AirSpace Season 2, Episode 9

Walking on the Moon Part 2

Nick:

Hi and welcome to AirSpace. This is part two of our special Apollo At 50 series.

Emily:

In our last episode we talked about the science that astronauts, Nick Armstrong and Buzz Aldrin conducted on the moon. This episode, we want to talk about the lunar science Apollo astronauts enabled back on Earth.

Nick:

With 842 pounds of moon rocks transported back to Earth, we've had a lot to study over the last 50 years.

Matt:

And only some of those rocks were studied back 50 years ago. NASA scientists made a plan to keep a large portion of the lunar samples sealed off and totally pristine for the last 50 years until now.

Nick:

Today, we'll hear from space scientists who are unsealing those samples for the first time this summer.

Emily:

The most exciting thing to me is that we can look at these samples with techniques that weren't even developed or even maybe thought of when the Apollo samples first came back to the Earth.

Matt:

And we'll talk with one lunar geologist who was working on a proposal to go back to the moon with a rover. It could dive deeper into lunar mysteries than ever before.

Emily:

Usually when we're studying these materials, we can use satellite data but that's only showing us the top microns to upper meter or so of the surface. With this we're really peering in. This hole is a hundred meters deep. It's about 25 giraffes to haul.

Nick:

Giraffes, moon pits, and lunar intrigue. We're talking about the legacy of the Apollo missions and the lunar science of the future. It's all coming up next on AirSpace from the Smithsonian's National Air and Space Museum distributed by PRX.

On December 14th, 1972, Apollo 17 commander Gene Cernan left the last human footprints on the surface of the Moon.

Gene Cernan:

We leaves as we came, and, God willing, we shall return with peace and hope for all mankind. Godspeed the crew to Apollo 17.

Matt:

So 50 years ago, the decision was made to study some of the lunar samples in all varieties of ways and save some for later.

Emily:

Later is now it has arrived this summer.

Nick:

That's really exciting for us but can you imagine how frustrating it would be to be a scientist rummaging through a lab in 1976 and find a box of moon rocks sealed till 2019? Come on.

Emily:

Well, but the good news is of the 2200 samples, the 842 pounds of rocks. It was less than 1% of that that was put into these really special sealed containers.

Nick:

So we're not talking about a lot of Apollos Ziploc bags.

Matt:

Yeah. A little less than four pounds of rocks.

Emily:

What's inside. These canisters have never touched Earth's atmosphere. And that's really important because I mean, if you've ever seen a rusty bike on the side of the road or anything like that, part of that happens because of the interaction between the chemicals that the thing is made out of and oxygen and water and all of those things kind of making it rusty.

Nick:

Earths atmosphere. We love it but it's very corrosive and kind of bad for you in some way.

Emily:

But I also think that it's easy to forget rocks trap bubbles of gas inside of them which is kind of counter-intuitive because you, unless you use a pumice stone on a regular basis, most rocks are really heavy and they sink. So to imagine that there's any part of a rock that has gas bubbles in it is kind of, it's weird, right? But that's part of why sealing these things up is so important because scientists want it. Scientists rely really heavily on being able to tap into those gas, bubbles.

Nick:

So there's gas bubbles in moon rocks...

Emily:

Yes.

Nick:

Even though there's no atmosphere.

Matt:

Well, if you think about, it's that gas is really more from when the rock was formed than from the rock just sitting on the surface of the moon.

Nick:

And it's still gaseous.

Emily:

Yeah.

Matt:

There's gases coming out of the hot magma and then it forms into the rock and some of that gas gets trapped.

Emily:

Trapped.

Nick:

So in that case, what's the priority. When you open this, do you run the exact same experiment that you ran on the moon rocks back in the 1970s to see if it mattered that you sealed them? Or do you run some new tests that we know how to do now, or have the equipment to do that we didn't have 50 years ago?

Emily:

Both.

Matt:

Yeah.

Emily:

I mean, you don't have the same equipment.

Matt:

You know, the real thing here is that we haven't changed the types of tests that we do necessarily but we've just gotten much better instrumentation that's more reliable. The error bars are smaller. So, you know, the hope is that these tests aren't necessarily going to come up with different results but maybe more precise results than what we got back in the 60s and 70s.

Emily:

I envision them opening up this container so that they can divide it up amongst the teams that are going to be studying the sample.

Nick:

Right. They're currently at Johnson Space Center in the lunar receiving lab?

Matt:

Mm-hmm (affirmative).

Nick:

And they will be going to universities across the country including the Bay area Environmental Research Institute, the University of Arizona, UC Berkeley. NASA aims in California we'll get a sample of this as well as NASA Goddard in Maryland, in our backyard.

Emily:

And even closer. So maybe the front yard, not the backyard. The natural history museum just across the mall from Aaron Space is part of one of these teams. So, it will be participating in the experiments that they're doing on these samples.

Matt:

And I actually had the opportunity to sit down with two scientists who will be working with the pristine samples this summer. Doctors, Barbara Cohen, and Natalie Curran work at NASA Goddard in Maryland. The pristine sample their team is working with won't be the first time these two have gotten to work with lunar rocks but as Dr. Cohen told me, there's a lot to be excited about when it comes to unsealing something pristine.

Dr. Curran:

The most thing to me is that we can look at these samples with techniques that weren't even developed or even maybe thought of when the Apollo samples first came back to the Earth. When we brought the Apollo samples back, we thought that they were completely dry. And we thought the water that we measured, because we did measure water in those Apollo samples, we thought it was Earth contamination. And so, it's really exciting to open these samples up and determine whether that was contamination or whether that was real and examine it with a whole bunch of new laboratory techniques.

Matt:

What value do those questions have to, you know, earthlings here, you know, us terrestrial dwellers. What can we learn about our own lives and our own history of our planet?

Dr. Cohen:

So, one of the most exciting things I think we found out from the Apollo samples when they were brought back is how old they actually are. So, some of the youngest rocks that we find on the Moon and that have been dated are actually older than the oldest [inaudible 00:06:59] that we have. So, that kind of history on the Earth has been kind of wiped out. We have things called plate tectonics that kind of remove this evidence. The Moon has this really nice archive of processes that will happen in a solar

system before the evidence that we have here on Earth. So, that's one of the most exciting things I think. In the history of the solar system. So, and that has big implications for, you know, habitability on the Earth. You know, when did we arrive or develop on the Earth or some, you know, things like that.

Dr. Curran:

One of our biggest questions about life on Earth, is how much water was there on the early Earth? Where did it come from? Was it... Was it all there to begin with or did it come in by comets later on? And that has huge implications for when life was able to develop. We use the Moon to tell us about those processes that were happening in the early Earth Moon system.

Matt:

So tell me a little bit about the difference between working with the old Apollo samples, which you've already been working with and these new, more pristine samples.

Dr. Curran:

Well, we don't know a lot about these new pristine samples yet. We haven't opened them. We have a meeting where all of the teams who were selected for this opportunity will come together and form what we call a consortium... Decide how we're going to open the sample. And then Johnson Space Center will actually open the samples and we'll take our first look. We have our previous experience to guide us. We are using an Apollo 16 drive to right now.

Dr. Cohen:

All that means is it's a drill has drilled into the surface down to just under a meter and taken material from the actual surface. So...

Dr. Curran:

So, we have an idea of what's probably there but we never know till we open it.

Matt:

How much more accurate is the equipment that you're using now versus what was used during the Apollo era?

Dr. Cohen:

The accuracy has got a lot better and we can also use a lot smaller samples now. Not saying that we wasted a lot back in the day, but you know, it's like, you know, mobile phones, the technology 15 years ago was completely different to what it is now,

Matt:

How small are the samples that you'll be using?

Dr. Cohen:

Quite tiny. You know, you don't want to sneeze and blow them away. So, currently we're using samples that are on the millimeter scale down to a few sub microns as well.

Matt:

And the way that these samples have been stored, have they just been unseen for this whole time? And is there a chance that when they're opened, you're going to see a type of moon rock that wasn't seen in the samples that were opened back in the 60s and 70s?

Dr. Cohen:

Well, so that's the thing. No one's had a look at this... So, one in particular sample that we're looking at is an Apollo 17 drive tube. Now we do have rocks from the same missions. So, they might be like that. We also might have exotic stuff that come from other areas on the moon that we've never sampled before. So it's cool. I think we both pinch ourselves every time we're looking at these samples. So.

Dr. Curran:

Absolutely.

Dr. Cohen:

Yeah.

Dr. Curran:

We're not going to find exotic materials on the Moon just because it's the Moon. The Moon is made out of rocks and those are made out of elements that we know and love when we know how they combine and how they work to form minerals and rocks. So, we're not going to find things like unobtainium...

Matt:

Like from the movie, The Core.

Dr. Curran:

Or vibranium, like you would in Black Panther. Those are made up elements that don't really exist. So...

Matt:

Yeah. It's not going to be a rock that we've just never encountered before.

Dr. Curran:

You can never say in science that's impossible.

Matt:

Right.

Dr. Curran:

But it is unlikely. What's more likely though, is that we'll find things that come from places on the Moon that maybe we haven't been to and that we can use those rocks to understand more about places that are beyond our reach with Apollo.

Matt:

So, you know, you've already expressed the excitement that comes with handling these lunar samples and sort of being part of Apollo, even though you weren't around for it. Can you remember the first time that you ever handled a moon rock? And what was that like for you?

Dr. Cohen:

Absolutely terrifying. Yeah. Growing up, I always thought NASA was this far away place that you can never work for. Or, you know. I didn't even know planetary scientists or geologists worked at NASA. I just thought it was astronauts. And so when I first got to realize that you could actually handle these samples and, you know, look up what they're made up of, was, I don't know, probably the best day of my life and also the scariest. I don't know. You never get complacent when you're looking at them. It's just, you're so careful. And I still in the back of my mind of where this actually came from and like be careful.

Matt:

Yeah, you actually have to destroy a little bit of a lunar sample every time you do a test. Does that, you know, ever make you feel a little sad that a little piece of Apollo is kind of, you know, disappearing as you use it?

Dr. Cohen:

Definitely. I think... I mean, but it's for science. So it's a good thing. You know, we need to learn all we come from these rocks and it's unfortunate that one of these techniques that you use is to destroy it and find out what gutters are made inside. But we do everything that we can before we destroy them. You know, we look at what's what the sample is made up of. It's petrology and what minerals are in there before we destroy it. So, we kind of know a lot more first.

To be honest, out of all the Apollo samples that we do have, we've probably not gone through 50% of the samples. So, there's still a lot of samples left for the future. Either way, 50 years ago when they decided to not open every single sample... It was a great investment in the future. Especially with, you know, how technology changes. So, wait in another 50 years, would be cool. The best thing would be to get more geologists back on the Moon and collect more samples. So, then not so rare.

Dr. Curran:

People think we're done. We're far from done.

Dr. Cohen:

There's a whole lot left to explore on the lunar surface.

Matt:

That was Dr. Nat Curran and Dr. Barbara Cohen from NASA Goddard.

Emily:

So, there were three vials of space rock sealed up on the Moon. We're opening one of them this year. Which is such a beautiful, like 50 year, like retrospective. And here's a great way of celebrating it. That is also scientifically valid. But what I'm really curious about is, I mean, part of what all these scientists are going to work on is... Did it matter that these rocks were sealed up?

Matt:

Mm-hmm (affirmative).

Emily:

And it's curious because if it worked...

Matt:

Meaning what?

Emily:

Essentially did sealing these samples on the surface of the Moon preserve what they think it would preserve like gases or other kinds of volatiles that may have come from the rocks. Because if it worked, it then starts this battle of when are we going to open up the other two remaining vials? If it doesn't work, are we going to open up another one immediately? Are we going to continue to wait for some reason?

Matt:

Or, you know, conversely, like if we decide that we are going to go back to the Moon and we start collecting new samples, how important will it, will those old samples be?

Nick:

More or less, do you think?

Matt:

Well, I mean, I'm thinking they would be a little less important just because, you know, not a lot geologically has happened on the Moon since we were last there. So it should still be basically in the same state.

Nick:

Still [crosstalk 00:14:49] first in our hearts, first back Earth, but not...

Matt:

From a historical standpoint, they're still incredibly valuable. From a scientific standpoint, I think they become a little less valuable.

Nick:

I disagree.

Matt:

You disagree. Oh, tell me.

Emily:

I mean, we're not necessarily going to be going back to the places we were. So I think that the lunar samples are going to continue to be incredibly valuable.

There's a lot of proposals that are being written to send missions to the Moon to do sample return, to do in situ sample, to go back and orbit the Moon and even just send people back to the Moon. And I'm super pumped to talk about some of these. And I don't think we have time to talk about all of them. So what I'm going to do is I'm going to introduce you all to my friend, Jenny, she's more officially known as Dr. Jennifer Whitten. A professor at Tulane University and she's a planetary geologist. And she specializes in volcanic activity and impact craters. Those are the craters that form on planetary surfaces where something sort of crashed into the surface. So, Jenny and I talk a lot because we work together on lots of different kinds of projects. So it was a little weird to talk to her as a podcast host but it was also really fun because she is part of a discovery class mission proposal, Moon Diver. The missions called Moon Diver, not the name of the proposal.

Matt:

It sounds like a James Bond movie.

Emily:

It does. Hmm. Moonraker. This is called Moon Diver.

Matt:

So, Emily. The discovery class missions. Those are the smaller, more affordable missions that NASA runs through its discovery program.

Nick:

Yeah. But let's define affordable on the scale of NASA.

Matt:

Yeah. So what does that mean? What is affordable? How many millions of dollars is an affordable mission?

Emily:

Like 500 million dollars.

Matt:

Oh, that's nothing.

Emily:

It's nothing.

Nick:

No, that's a couple of Avengers movies.

Emily:

This is called Moon Diver and it's especially exciting because Jenny loves the Moon.

Dr. Jennifer Witten.

Oh, I love the moon. The Moon is my favorite.

Emily:

Moon Diver is a really interesting mission concept that's being proposed because it's situated right at this intersection between lunar science and human exploration.

Dr. Jennifer Witten.:

The Moon Diver mission is all about driving a single axle rover across the lunar surface and repelling into a hole. And Moon Diver would basically land on a lander and then it would roll off the lander, drive itself towards a lunar pit. And when it got to the pit, it could repel down.

Emily:

Can you describe what this robot looks like? It's a really unique design.

Dr. Jennifer Witten.:

Yeah, no, this robot is an extreme terrain rover and the way they've actually designed it, the name of it is Axle. So, it's a single axle with two wheels. For those who maybe aren't really thinking about a car axle with the two wheels, you can also think of the Axle rover as an empty spool of thread. where it's got a thinner column that's sort of horizontal to the surface and then two wheels on either end of that there. So what the Axle does, is it will drive itself and all of instruments are in the wheel wells of the rover. And it will repel down into this lunar pit and a part of the time the rover will be touching the surface of the wall of the pit. And for part of the time it might be hanging there. So you can kind of almost think of it as like a yo-yo with this tether. It'll be able to lower itself down or if it gets stuck, we can bring it back up and reposition and then try and continue traversing down into this lunar pit.

Emily:

Where are these pits on the Moon and how did they form?

Dr. Jennifer Witten.:

These pits are basically formed when you had a void in the ground and these holes... Actually, they're not straight cylinder poles into the ground. There's a little bit of a funnel at the top. So when the Axle rover drives to it, it will drive down this funnel with a slightly gentler slope before it reaches these vertical or near vertical walls.

In them, exposed within them are layers of lava flows. And probably the most exciting part of this, other than the fact that we're going to potentially be the first mission to repel down into a planetary surface, that's not Earth, is that we're going to be looking at rocks in situ. Which is really unique for the Moon. We had the opportunity and the late 60s and 70s of sending Apollo astronauts to the Moon.

And they collected tens of kilograms of lunar samples that were brought back and analyzed in the lab. But most of those samples are what we call float. All of those rocks were small pieces, probably the size of your wrist that were on the surface. And we don't know where they formed. We didn't find them in the place that they formed. They were transported there by impacts or the formation of lunar soil. But with Moon Diver, we're going to get to see lunar rocks in the place where they formed.

Like, if you're going down the freeway and you see the big cliffs of rocks on the side. You can often see that there are layers of rock. And in geology, sort of generally things get put down in

horizontal layers. And so you get kind of this layer cake effect and the stuff at the bottom is the stuff that happened first and the stuff at the top is what happened most recently. So what's really cool about these pits is that you get this essentially, history book of this certain period of lunar history.

Building on that, you have this layer cake where the old stuff is on the bottom and the young stuff is on the top. But usually when we're studying these materials, we're studying them from the surface. So we can use satellite data. But that's only showing us the top microns to upper meter or so of the surface. With this were really peering in. This hole is a hundred meters deep. And one of the people on the team did a really fun, length calculation there. So the depth of this pit is about 25 giraffes to haul. If anybody's really interested in measuring anything in giraffes... Probably not. So for those who are maybe more inclined to paying attention to sports, that's about a football field deep. And about half of that depth is this vertical wall. This section of lava flows. And then below that is void space or there's, there's no wall, it's a hole.

Emily:

Okay. So, how deep were the Apollo astronauts able to core down and get into the subsurface? Just for reference.

Dr. Jennifer Witten.:

Yeah, sure. No. The Apollo astronauts at most drilled about two meters into the surface. So we're comparing two meters, which just as the regolith, that lunar soil. That's what we have versus this Moon Diver, which is really going and measuring the first 50 meters.

Emily:

There's obviously going to be a camera on this, on Axle.

Dr. Jennifer Witten.:

Oh yeah.

Emily:

What other kinds of capabilities is Axle and its lander going to have?

Dr. Jennifer Witten.:

This rover is a really fascinating, really cool. Really cool. So this is, it sounds, you know, single axle, it's got two wheels, it's an extreme terrain rover. So, it's symmetric and that you could, it could land upside down. And because it's symmetric, it can do the exact same thing as if it was right side up... Because it's just an axle. And then all of the instruments are located in the wheel wells. We have a one instrument, which is actually two cameras that will be used for both navigation and science. And those are actually going to be on the axle portion of the rover. So it'll have two little eyes on it's axle basically.

Emily:

Oh, it does have two little eyes. I'm looking at a cheat sheet picture.

Dr. Jennifer Witten.:

Yeah. So it kind of makes it look really adorable. Like a little rover person. We're going to look at the elemental chemistry but we're also going to look at the mineralogy by using a multi-spectral imager.

Which can tell us something about the history of these surfaces. And then we have this alpha particle x-ray spectrometer, which is measuring the elemental chemistry. So we'll be able to go from mineralogy to elemental chemistry and really break down the composition of these rocks.

Emily:

This is an un-crude robot that people aren't going with. It people aren't going to be controlling it from the surface of the Moon, but Moon Diver's really cool because it's helping to answer some questions about what we need for astronauts to survive long-term on the surface of the Moon.

Dr. Jennifer Witten.:

Yeah. The Moon has very extreme temperature swings. And so when we're trying to design a spacecraft, especially spacecraft that we want to, you know, like a long-term base. That material that is making up those structures is going to have to survive huge temperature swings and that's not exactly feasible. So, what we want to do is we want to find locations on the lunar surface where the temperatures are a little bit more stable. And so the variation is not as great as in other locations. And caves have become a region of interest, a site of interest for people who want to build human basis. Either long-term or a little bit shorter term. And these end up being really great potential locations. These pits or void spaces have shielding from radiation, shielding from micrometeorite bombardment, which happens all the time. You have these really small particles that are constantly hitting planetary surfaces. It also doesn't have very large temperature swings so that when you're building these materials, these structures, you're sort of avoiding that really large temperature variation.

Emily:

What kind of timeline are we looking at with respect to when we might see Axle on the surface of the Moon?

Dr. Jennifer Witten.:

Yeah. So, NASA is hosting a discovery program competition and the Moon Diver mission concept is something we're preparing to submit to this discovery program. And they just announced that they were going to have a new competition. And when they do that, anybody in the community can come up with a different mission concept and write it up and then submit it to this call. And then the whole idea is that by April, 2021, we'll know which proposal NASA has selected. And if Moon Diver gets selected, we'll be on the lunar surface around 2025, 2026, depending on the launch window. So, you know, in the next five years, five plus years, you could be watching an adorable little rover repel down into the depths of the lunar surface.

Matt:

Wow, how exciting would that be? Knowing that you might be planning the future of lunar exploration?

Emily:

Moon Diver is not the only mission concept that's being proposed and being explored. We've got robotic missions, we've got orbital missions, we've got crude missions, sample return, not sample returns, setting up seismic networks, finding more water on the Moon. I mean, you name it. People are talking about it and it's all really exciting science.

Nick:

Do you mean crude missions as in uncouth?

Emily:

No. I mean, crude mission is human space exploration.

Nick:

So, we're sending people back.

Emily:

That's the goal. I mean, I think one of the things that we need to do in order to get to Mars is to do some proof of concept studies by putting people on the Moon first.

Matt:

And like you, Emily, I'm interested in thinking about the possible future of human exploration on the Moon and how, you know, we could prepare for that. And so I'm kind of interested, not necessarily in the Moon itself, although of course I love the moon rocks, but in the hardware that we've left on the Moon. And how it's held up over time, what it's experienced being, you know, that exposed to solar radiation and you know, all of the other effects that materials are exposed to in space. And so, you know, maybe it's the curator in me, but I would really like to send a mission to visit some of those landing sites.

Emily:

As we start to put more and more people on the moon. Do you want to go and collect all the things that the Apollo astronauts left there and put them into a museum to continue to preserve them on the Moon, like a Moon museum? Or would you want to send them home or would you want to leave them where they are as they are?

Matt:

I think we could be strategic and maybe bring a couple of things back to Earth for display. But really what I'd like to see is an effort to preserve and curate those artifacts in situ, there on the Moon. I don't know how we will do it but I think that's what we should do.

Emily:

You just want to collect all the things.

Matt:

Just most of the things.

Nick:

Lunar intrigue.

Emily:

Lunar intrigue.

Nick:

Band name, calling it. It's this episode to band name.

Emily:

Somebody is going to have to go through our archives and start making a list of all the band names we've called.

Nick:

But the bands that we haven't started... It would be another header for that list.

Emily:

I also have to learn how to play an instrument or sing or something.

Matt:

I think you could probably play the harmonica intuitively.

Emily:

Well, I'm just trying to really fall back on the fact that geology rocks and I'm sort of hoping that'll just let me cruise through.

Dr. Jennifer Witten.:

I'm going to call that a mic drop right there.

Matt:

That's it for this episode of AirSpace.

Emily:

One of our listeners, Jay, had listened to our Rock on the Moon episode about music in space. And he let us know that Mickey Kapp who made a lot of the mixed tapes for the Apollo astronauts recently passed away on June 11th of 2019. And he was 88 years old.

Matt:

You can read his obituary in the New York Times.

Emily:

AirSpace is produced by Katie Moyer.

Nick:

Jocelyn Frank.

Matt:

Michelle Harvin.

Emily:

With help on this episode from...

Nick:

Lizzie Peabody and Ellen Rolfes.

Emily:

Mixed by Tarek Fouda.

Matt:

Special thanks to Jason Orfanon, Genevieve Sponsler, and John Barth.

Nick:

We'll be back in two weeks with an episode about witches.

Matt:

No, your calendar is right. It's not a Halloween special. We're talking about a group of famous and deadly female pilots from world war II.

Emily:

Follow us on Instagram at AirSpace Podcast.

Nick:

We're going to post photos of Jenny and Emily doing geology in the field.

Matt:

And destroying a land rover.

Emily:

Oh I could post that photo. We didn't destroy it. It came destroyed. It was not our fault.

Nick:

Doctors Whitten and Martin, everybody.

Rocks are just like us.

Emily:

Full of gas or full of hot air.

Speaker 8:

From PRX.