WESTERN SCIENCE SPEAKS PODCAST
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EPISODE TITLE

Meteorites tell the story of the solar system

PODCAST SUMMARY

Dr. Desmond Moser joins the podcast to explain how his latest paper, detailing the analysis of meteorites, can explain the history of Earth, and all our neighbours in the solar system.

INTERVIEW

You're listening to the Western science speaks podcast. Presented by Henry Standage.

Henry Standage 0:28
All right, welcome to the Western Science Speaks Podcast. One of my favorite clichés of science fiction movies is the discovery scene where a character find something supernatural, but has no idea where or what it came from. This week on the podcast we have as close to a real life version of that as you're likely to find, except we're lucky enough to actually know where it came from. Dr. Desmond Moser has been studying Meteor fragments that landed on Earth from Mars. These findings can tell us a lot about the history of the planet, including dispelling some existing notions that the academia community had. He came on to the pod to talk about his findings, take us through the journey that these supernatural artifacts went on to get to Earth. I even got him to give his take on Elon Musk, and his proposed Mars venture. Here we go.

I'm sitting down with Dr. Desmond Moser. It's a beautiful day outside, sometimes when you're with the earth science people, it'll be super ugly outside and it's not as inspiring. It is lovely today. So thanks for coming. I guess by the time this podcast comes out, your work will have been published for a couple months now. But this is kind of the calm before the storm, if you will. So, yeah, so let's hop into it. You look at minerals and you look at them on a large time scale. How is it even possible for us to get our hands on minerals from millions years ago from other places in the solar system.

Desmond Moser 2:03
Okay, yeah, well, there are some minerals that are just naturally long lived and they've got incredible survivor characteristics. And they occur on the rocky planets. Of course, we're not talking about minerals and planets like the gas giants, because they're made of light elements, but for the rocky planets from, you know, basically from the asteroid belt inward with Mars, or Venus etc., there are these minerals that form as some of the first formed phases to condense out of the solar system cloud, when they're pre solar discs first starts out in the sun, it's just forming. So they continue to form through natural processes through you know, volcanic activity throughout the last four and a half billion years, and now so there is just to say that these minerals occur, they're very tiny, but they occur on most of the planets that we have samples from. Now, how do we get those samples that's the other part. That's pretty cool. Of course, we go outside the building here today on campus and, and dig up some sand or, and we would find these minerals, and some of them will be quite old from the Canadian shield washed down

here by glaciers, but from other planets we need a piece of the planet's surface to make it here. From the moon, we've got samples that humans have brought back. But by and large, most of the samples we have are in the form of meteorites, so that pieces of other planets, where there's been an energetic event usually a meteorite strike on another planet that knocks pieces out of the escape velocity of that planets gravitational field. And then they start wandering around the space until the earth comes and grabs them.

Henry Standage 4:07
That just seems so absurd to me, what are the odds they would land here? Out of all the places? I mean, I'm sure they're floating around for a while, but it just seems incredible.

Desmond Moser 4:17
Yeah, well, there's actually little bits falling all the time to earth, and there's a steady flux of material going between planets, some planets, of course, the larger planets can attract more, if it's nearby. But it is pretty amazing. I totally agree with you. Some of the facts, some of the pieces of Mars that have been found - there's about 120 or 130 known pieces of Mars that have come to earth in that way. And there's actually been a few falls recently where they've actually been observed. So they've seen a fireball coming into the northern Sahara Desert. And they go the next day, and they find bits of the meteorite, and turns out is from Mars.

Henry Standage 4:57
When it falls to earth, and then it's discovered, what's the process there? So somebody finds it that brings the bring it to a lab, it gets identified. And then is it an antique? Is it put away somewhere safe? How do you as a researcher, get the opportunity to have a look at it?

Desmond Moser 5:16
Yeah, this is a nice case of a win-win between market dynamics and science. So well, a while ago, meteorites started becoming quite collectible. People were interested in them, so they had value and more people wanted them, the more value they had. And historically, a lot of the collecting was done from places like the Antarctic ice caps. Although meteorites were found everywhere, through large government organized expeditions to remote places, but increasingly in the, in the of 80s, 90s more findings were made in the northern part of Africa, in the Sahara, and desert region. And so once it became known as these stones were value, then local people's nomadic peoples would keep an eye out for them. And so now there's been a huge treasure trove of meteorites that are available from collectors, artisanal collectors wandering around the desert, spotting these things with very skilled eyes and bringing them to dealers in places like Morocco, where people from around the world will come to, deal with the collector and make deals with dealers. Now, the other part of your question was, how do we get access to them? So now they're in the hands of the dealers, but it doesn't have true value until it's officially -

Henry Standage 6:43
So the dealers, it's the same thing as saying art collector?

Desmond Moser 6:46
Yeah, exactly. Exactly. Exactly. But if you want to purchase a piece of art, you want to know it's a Rembrandt? So you want to have it authenticated. And so that's where the scientists come in. So there's an international Meteor meteoritic group that will analyze, your meteorite and tell you where it's from, and tell me if it's an asteroid from the moon, and then give it a unique number. And the cost of doing

that is that you have to leave a reference slice of the meteorite with the international organization and then sciences can study those pieces. So it becomes part of the scientific community, a small piece of the meteorite. And of course, the more research is done and the more special a meteorite is, the more value it has. The he media collectors are usually very excited to get research and not just for monetary value, a lot of them are genuinely thrilled to have a piece of space, another planet in their possession. So it's a winner.

Henry Standage 7:53
Okay, so let's take it back, when these meteorites are first sent flying through space down to earth. How did they survive and their signature, how are we able to identify them? And how are we able to pair it with a planet, say, this is from Mars.

Desmond Moser 8:13
OK, so the surviving part, it's kind of cool. They'll launch from another planet as a fragment. And if that planet has an atmosphere that will undergo some heating, from the energy of the event that launched them in the first place, and maybe a little bit of friction heating as they leave the planet, then they're, they're basically at Space temperatures, ultra-low temperatures, until they get captured by a planet like Earth, in which case you've seen the fireballs etc. in space. There's that heating of the outer part of the meteorite. Heating is so short, and the speed of diffusion of heat into the meteorite is so slow, because rocks are really good insulators that you only really modify the outer margins of the meteorite, you know, a few millimeters. And so the interior of the meteor, it stays intact. So there is a chance for some partial melting or, you know, some fracturing and things, during that whole process. Although not always, like the piece of Mars that we studied is remarkable in that it has very little, or has been very little affected by that ejection from Mars landing on Earth.

Henry Standage 9:27
Where did the piece you looked at land on earth?

Desmond Moser 9:30
It's also from Northwest Africa.

Henry Standage 9:32
Okay, is there a reason why they tend to fall in that region?

Desmond Moser 9:36
They're falling everywhere, but that's because it's dry, you know these things are not, you know, formed on Earth. They're not stable under water rich environment, so they'll start breaking down.

Henry Standage 9:46
How have people primarily been looking at these minerals in the past? And how did you and your lab look at them differently?

Desmond Moser 9:54
All right, well, we haven't named these minerals yet and there's thousands of different minerals types. People around the world use these minerals on Earth to date events in our history. But what fewer people do, aside from getting an age on these minerals is to look at the micro scale and nanoscale structures within these minerals, in addition to getting their age, and that's what we've done differently with our lab here at Western, you know, developed, assembled some electron microscopy tools, and,

together with other groups around the world, used a technique called atom probe microscopy, where we can actually make a 3d image of the atoms and their distribution.

Henry Standage 10:44
What do these structures tell us?

Desmond Moser 10:46
Well, you can imagine with the meteorite impact, there's a lot of force and there's a lot of heat. And those two things, do very specific things and leave very specific signatures within the crystal. Sometimes it scrambles the atoms, sometimes it organizes the atoms into clusters that we don't normally see. So there are all these special micro and nanoscale features that tell us that, oh, this crystal has actually seen a giant impact event of incredible forces that we only see in the interiors of planets for a microsecond. Or from a shock wave, or the intense, you know, thousands of degree Celsius temperatures that the impact energy creates.

Henry Standage 11:32
Is that the photo that you had that you showed me before?

Desmond Moser 11:38
Those photos were up one of those crystals sitting in a rock fragment from Mars

Henry Standage 11:43
There're all these colors which I assume tell you different things about the properties.

Desmond Moser 11:48
Those colors were differences in light at the rate at which the light passes through or the vibrational directions of light going through. I didn't show you some of the these other images of the atoms, they're in our paper. But basically, you would see it would look like a gumdrop with a clump of sugar with all those little tiny sugar particles, the anatomy, and you would see little clusters of certain types of elements. Sometimes they form little strings. Sometimes the crystal itself is, shifted like a deck of cards, so you get a little zones between material within. So all those things we don't know of any other way to form those except by mirror and impacts.

Henry Standage 12:35
Yeah, we're going to have to find a way to post the pictures with this podcast is for listeners. They're awesome. They're pretty cool to see. What did the crystals tell us about the history of the solar system?

Desmond Moser 12:49
Yeah, they can tell us a lot. And they can tell us, as I just described, whether a giant impact had occurred within the vicinity of that crystal when it was a mineral on the inner crust of the planet. There are also other chemical indicators in their isotopic compositions that tell us things like; did that magma that generated that crystal come straight out of the interior of the planet? Or was it recycled near the surface of the planet? The most impressive thing I think, from these crystals, you can tell whether there was an ocean around or not, whether there was liquid water on the planet at the time.

Henry Standage 13:33
That's huge!

Desmond Moser 13:34
Yeah, so you can use it on earth to show that liquid water was was here on Earth at least 4.3 billion years ago. So that was already a huge advance. And what we've seen with these tools and crystals from Mars is that they're actually even older, they're the oldest known minerals like this from a solar system body that we know of from a planet. You can get slightly older from the first asteroids formed, but the planets didn't make it. But for the planets that made it, these are the oldest planetary reocon crystals. And they tell us that actually not much has happened to them since 4.48 billion years ago, we get the age of the crystals, and then we don't see any of these signatures of these giant compartments. So to get to your second point, what does that tell us about anything new about the solar system? There's been a debate raging for 50 years since since the Apollo samples came back about whether the inner solar system suffered this massive bombardement. Long after, 500 million years after the planets originally formed, was there a second bombardment and would it have sterilized any life forms that would have existed at that time? And what the survive of the presence of these little 4.48 billion year old crystals from Mars in near pristine conditions, tell us Is that, no that didn't happen didn't happen on Mars. And if it didn't happen on Mars, then it probably didn't happen on Earth. They called it the late heavy bombardment. But there's been growing evidence calling that into question. And that theory and question and now we think are results supported by the trend that there was no nothing sufficient to rework and rebuild the whole planet.

Henry Standage 15:29
So that squashes any conspiracy that we had life on Mars before Earth.

Desmond Moser 15:37
No, it doesn't actually. Actually that's the purpose of the paper, saying that based on the Martian evidence alone, forget the rest of the solar system, as early as 4.2 billion years ago. Things that cool down and become low impact, could host life as we know it potentially. We can say life is there, and certainly the platform had the right conditions to allow life as we know it to live there 4.2 billion years ago. And then the next part is that extends to the Earth. You know, if we had water then this bombardment didn't occur on Mars, and there's no reason why it would occur just on Earth.

Henry Standage 16:21
Yeah. And we've known for a few years now that there's water on Mars. I remember I think finding that out in elementary school, or maybe early high school, sounds like that could have broken the news if we found out. That was a big one.

Desmond Moser 16:35
Yeah, the water we have on our Mars today is mostly ice and then subsurface because Mars lost its atmosphere. Early on, though, is probably more clement and more habitable than today. Now it's a dry, relatively arid surface, getting bombarded with lots of cosmic rays that destroy organic molecules. In the early days, it would have been a lot more favorable.

Henry Standage 17:04
And I imagine the likelihood of pieces of Mars coming down to Earth is much higher than other planets because Mars is our closest companion. But could say, a piece of Jupiter fall onto Earth?

Desmond Moser 17:21
Probably not, it's made of ice and light elements that probably vaporize before that and other properties. Yeah, you need something with a really high melting temperature and material like that,

from one of the large planets is buried so deeply in the interior of the planet. I can't see any surface bombardment, reaching deep enough to get that stuff out.

Henry Standage 17:43
But it is possible that a planet that far away, we're talking really far away when we get past Mars could still fall to Earth. Like if we get a piece of Uranus or Pluto.

Desmond Moser 17:53
I guess when you're getting out there, you're getting to, you know, the Kuiper Belt and you know, it's particles. So yeah, you could get to material. So there are the really primitive meteorites that fall on Earth that come from further out. Another famous one here for Western was the was the one that fell in the Yukon. Tagish Lake, which was a very primitive meteorite with clay particles. And no ice.

Henry Standage 18:24
Do we know where it was from?

Desmond Moser 18:30
Outside of my part of the solar system.

Henry Standage 18:32
True. How has Mars changed as a planet from when these minerals first came to exist? I guess we kind of talked about that a little bit..

Desmond Moser 18:45
Yeah, it has changed. In the early days, Mars would have been more like Earth, and that it had a core, a molten core and a magnetic field. Why does that matter? The magnetic field actually creates an atmosphere that protects the planet from incoming cosmic and solar radiation, the type of stuff that destroys life forms and largely erode an atmosphere. So by having that spinning Molten Core, you actually have this, this force field around the planet that protects the atmosphere and the water and makes it more viable.

Henry Standage 19:28
You seem like a good person to ask - what's your thoughts on Elon Musk wanting to live on Mars?

Desmond Moser 19:40
Well there's a whole bunch of layers to that, you know. I'm planetary geologists, but I'm also an Earth scientist. And I was at one point in charge of the graduate program in environmental sustainability here. I loved the idea of going to a place that's relatively uninhabitable because you will learn something about technology. Same way we learned a lot with the Apollo missions, on the other hand in terms of a mass migration, I think we were just going to mess up another planet.

Henry Standage 20:24
Well, you said Mars hasn't changed that much in the 4.2 billion years, right?

Desmond Moser 20:32
It has changed quite a bit in that it went from this period when it had flowing water. In the early times when they had an atmosphere it was protected for about three and a half billion years, then it started losing his atmosphere started drawing in

Henry Standage 20:45
Right but it's beautiful that it hasn't like changed that much compared to say Earth which we've totally messed up.

Desmond Moser 20:53
Yeah, that all depends on where you're looking at it from. The Earth is is changing a lot. But it's not changing beyond the limits of where it's been in the past. It's not about the earth is about us. After we're gone, the earth will be stabilized.

Henry Standage 21:18
The new year I keep reading everywhere is 2050.

Desmond Moser 21:22
It's pretty scary.

Henry Standage 21:30
Are these pieces of Mars the furthest back we can find conditions supportive of life outside Earth in our solar system?

Desmond Moser 21:42
Probably right now. Yes, the there aren't many ancient fragments of say they're known for age but fragments of the earth left. So the oldest pieces of the earth that we have are these tiny little Zircon crystals. The rocks that they formed from are totally gone. All we have are these little survivors. So we don't have any rock record from this period of, you know, 4.4 to 4.2 billion years. The oldest rock on Earth known is 4.0 billion years. When we get back to other bodies, the moon's rock record has been modified, But certainly there's more old material on the Moon, and Mars is really probably the best place. We haven't been to Venus we haven't, you know, that's an extreme place of mercury as well. Temperatures are getting near the melting temperatures of some rocks. But in terms of Mars, what are the odds that we get a piece of the oldest crust known in the inner solar system, the hundred and 20 or so pieces of Mars that make it to Earth. So, the odds are there's probably a lot more of this stuff up there on on Mars. And this is what we highlighted, the close of the paper, is that if this can be sampled by a relatively recent meteorite impact with Mars, a small one that sent this thing to Earth, It's probably accessible to human missions and rovers.

Henry Standage 23:20
How far back do you think this piece could be from? When do you think it flew off?

Desmond Moser 23:25
Oh, they've actually done that. So once it gets out of the atmosphere or away from the planet, it actually gets bombarded with cosmic rays and changes the meteor chemically so you can date you know, the space and these changes happen so you can actually get a rough age of when it was launched. So it's the estimate is, you know, on the order between five and 20 million years ago, is when the piece that we studied left Mars.

Henry Standage 23:49
So long trip.

Desmond Moser 23:50
Long trip, and then it's probably been on Earth, you know, at most 100,000 years,

Henry Standage 23:57
I thought going from Kingston to London was bad.

That's it for us this week. Hope you enjoyed the interview. As I mentioned, there are some stunning photos from Dr. Moser's research. If you want to check them out, they'll be on our website, I highly recommend you do. But for now, I'm Henry Standage, signing out. Thanks for tuning in.