system is. We can look at a rock like this. [00:21:00] But most of the stuff is in the sun. Now, you think, "Well, we can't go sample the sun. That would be crazy, right?" But the sun gives out the solar wind and so we sent a spacecraft called Genesis. This is an artist concept of Genesis and it collected bits of that solar wind that impacted the spacecraft. Brought it back to Earth so we could actually measure the composition of the sun and compare it to the composition of a meteorite like this. So, because of the questions we're asking in here, we're flying spacecraft, half a billion dollar missions in order to answer those questions.

Maggy: [00:21:30] Have any other meteorites inspired spacecraft missions?

Tim: Yeah. So let's look at this one. This is a meteorite called Zagami. It fell in Nigeria in 1962. Maybe we can get a closeup of that. And if you look at this rock, okay, this part that's important is this little bit right here. That little black pocket right there that you can make out.

Maggy: Now, to me, that doesn't look like much.

Tim: It doesn't look like much. No, it's not too impressive, is it? But imagine that this rock was sitting wherever it was and it was having a day. We don't know if it's a good day or a bad day. [00:22:00] It's a rock. (Laughter) and something hit the surface and a shock wave passed through and melted that little bit. If you pluck that out and you measure the nitrogen. Remember, we all breathe lots of nitrogen every day. 80 percent of the air is nitrogen. And the noble gases. You may not know the noble gases. Helium, neon, argon, krypton, xenon and radon, if you measure those, they're almost a dead match for those measured in the Martian atmosphere by the Viking Lander in 1976. Even though we've never brought a rock back from Mars, we have Martian samples in our laboratory that we can study. [00:22:30]

Maggy: So this right here is a piece of Mars?

Tim: This is a piece of Mars. So I'm holding a piece of Mars. Now, my favorite game when I was a kid ... I was born in 1964; Sesame Street came on the air in 1969, so I was the first generation of school aged kids who played my favorite game, "Which one of these is not like the others?" (Laughter) So which one of these is not like the others? This one is not like the others. And how, Maggy, do we know this is not like the others?

Maggy: This comes in its own saucer.

Tim: It does. It comes in its own flying saucer. That's how we know it's a special rock. But this Martian meteorite is 4 billion years old. [00:23:00] It survived the warm, wet period on Mars. We think water flowed across the surface of Mars and has minerals in it that (were) formed by water. So 20 years ago, scientists argued that this rock, Allan Hills 84001, actually contained evidence of past life on Mars. (It was a) really controversial finding. People still debate that a lot. But it launched probably 10 spacecraft to Mars, because suddenly, we wanted to know could environments exist that hosted life on Mars?

Maggy: And you worked on some of those spacecraft missions.

Tim: I did. I did. [00:23:30] I worked on (a) mission called "Spirit and Opportunity, The Mars Exploration Rovers." We actually drove these rovers around the surface of the Mars. Here, you can see an animation. This is called the rock abrasion tool. It's actually like a little grinding device that we can use to grind into the surface to see fresh rock. And so I spent five years helping to operate these on the surface of Mars.

Maggy: What it's like driving one? I can imagine it's kind of exciting.

Tim: You would think so, but it's more like watching paint dry. (Laughter) So what you're really doing is you're writing a complex computer program every day and you send that out [00:24:00] to the spacecraft and you say, "Go do this." And then it does all that and then it writes back to us. Now, you'd probably think, "Man, you're really like covering a lot of Mars. You're doing a lot of stuff." I mean here we can see some, some images.

Maggy: Exploring a new frontier.

Tim: Oh yeah, really. I mean going out there. So you'd think this is super exciting. So how fast do you think the Mars rover can actually go?

Maggy: It's a really good question. Actually ...

Tim: Do you think ... Do you think we should ask the ...

Maggy: I think that's a good idea.

Tim: Okay, let's see what they think.

Maggy: Yeah. Here-, here's another opportunity to participate in a live poll with us. [00:24:30] This poll appears to the right of your video screen. Tell us how fast can a Mars rover go? 1,000 miles per hour? 100 miles per hour? 10 miles per hour? 1 mile per hour? or 0.1 miles per hour? Take a moment to think about it and put your answer in the window to the right. (Music) [00:25:00] All right Tim. We're both watching it.

Tim: Yeah.

Maggy: We can see ...

Tim: Yeah.

Maggy: ... that 1 mile an hour and 0.1 mile an hour, that's a toss up depending on ...

Tim: Yeah.

Maggy: ... what it's coming in.

Tim: And you get some people think 10 miles per hours too. So, I don't know. Why don't we take a look. Let's see how fast the thing really goes. (Laughter) so this is an engineering model at the Jet Propulsion Lab and this is to- ...

Maggy: Is it moving?

Tim: Yeah, this is top speed. [00:25:30] (Laughter) So on a really good day, the thing will move about 100 meters and takes about two or three hours to do. So what's 100 meters, it's a 16th of a mile per hour ... Uh, about a 30th of a mile. So even the 0.1 mile per hour is way too fast for how we go. (Laughter) to put it in another way, we thought the rover was only designed to last 90 days on Mars. Okay? It's actually lasted 13 years. One of the two has lasted 13 years and it finally finished a standard marathon distance, [00:26:00] 26.2 miles.

Maggy: Wow.

Tim: So imagine if what takes you, I don't know, a really good runner on Earth three to four hours takes 13 years for us to do with this thing on Mars. But remember, the spacecraft costs a half a billion dollars. You need to be really careful with it, because you don't want to make the people at NASA or up in Congress mad that you've wrecked their rover.

Maggy: So at half a billion dollars for each rover ...

Tim: Yeah.

Maggy: ... why actually send these rovers to Mars? [00:26:30] Why don't we just study the meteorites that come from them?

Tim: Really good question. Because, when we take a meteorite like Zagami here, we have a rock from Mars, but what we don't have is the context for that rock. We don't actually know where this rock came from on Mars.

Maggy: Oh.

Tim: Or how it's related to all the other rocks. So it's the equivalent of going, for example, to the city dump and someone hands you 12 random rocks and says, "Oh, can you explain the geology of the earth?" Well, of course you can't. You need to know that context. So when we fly spacecraft missions, sometimes we're looking for new kinds of rocks, and sometimes we want the context for rocks we already have.

Maggy: So are there any missions currently planned?

Tim: [00:27:00] Yeah, there's one called Osiris Rex that I work on. It's run out of the University of Arizona, but it's going to visit an asteroid. Remember, we talked about Allende, which is a carbonaceous chondrite. This is going to go visit an even more primitive type of carbonaceous chondrite where we don't just have the elements that help to make up life, but some of those molecules that combined in special ways to makeup life.

Tim: And so this a-, this mission we've been working on for 10 years, it's going to launch next year. It's going to get to the asteroid in 2019, [00:27:30] return in 2023. And if you're out there watching and you're on, say, 7th or 8th grade, you still have time to go to high school and college and graduate school and get a post doc and then actually be one of the people to study these samples, because we're going to still be working on these in 2030. And so you have the chance to be involved in things that ... You know, these missions will last 20 or 30 years, and you can be involved in one of them.

Maggy: Wow. That's awesome. Tim, this has been so fascinating. I love getting the opportunity to learn about meteorites in the spacecraft missions that you've [00:28:00] worked on. Thank you so much for being here.

Tim: Sure. Happy to be here.

Maggy: Can you tell our viewers where they can learn a little bit more?

Tim: Sure. You can go to the Mineral Sciences website where we have more information about meteorites. And of course, if you're ever in Washington DC, come by the Smithsonian. We have a great exhibit of meteorites. You can go to the Jet Propulsion Lab, which is the home of the Mars rover, and they have information on all the missions they run out of there, a lot of which were based on questions asked by meteorites.

Maggy: Awesome. Thank you so much.

Tim: Oh, glad to be here.

Maggy: And thank you viewers for all of your awesome questions. If you want to see this broadcast later this evening, it will be archived at qrius.si.edu. (Music)

Announcer: Thanks for watching. We hope you will join us for the next season of Smithsonian Science How? starting this fall. Check out our schedule and register for upcoming shows on our website, qrius.si.edu.