



SILICON  
VALLEY

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LIVE

1  
00:00:00,000 --> 00:00:11,160  
(Music)

2  
00:00:11,160 --> 00:00:12,540  
Matthew Buffington: Hey, folks.

3  
00:00:12,550 --> 00:00:13,550  
Thanks for joining us.

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00:00:13,550 --> 00:00:16,290  
We're going to jump into an intro in a little  
bit while we wait for some people to jump

5  
00:00:16,290 --> 00:00:17,290  
online.

6  
00:00:17,290 --> 00:00:18,290  
But don't be shy.

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00:00:18,290 --> 00:00:20,550  
Jump in the chat, and we're going to be looking  
for your comments.

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00:00:20,550 --> 00:00:23,019  
But I wanted to start it off.

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00:00:23,019 --> 00:00:24,789  
We were chatting earlier, Jim.

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00:00:24,789 --> 00:00:27,390  
We talk about this NASA in Silicon Valley  
Podcast.

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00:00:27,390 --> 00:00:31,599  
Jim has his own podcast -- so there's a plug  
for that -- called Gravity Assist.

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00:00:31,599 --> 00:00:32,599

Jim Green: Right.

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00:00:32,599 --> 00:00:36,120

Host: And the thing that I get a kick out of is, at the end of the show, you always

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00:00:36,120 --> 00:00:41,910

talk to the people of like: "What was your gravity assist to landing at NASA or working

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00:00:41,910 --> 00:00:42,910

on space?"

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00:00:42,910 --> 00:00:43,910

Jim Green: Yeah, absolutely.

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00:00:43,910 --> 00:00:44,910

Host: So I'm going to pivot the question to you.

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00:00:44,910 --> 00:00:45,910

Jim Green: All right.

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00:00:45,910 --> 00:00:47,330

Host: What was your gravity assist?

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00:00:47,330 --> 00:00:48,480

How did you end up at NASA?

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00:00:48,480 --> 00:00:51,520

Jim Green: Well, I was always good in math and science.

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00:00:51,520 --> 00:00:56,950

And I actually watched all the Star Treks from the very beginning.

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00:00:56,950 --> 00:00:59,030

This was with William Shatner and Leonard

Nimoy.

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00:00:59,030 --> 00:01:00,030

Host: Nice.

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00:01:00,030 --> 00:01:04,339

Jim Green: And really enjoyed that, but I ended up working in an observatory.

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00:01:04,339 --> 00:01:08,940

I ended up having a 12-inch Alvan Clark refractor at my beck and call.

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00:01:08,940 --> 00:01:11,760

I was able to build the instruments on the back end of it.

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00:01:11,760 --> 00:01:17,010

Then I started doing a lot of astrophotography and then developing my own film.

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00:01:17,010 --> 00:01:18,420

Host: Nice.

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00:01:18,420 --> 00:01:23,729

Jim Green: The high-school chemistry teacher just opened the doors.

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00:01:23,729 --> 00:01:28,170

I had the keys to the school.

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00:01:28,170 --> 00:01:29,170

I was trusted.

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00:01:29,170 --> 00:01:30,170

Host: Nice.

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00:01:30,170 --> 00:01:31,170

Jim Green: Here's the keys to the school.

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00:01:31,170 --> 00:01:33,880  
Go down and observe whatever you wanted to,  
et cetera.

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00:01:33,880 --> 00:01:38,390  
And then some of the stuff actually got published  
in Sky & Telescope.

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00:01:38,390 --> 00:01:45,800  
So when I left high school as a senior, I  
knew exactly what I wanted to do: I was going

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00:01:45,800 --> 00:01:47,159  
to be an optical astronomer.

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00:01:47,159 --> 00:01:48,159  
Host: Okay.

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00:01:48,159 --> 00:01:52,891  
Jim Green: And then I went to University of  
Iowa and took Astronomy 101.

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00:01:52,891 --> 00:01:53,891  
Host: A shout-out to Ames, Iowa.

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00:01:53,891 --> 00:01:55,890  
Not the same location, but we constantly get  
it confused.

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00:01:55,890 --> 00:01:58,340  
Jim Green: Yeah, Iowa has got some really  
great schools.

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00:01:58,340 --> 00:02:01,330  
But I'm talking about the Hawkeyes, not the  
Cyclones.

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00:02:01,330 --> 00:02:02,330

Host: Nice.

46  
00:02:02,330 --> 00:02:09,640  
Jim Green: So I had Astronomy 101 from James Van Allen, and the place was packed -- 400

47  
00:02:09,640 --> 00:02:12,280  
or 500 people crammed in there.

48  
00:02:12,280 --> 00:02:17,780  
And at the end of that, I got an A. There was a certain number of people that got an

49  
00:02:17,780 --> 00:02:22,950  
A. And then the second semester he didn't teach it, but he went on to other things.

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00:02:22,950 --> 00:02:26,510  
I picked another course called Readings in Astronomy.

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00:02:26,510 --> 00:02:28,400  
It was taught by staff.

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00:02:28,400 --> 00:02:29,400  
Host: Okay.

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00:02:29,400 --> 00:02:31,730  
Jim Green: Room 701, Van Allen Hall.

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00:02:31,730 --> 00:02:32,730  
Show up.

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00:02:32,730 --> 00:02:35,900  
So I walk in there, and it's a store room.

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00:02:35,900 --> 00:02:38,959  
There's tapes everywhere and bookcases and printout.

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00:02:38,959 --> 00:02:43,630  
I'm going through the course catalog: "Am  
I in the right room at the right time for

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00:02:43,630 --> 00:02:45,160  
Readings in Astronomy?"

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00:02:45,160 --> 00:02:48,820  
And Van Allen leans behind a bookcase and  
says: "No, Jim.

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00:02:48,820 --> 00:02:51,120  
You're in the right place, and you're my only  
student."

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00:02:51,120 --> 00:02:53,720  
And that was my second gravity assist.

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00:02:53,720 --> 00:03:00,620  
And what I did was I used the observations  
I did with the Alvan Clark refractor -- I

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00:03:00,620 --> 00:03:06,099  
took a picture of the sun every day for six  
months, and I did sunspot rotation.

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00:03:06,099 --> 00:03:08,860  
I made measurements of the sunspots.

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00:03:08,860 --> 00:03:11,730  
I wrote a scientific paper.

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00:03:11,730 --> 00:03:12,860  
He was the reviewer.

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00:03:12,860 --> 00:03:16,500  
And I understood, at the end of that, what  
research was all about.

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00:03:16,500 --> 00:03:18,040

And I was [hooked].

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00:03:18,040 --> 00:03:24,420

And so at that time I was on their 54th experiment on their satellite.

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00:03:24,420 --> 00:03:28,240

And so for me doing astronomy, I could do it from spacecraft.

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00:03:28,240 --> 00:03:32,280

And it was just a normal evolution to just get involved in that.

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00:03:32,280 --> 00:03:36,460

Greg Schmidt: Well, and Jim, also the Van Allen that you mentioned, a lot of people

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00:03:36,460 --> 00:03:40,700

probably don't know who he is and what's named after him, too.

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00:03:40,700 --> 00:03:46,020

Jim Green: Well, he is our really first true space scientist.

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00:03:46,020 --> 00:03:54,990

He developed an instrument that went on Explorer 1, and that was launched on the 31st of January

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00:03:54,990 --> 00:03:58,340

60 years ago.

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00:03:58,340 --> 00:04:02,890

We're coming up to the 60th anniversary, so 1958.

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00:04:02,890 --> 00:04:09,769

The spacecraft goes up and enters these high-radiation environments, and they figure out what it

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00:04:09,769 --> 00:04:10,769

is.

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00:04:10,769 --> 00:04:15,790

And by May of that year, he announces the discovery of the Van Allen radiation belts.

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00:04:15,790 --> 00:04:16,870

Host: Oh, wow.

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00:04:16,870 --> 00:04:17,959

Jim Green: Yep.

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00:04:17,959 --> 00:04:20,180

Host: Well, so I'll pivot on --

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00:04:20,180 --> 00:04:21,829

Greg Schmidt: Kind of cool.

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00:04:21,829 --> 00:04:23,479

Jim Green: Very cool, yes.

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00:04:23,479 --> 00:04:31,000

Host: If you're just joining us, you're watching or listening to the -- it's either the 76th

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00:04:31,000 --> 00:04:35,580

episode of the NASA in Silicon Valley Podcast or our first ever episode of NASA In Silicon

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00:04:35,580 --> 00:04:37,490

Valley Live.

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00:04:37,490 --> 00:04:43,120

So folks, if you didn't know, this is a conversational

podcast to meet with the various researchers,

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00:04:43,120 --> 00:04:49,000

scientists, engineers and overall cool people throughout NASA and here at NASA's Ames Research

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00:04:49,000 --> 00:04:50,949

Center in Silicon Valley.

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00:04:50,949 --> 00:04:57,030

So if you're a fan of the audio podcast, obviously we're doing something a little bit different:

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00:04:57,030 --> 00:05:01,310

We're doing, for the first time, live on video and on Twitch TV.

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00:05:01,310 --> 00:05:05,690

But first and foremost, a shout-out to the live audience who is watching us.

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00:05:05,690 --> 00:05:09,400

And on the chat I see a lot of shout-outs coming through.

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00:05:09,400 --> 00:05:12,190

We're going to start things off by chatting with folks.

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00:05:12,190 --> 00:05:13,560

We're going to talk about the moon.

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00:05:13,560 --> 00:05:19,380

We have some cool things to show you guys, actually -- at least virtually online visiting

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00:05:19,380 --> 00:05:21,930

different locations on the moon.

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00:05:21,930 --> 00:05:24,600

I'm your host, Matthew Buffington.

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00:05:24,600 --> 00:05:27,720

And if you notice me looking at my laptop,  
it's because I'm looking at the chat room

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00:05:27,720 --> 00:05:29,040

as much as possible.

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00:05:29,040 --> 00:05:34,290

And so when I'm looking over here trying to  
find questions, my co-host, Abby Tabor, is

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00:05:34,290 --> 00:05:35,890

going to be moving things along.

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00:05:35,890 --> 00:05:36,890

Abby Tabor: Yes.

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00:05:36,890 --> 00:05:37,890

Yes, exactly.

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00:05:37,890 --> 00:05:41,290

So maybe right now I could introduce our guests  
to the audience.

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00:05:41,290 --> 00:05:46,820

So we have here, all the way from NASA Headquarters,  
Dr. Jim Green, who is the director for Planetary

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00:05:46,820 --> 00:05:47,880

Sciences.

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00:05:47,880 --> 00:05:52,680

And also more locally here at Ames, we have  
Dr. Greg Schmidt, who is the deputy director

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00:05:52,680 --> 00:05:57,040

or NASA's Solar System Exploration Research  
Virtual Institute.

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00:05:57,040 --> 00:05:58,040

Greg Schmidt: A mouthful.

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00:05:58,040 --> 00:05:59,040

Abby Tabor: Is that it?

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00:05:59,040 --> 00:06:00,040

Greg Schmidt: Yes, you got it.

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00:06:00,040 --> 00:06:01,040

Abby Tabor: SSERVI.

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00:06:01,040 --> 00:06:02,040

Greg Schmidt: Right, SSERVI.

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00:06:02,040 --> 00:06:03,040

Abby Tabor: I'll call it SSERVI.

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00:06:03,040 --> 00:06:04,850

Host: And there's a bit of a lunar back story  
to just that name and to the institute altogether.

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00:06:04,850 --> 00:06:05,850

Greg Schmidt: There is.

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00:06:05,850 --> 00:06:06,850

There is, yeah.

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00:06:06,850 --> 00:06:10,070

Host: But before we get into the good stuff  
and we start talking about the moon, a little

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00:06:10,070 --> 00:06:13,400

bit of housekeeping for the old audio and  
the new Twitch audience.

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00:06:13,400 --> 00:06:16,240

This is basically a new format we're trying out.

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00:06:16,240 --> 00:06:17,340

We've never done this before.

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00:06:17,340 --> 00:06:19,009

We're figuring this out as we go.

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00:06:19,009 --> 00:06:26,080

We're going to continue to do this for the next couple weeks on [twitch.tv/nasa](https://twitch.tv/nasa), basically

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00:06:26,080 --> 00:06:31,320

doing this podcast but on Twitch and going through the chats.

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00:06:31,320 --> 00:06:36,940

But basically the plan is for us to keep talking to some experts, take questions from everybody.

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00:06:36,940 --> 00:06:39,610

If you can't catch us live, that's no big deal.

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00:06:39,610 --> 00:06:47,300

You can find us on [youtube.com/nasaames](https://youtube.com/nasaames) and also on RSS podcast services throughout the

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00:06:47,300 --> 00:06:49,070

Solar System and beyond.

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00:06:49,070 --> 00:06:52,850

And I think our plan is we'll have those up by Tuesday.

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00:06:52,850 --> 00:06:55,410

So we talked about Jim's Gravity Assist.

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00:06:55,410 --> 00:06:58,860

Greg, tell us about how you joined NASA, how you ended up in Silicon Valley.

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00:06:58,860 --> 00:06:59,860

Greg Schmidt: Yeah.

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00:06:59,860 --> 00:07:03,770

Well, the story starts a really long time ago.

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00:07:03,770 --> 00:07:10,259

And I'll do a quick fast-forward because when I was already at NASA, I was over at my mom's

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00:07:10,259 --> 00:07:14,220

house one day and she says: "Greg, I want to show you something."

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00:07:14,220 --> 00:07:19,610

She shows me this little thing drawn by a 6 year old who turned out to be me a really

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00:07:19,610 --> 00:07:24,449

long time ago, and it was a drawing of a few spaceships.

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00:07:24,449 --> 00:07:27,680

And it said: "When I grow up, I want to work for NASA."

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00:07:27,680 --> 00:07:28,919

Host: Nice.

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00:07:28,919 --> 00:07:33,639

Greg Schmidt: This was during the Gemini program.

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00:07:33,639 --> 00:07:38,050

And I remember the Mercury program, too, although I was really, really young then.

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00:07:38,050 --> 00:07:46,509

So I guess it was probably in the 31st chromosome somewhere in here, you know, kind of destined

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00:07:46,509 --> 00:07:47,509

to be.

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00:07:47,509 --> 00:07:50,190

My dad also was here.

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00:07:50,190 --> 00:07:53,250

My parents met here at NASA Ames Research Center.

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00:07:53,250 --> 00:07:54,250

Host: Nice.

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00:07:54,250 --> 00:07:56,660

Greg Schmidt: My wife and I met here at NASA Ames Research Center.

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00:07:56,660 --> 00:07:57,820

It's kind of the family business, I suppose.

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00:07:57,820 --> 00:07:59,349

Jim Green: Did you get married here?

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00:07:59,349 --> 00:08:00,400

Greg Schmidt: We didn't.

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00:08:00,400 --> 00:08:01,400

Jim Green: No?

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00:08:01,400 --> 00:08:02,400

Oh, well.

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00:08:02,400 --> 00:08:03,990

There's a big wind tunnel you could have . . .

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00:08:03,990 --> 00:08:04,990

Greg Schmidt: Yeah.

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00:08:04,990 --> 00:08:06,259

That would have been a nice setting, yeah.

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00:08:06,259 --> 00:08:09,860

I would have had to convince my wife, I think.

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00:08:09,860 --> 00:08:16,410

So my dad was the guy that proved that it was possible to navigate to the moon during

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00:08:16,410 --> 00:08:17,420

the Apollo era.

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00:08:17,420 --> 00:08:19,020

This was right around 1960.

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00:08:19,020 --> 00:08:20,419

Abby Tabor: Really?

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00:08:20,419 --> 00:08:21,819

Greg Schmidt: Yeah.

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00:08:21,819 --> 00:08:22,819

Yeah.

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00:08:22,819 --> 00:08:26,300

And so fast-forward a little bit to my teen years.

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00:08:26,300 --> 00:08:31,180

Like Jim, I was good in science and math and whatnot.

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00:08:31,180 --> 00:08:33,579

I built my own observatory.

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00:08:33,579 --> 00:08:36,689

We have a family ranch about an hour and a half from here.

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00:08:36,689 --> 00:08:40,369

And I built an observatory, ground my own mirror and everything --

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00:08:40,369 --> 00:08:41,369

Abby Tabor: No kidding?

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00:08:41,369 --> 00:08:42,369

Wow.

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00:08:42,369 --> 00:08:44,259

Greg Schmidt: -- and used that for a few years.

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00:08:44,259 --> 00:08:50,970

And then when I was out of graduate school, I just was talking with someone who happened

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00:08:50,970 --> 00:08:56,330

to work here, and she said: "You need to come by and meet some people."

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00:08:56,330 --> 00:08:57,999

That was 33.5 years ago.

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00:08:57,999 --> 00:08:59,249

Host: Oh, wow.

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00:08:59,249 --> 00:09:01,319

Jim Green: It starts by looking up --

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00:09:01,319 --> 00:09:02,319

Abby Tabor: Yeah.

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00:09:02,319 --> 00:09:03,319

Greg Schmidt: It starts by looking up.

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00:09:03,319 --> 00:09:04,980

Jim Green: -- and being fascinated by what you see.

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00:09:04,980 --> 00:09:06,089

Greg Schmidt: Yeah.

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00:09:06,089 --> 00:09:11,029

Yeah, that's a message that I think we can share with everyone out there.

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00:09:11,029 --> 00:09:14,700

You don't have to work at NASA, of course, to be interested in this stuff.

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00:09:14,700 --> 00:09:18,629

There's a lot of people interested, and there's so much cool stuff to see out there.

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00:09:18,629 --> 00:09:23,589

Jim Green: What's really unfortunate over time is many of our big cities, it's hard

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00:09:23,589 --> 00:09:26,480

to see beyond a few stars and maybe a couple planets.

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00:09:26,480 --> 00:09:28,600

Greg Schmidt: It is, yeah.

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00:09:28,600 --> 00:09:33,959

Jim Green: But getting out, finding an opportunity to just go out where there's no lights, and

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00:09:33,959 --> 00:09:37,910

lay in a field and look up, and look at the Milky Way.

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00:09:37,910 --> 00:09:38,910

Greg Schmidt: Uh-huh.

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00:09:38,910 --> 00:09:39,910

Yeah.

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00:09:39,910 --> 00:09:40,970

Jim Green: It looks like the sky is on fire.

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00:09:40,970 --> 00:09:41,970

Greg Schmidt: Yeah.

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00:09:41,970 --> 00:09:42,970

Yeah.

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00:09:42,970 --> 00:09:47,560

Jim Green: And recognize that the history of humankind went through the era where the

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00:09:47,560 --> 00:09:51,119

sky played a dominant role in their thinking and their culture.

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00:09:51,119 --> 00:09:52,119

Greg Schmidt: That's right.

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00:09:52,119 --> 00:09:58,959

Jim Green: The identification of the planets had been known, at least six out of the eight

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00:09:58,959 --> 00:10:06,750

or nine depending on your persuasion.

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00:10:06,750 --> 00:10:12,730

And that's such a fascinating part of our life here on earth: the sky is included.

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00:10:12,730 --> 00:10:13,730

Greg Schmidt: Yeah.

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00:10:13,730 --> 00:10:17,319

Jim Green: And now we have an opportunity to go out and visit those objects that we

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00:10:17,319 --> 00:10:18,739

see, like the moon.

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00:10:18,739 --> 00:10:20,149

Greg Schmidt: It's so cool.

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00:10:20,149 --> 00:10:23,720

And the very word "planet" comes from the Greek planetos, which means "wanderers."

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00:10:23,720 --> 00:10:24,720

Jim Green: That's right.

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00:10:24,720 --> 00:10:25,720

Abby Tabor: That's right.

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00:10:25,720 --> 00:10:30,449

Greg Schmidt: And these were stars that didn't behave like the rest of the stars.

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00:10:30,449 --> 00:10:36,850

They actually moved with respect to the background, and the ancients didn't know why that was.

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00:10:36,850 --> 00:10:42,189

It wasn't until relatively modern times, just a few hundred years ago, that people finally

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00:10:42,189 --> 00:10:43,189

figured that out.

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00:10:43,189 --> 00:10:44,189

Jim Green: That's right.

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00:10:44,189 --> 00:10:45,189

Greg Schmidt: Yeah.

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00:10:45,189 --> 00:10:49,839

And not until our generations here that we actually have been able to send probes to

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00:10:49,839 --> 00:10:52,949

them through Jim's program at NASA Headquarters.

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00:10:52,949 --> 00:10:54,209

Jim Green: Yeah.

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00:10:54,209 --> 00:10:58,230

So in time, there's been just a number of revolutions in the way we think.

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00:10:58,230 --> 00:11:05,100

Copernicus, as an example, was the one that really proposed that all of these planets

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00:11:05,100 --> 00:11:08,319

moved around the sun.

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00:11:08,319 --> 00:11:16,100

And then, of course, Tycho Brahe observing the planets in really precise ways and giving

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00:11:16,100 --> 00:11:17,810

that data to a mathematician, Johannes Kepler.

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00:11:17,810 --> 00:11:18,920

Greg Schmidt: Yes, totally.

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00:11:18,920 --> 00:11:23,439

Jim Green: And Kepler then really figured out what was happening.

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00:11:23,439 --> 00:11:24,879

In fact, he did it with Mars.

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00:11:24,879 --> 00:11:33,149

And he was able to do it because Mars's orbit has a nice little eccentricity about it, and

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00:11:33,149 --> 00:11:35,119

it was hard to fit that.

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00:11:35,119 --> 00:11:40,829

And that forced him into a mathematical construct called an ellipse.

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00:11:40,829 --> 00:11:47,549

And then once that data was ordered in that way, things just fell right into place and

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00:11:47,549 --> 00:11:49,860

created the laws, Kepler's Laws.

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00:11:49,860 --> 00:11:52,489

And we use those today.

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00:11:52,489 --> 00:11:57,190

And we're starting that next set of revolution[s], and that is using those equations, building

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00:11:57,190 --> 00:12:01,480

on the past, getting out into the Solar System by those equations.

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00:12:01,480 --> 00:12:02,480

Greg Schmidt: Yeah.

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00:12:02,480 --> 00:12:03,480

Abby Tabor: Awesome.

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00:12:03,480 --> 00:12:08,220

Host: Well, giving a slight shout-out over to the Twitch chat, there was -- let me look

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00:12:08,220 --> 00:12:09,220

at this.

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00:12:09,220 --> 00:12:10,850

Droptimus Prime said: "No.

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00:12:10,850 --> 00:12:12,910

Don't look at the Twitch chat, for the love of God."

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00:12:12,910 --> 00:12:18,209

And then another person, [Snid Ramayone], says: "Good luck going through the chat to

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00:12:18,209 --> 00:12:19,529

find real questions."

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00:12:19,529 --> 00:12:20,889

So we're going to try our best.

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00:12:20,889 --> 00:12:22,680

Don't be shy with the feedback.

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00:12:22,680 --> 00:12:25,112

We're trying to figure out how this whole thing works and [crosstalk].

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00:12:25,112 --> 00:12:26,112

Jim Green: But it doesn't matter.

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00:12:26,112 --> 00:12:27,112

We'll give real answers.

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00:12:27,112 --> 00:12:28,112

Host: Exactly.

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00:12:28,112 --> 00:12:29,112

Greg Schmidt: We will.

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00:12:29,112 --> 00:12:30,112

We will.

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00:12:30,112 --> 00:12:31,112

Host: But let's pivot on over to the moon.

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00:12:31,112 --> 00:12:32,670

We call this "We're going back to the moon."

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00:12:32,670 --> 00:12:34,809

In a lot of ways, we never really left.

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00:12:34,809 --> 00:12:35,809

Greg Schmidt: Correct.

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00:12:35,809 --> 00:12:38,029

Host: But it is about putting astronauts on the moon.

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00:12:38,029 --> 00:12:43,990

But you guys have just wrapped the [lunar science and landing sites workshop].

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00:12:43,990 --> 00:12:44,990

Greg Schmidt: Right.

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00:12:44,990 --> 00:12:45,990

Yeah, yeah.

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00:12:45,990 --> 00:12:47,241

Host: So why don't you guys talk a little bit about what was that workshop, what did

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00:12:47,241 --> 00:12:48,241  
you guys do?

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00:12:48,241 --> 00:12:49,981  
It just wrapped up two hours ago.

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00:12:49,981 --> 00:12:50,981  
Greg Schmidt: Yeah, it did.

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00:12:50,981 --> 00:12:51,981  
Host: So tell us a little bit about that.

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00:12:51,981 --> 00:12:56,040  
Jim Green: So it was just really, I think, a seminal event in terms of what will happen

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00:12:56,040 --> 00:13:00,179  
next in the exploration of the moon.

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00:13:00,179 --> 00:13:05,610  
As you point out, Matt, we've been to the moon the whole space era.

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00:13:05,610 --> 00:13:08,290  
Right now, for instance, we have an orbiting satellite.

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00:13:08,290 --> 00:13:11,069  
It's called the Lunar Reconnaissance Orbiter.

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00:13:11,069 --> 00:13:13,730  
It's a fabulous, fabulous spacecraft.

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00:13:13,730 --> 00:13:18,410  
And it's very healthy, with all kinds of spectacular instruments.

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00:13:18,410 --> 00:13:24,309

In fact, it's got one instrument on it that is a high-resolution imager.

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00:13:24,309 --> 00:13:28,569

If this table sat on the moon, it could see it.

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00:13:28,569 --> 00:13:30,009

All right?

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00:13:30,009 --> 00:13:37,999

And that really . . . It's an enabling capability because we then can use that to be able to

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00:13:37,999 --> 00:13:43,939

study the moon in high-resolution detail that allows us then to pick out places we want

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00:13:43,939 --> 00:13:49,369

to go to do all kinds of different science and land safely.

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00:13:49,369 --> 00:13:50,970

And that's what's really critical.

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00:13:50,970 --> 00:13:56,860

In fact, LRO has been observing the moon for quite a while and has observed many of the

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00:13:56,860 --> 00:13:58,619

Apollo sites.

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00:13:58,619 --> 00:14:05,379

In fact, you can get on the Web and do a Lunar Reconnaissance Orbiter sort on that and look

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00:14:05,379 --> 00:14:08,370

for Apollo landing sites.

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00:14:08,370 --> 00:14:13,240

I think we've got one that we just pulled off the Web you can take a look at.

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00:14:13,240 --> 00:14:15,269

It's from Apollo 17.

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00:14:15,269 --> 00:14:16,269

Greg Schmidt: Seventeen, yeah.

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00:14:16,269 --> 00:14:17,269

Uh-huh.

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00:14:17,269 --> 00:14:18,269

Jim Green: Yeah, the last time humans were on the moon.

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00:14:18,269 --> 00:14:20,899

Abby Tabor: Do you continue studying those same sites?

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00:14:20,899 --> 00:14:21,899

Is that why you brought it up today?

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00:14:21,899 --> 00:14:25,040

Jim Green: We do, and we do that through a variety of mechanisms.

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00:14:25,040 --> 00:14:29,470

One way we do that is through the samples they brought back.

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00:14:29,470 --> 00:14:38,369

They brought back about 850 pounds of material, both rock but also loose soils, the regolith.

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00:14:38,369 --> 00:14:44,100

It may be a little less than that, but on that order.

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00:14:44,100 --> 00:14:48,290

We're interrogating those, and we're learning all kinds of things about those, which is

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00:14:48,290 --> 00:14:49,629

really fascinating.

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00:14:49,629 --> 00:14:56,629

Another way we actually still use those sites is they also put out a series of retro reflectors.

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00:14:56,629 --> 00:15:03,929

This enables us to fire a laser beam, hit that, and then have it come back.

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00:15:03,929 --> 00:15:04,949

And all we do is time it.

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00:15:04,949 --> 00:15:05,949

Abby Tabor: Huh.

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00:15:05,949 --> 00:15:12,769

Jim Green: And since a lot of early physics work was done in terms of determining the

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00:15:12,769 --> 00:15:18,671

speed of light, we can easily then take that knowledge and figure out how far away the

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00:15:18,671 --> 00:15:19,671

moon is.

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00:15:19,671 --> 00:15:26,279

By the time we emit the light and receive the light, it travels at the speed of light,

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00:15:26,279 --> 00:15:27,339

and we can calculate it.

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00:15:27,339 --> 00:15:31,570

And of course, that's about 2.5 seconds all the way up and back.

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00:15:31,570 --> 00:15:36,189

And we can calculate it to just a very small fraction of difference.

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00:15:36,189 --> 00:15:43,239

And what we're finding out in those 40 years that those laser-reflecting stations have

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00:15:43,239 --> 00:15:47,709

been there is that the moon is moving away from us.

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00:15:47,709 --> 00:15:52,829

Very slowly, very slowly, but it is doing that.

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00:15:52,829 --> 00:15:56,739

It's on the order of a centimeter or so a year.

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00:15:56,739 --> 00:15:59,699

And so after 40 years, it's clearly measurable.

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00:15:59,699 --> 00:16:04,209

Host: And during the course of the whole workshop you guys were all just hanging out talking

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00:16:04,209 --> 00:16:05,209

about this, or [crosstalk]?

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00:16:05,209 --> 00:16:07,660

Greg Schmidt: We were talking about -- yeah.

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00:16:07,660 --> 00:16:08,660

Host: That's great.

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00:16:08,660 --> 00:16:10,019

How did it all come together?

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00:16:10,019 --> 00:16:14,300

I know you had a lot to do with formulating it together, pulling it . . .

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00:16:14,300 --> 00:16:15,339

Greg Schmidt: Oh, yeah.

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00:16:15,339 --> 00:16:16,339

Yeah, absolutely.

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00:16:16,339 --> 00:16:20,989

And boy, I work with just the best team in the world, I think, one of them being this

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00:16:20,989 --> 00:16:22,129

gentleman back here.

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00:16:22,129 --> 00:16:24,339

I don't know if we can get a camera on him or not.

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00:16:24,339 --> 00:16:26,270

Host: Yeah, Dave has our cloud cam.

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00:16:26,270 --> 00:16:28,809

You can see Clive is waving.

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00:16:28,809 --> 00:16:32,730

Greg Schmidt: Clive Neal from Notre Dame University.

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00:16:32,730 --> 00:16:37,259

He and I co-chaired this wonderful thing.

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00:16:37,259 --> 00:16:39,500

We had people from all over the world.

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00:16:39,500 --> 00:16:42,529

We have quite a significant Japanese contingent.

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00:16:42,529 --> 00:16:45,100

They have a big interest in the moon.

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00:16:45,100 --> 00:16:47,739

We had some Europeans.

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00:16:47,739 --> 00:16:50,769

We had people from everywhere.

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00:16:50,769 --> 00:16:57,659

Jack Schmitt, who, along with Gene Cernan,  
were the two last people to walk on the moon

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00:16:57,659 --> 00:17:00,069

-- Jack was here.

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00:17:00,069 --> 00:17:02,290

He's in his eighties.

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00:17:02,290 --> 00:17:03,290

Jim Green: Remarkable man.

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00:17:03,290 --> 00:17:04,390

Greg Schmidt: He is sharp.

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00:17:04,390 --> 00:17:05,390

Jim Green: Unbelievable.

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00:17:05,390 --> 00:17:06,390

Greg Schmidt: Oh, my gosh.

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00:17:06,390 --> 00:17:07,680

Host: Also a former senator, right?

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00:17:07,680 --> 00:17:09,209

Greg Schmidt: A former senator.

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00:17:09,209 --> 00:17:10,209

Host: Yes.

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00:17:10,209 --> 00:17:11,209

Greg Schmidt: Yep, yep, yep.

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00:17:11,209 --> 00:17:15,459

He was there when the latest pivot to the moon was announced by the White House.

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00:17:15,459 --> 00:17:21,839

One of the really significant things that's going on right now is lunar commerce.

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00:17:21,839 --> 00:17:28,470

There's a brand-new industry they haven't yet launched, but they've been working on

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00:17:28,470 --> 00:17:33,330

this for a few years, a number of the companies.

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00:17:33,330 --> 00:17:37,500

What they want to do is deliver stuff to the moon.

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00:17:37,500 --> 00:17:40,929

They want to do that for NASA, of course, and for other space agencies.

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00:17:40,929 --> 00:17:44,399

But they want to start a whole industry up there.

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00:17:44,399 --> 00:17:47,420

And that, to me, is incredibly exciting.

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00:17:47,420 --> 00:17:54,860

And the way I see it is we are just on the edge of really having the moon be another

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00:17:54,860 --> 00:17:56,350

planet for humanity.

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00:17:56,350 --> 00:17:57,350

Host: Exciting.

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00:17:57,350 --> 00:18:00,000

Greg Schmidt: It's nothing short of that, yeah.

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00:18:00,000 --> 00:18:02,830

That's going to be a tough place to live, right?

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00:18:02,830 --> 00:18:05,299

There's no air.

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00:18:05,299 --> 00:18:06,970

We have found that there's water, though --

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00:18:06,970 --> 00:18:07,970

Host: Exactly.

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00:18:07,970 --> 00:18:13,529

Greg Schmidt: -- on the permanently shadowed craters on the poles and elsewhere.

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00:18:13,529 --> 00:18:20,870

And so we think that there's the resources to build domes, build habitats for ourselves,

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00:18:20,870 --> 00:18:27,730

and to supply water that we need, to break it into oxygen that we can breathe, and break

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00:18:27,730 --> 00:18:30,740

it into hydrogen and oxygen for fuel.

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00:18:30,740 --> 00:18:34,299

And so we think that we have all the resources that we need.

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00:18:34,299 --> 00:18:35,389

We just need to go there.

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00:18:35,389 --> 00:18:37,300

Host: Well, I can jump in on the chat.

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00:18:37,300 --> 00:18:42,409

There was a question from Mellow Canuck -- right on -- who was like: "Would a base on the moon

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00:18:42,409 --> 00:18:45,820

be surface or subterranean, or a mix of both?"

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00:18:45,820 --> 00:18:47,889

Greg Schmidt: Oh, that's a super-good question.

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00:18:47,889 --> 00:18:52,289

So I don't know if . . . I could take it first or whatever.

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00:18:52,289 --> 00:18:56,570

Jim Green: This is what . . . Not every place on the moon is created equal.

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00:18:56,570 --> 00:18:57,570

Greg Schmidt: That's right.

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00:18:57,570 --> 00:19:00,909

Jim Green: We're finding . . . Because this was all about what are the important sites

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00:19:00,909 --> 00:19:04,840

to go to, we were covering all sorts of fascinating locations.

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00:19:04,840 --> 00:19:10,799

Now, one type of formation on the moon, we call it a pit.

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00:19:10,799 --> 00:19:16,500

But in reality, it's probably a collapse of either a chamber that was a bubble of air

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00:19:16,500 --> 00:19:23,179

at one time where the ceiling has collapsed after the volcanic material cooled or, actually,

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00:19:23,179 --> 00:19:26,570

a lava tube from which the ceiling has collapsed.

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00:19:26,570 --> 00:19:27,570

Host: Okay.

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00:19:27,570 --> 00:19:35,669

Jim Green: And so that is a fascinating . . . There's 300 that we've identified so far already,

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00:19:35,669 --> 00:19:40,380

not only on the front side but also the far side of the moon.

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00:19:40,380 --> 00:19:48,140

And what's really fascinating about these is, indeed, if humans wanted to go into these,

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00:19:48,140 --> 00:19:49,919

they would have a number of advantages.

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00:19:49,919 --> 00:19:55,650

They would be an enormous amount of protection from the radiation environment that we know

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00:19:55,650 --> 00:19:57,220

exists.

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00:19:57,220 --> 00:20:02,279

And since the moon doesn't have a magnetosphere, a big magnetic field -- although it has remnant

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00:20:02,279 --> 00:20:07,850

magnetic-field pieces on it -- and it doesn't have an atmosphere to stop even the solar

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00:20:07,850 --> 00:20:14,669

wind that hammers the moon, places like these would be really important to be able to have

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00:20:14,669 --> 00:20:16,190

a station or a location.

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00:20:16,190 --> 00:20:23,350

So we're moving into a realm where it's not just only surface to be considered.

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00:20:23,350 --> 00:20:29,100

There are places that you could actually go and come down, create an inflatable, and be

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00:20:29,100 --> 00:20:32,931

able to live and work in an area that is a natural protection for you.

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00:20:32,931 --> 00:20:34,159

Host: Yeah, what are you saying?

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00:20:34,159 --> 00:20:37,120

Some of those tubes, they're always looking

at Earth because they're locked --

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00:20:37,120 --> 00:20:39,039

Jim Green: Yeah, because the moon is tidally locked.

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00:20:39,039 --> 00:20:44,429

Host: We might have been talking about this during lunch, so I remember.

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00:20:44,429 --> 00:20:45,429

Abby Tabor: Fill us in.

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00:20:45,429 --> 00:20:46,429

[General crosstalk]

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00:20:46,429 --> 00:20:47,429

Jim Green: So the moon is tidally locked.

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00:20:47,429 --> 00:20:55,220

Actually, we have a view of one of these, which is really great.

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00:20:55,220 --> 00:20:56,220

If we could bring it up?

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00:20:56,220 --> 00:20:57,220

Host: Oh, awesome.

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00:20:57,220 --> 00:20:58,220

Jim Green: All right.

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00:20:58,220 --> 00:20:59,220

Host: There we go.

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00:20:59,220 --> 00:21:00,220

Look at that.

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00:21:00,220 --> 00:21:01,220

Jim Green: All right.

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00:21:01,220 --> 00:21:02,220

So that, when you look at it, you may think it's a crater.

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00:21:02,220 --> 00:21:04,610

But if you really study it, you can determine it's so much different than what a crater

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00:21:04,610 --> 00:21:05,610

really looks like.

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00:21:05,610 --> 00:21:06,610

Male Voice: I don't see it.

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00:21:06,610 --> 00:21:11,360

Jim Green: And so you have a sun angle, and that sun is shining on one part of it.

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00:21:11,360 --> 00:21:14,960

And so you see the shadow in there.

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00:21:14,960 --> 00:21:18,760

And then you see very sharp edges.

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00:21:18,760 --> 00:21:23,780

And so, indeed, that's a fabulous pit we call it.

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00:21:23,780 --> 00:21:27,179

A skylight is another term that we use.

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00:21:27,179 --> 00:21:28,179

Abby Tabor: I've heard that.

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00:21:28,179 --> 00:21:31,370

Jim Green: But because the moon is tidally

locked on the near side --

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00:21:31,370 --> 00:21:34,789

Abby Tabor: That means that we only see one face of it, right?

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00:21:34,789 --> 00:21:35,789

Is that it?

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00:21:35,789 --> 00:21:36,789

Jim Green: Correct.

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00:21:36,789 --> 00:21:40,270

Tidally locked means one day on the moon is one orbit, also.

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00:21:40,270 --> 00:21:46,350

And that is because when the moon was formed early on, it was actually formed very close

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00:21:46,350 --> 00:21:47,350

to the earth.

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00:21:47,350 --> 00:21:50,389

And as we know and we just talked about, it's continually moving away.

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00:21:50,389 --> 00:21:55,940

But billions of years ago, one orbit around the earth was maybe five or six hours long.

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00:21:55,940 --> 00:21:59,179

Right now it's 28 days long.

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00:21:59,179 --> 00:22:09,130

And so that tidal locking means that one side faces the moon, and that's really caused all

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00:22:09,130 --> 00:22:11,710

kinds of different structures on the moon.

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00:22:11,710 --> 00:22:18,090

There's major differences between that near side than the front side.

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00:22:18,090 --> 00:22:23,059

But in this particular case, with these skylights, there are some that you can get into and then

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00:22:23,059 --> 00:22:25,210

constantly look up and see the earth.

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00:22:25,210 --> 00:22:27,730

Those would be prime locations for human exploration.

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00:22:27,730 --> 00:22:29,529

Abby Tabor: I kind of want to know more about that, though.

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00:22:29,529 --> 00:22:32,149

Why do the lava tubes all go in one direction?

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00:22:32,149 --> 00:22:33,230

Greg Schmidt: Oh, why?

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00:22:33,230 --> 00:22:38,220

Well, one of the things that I wanted to say, and then we can address that question.

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00:22:38,220 --> 00:22:42,600

So the earth is a really nice place to live.

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00:22:42,600 --> 00:22:48,750

We have this really thick atmosphere that shields us from all sorts of harsh radiation

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00:22:48,750 --> 00:22:51,509

from the sun.

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00:22:51,509 --> 00:22:58,590

There's things called coronal mass ejections,  
where you have these giant explosions on the

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00:22:58,590 --> 00:23:02,789

sun that send streams of high-energy particles  
our way.

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00:23:02,789 --> 00:23:05,190

And the earth protects us from that.

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00:23:05,190 --> 00:23:07,320

Our magnetic field protects us from that.

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00:23:07,320 --> 00:23:09,580

Our atmosphere protects us from that.

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00:23:09,580 --> 00:23:11,519

On the moon, you don't have that.

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00:23:11,519 --> 00:23:15,799

Now, Jim mentioned that there are small magnetic-field  
areas.

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00:23:15,799 --> 00:23:19,090

We took a look at those at this workshop.

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00:23:19,090 --> 00:23:22,000

And so you have to do something else to protect  
you.

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00:23:22,000 --> 00:23:23,950

And so this, putting a [crosstalk] --

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00:23:23,950 --> 00:23:25,730

Host: It's already made for you.

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00:23:25,730 --> 00:23:26,730

Greg Schmidt: Exactly.

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00:23:26,730 --> 00:23:27,820

Host: It's already there.

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00:23:27,820 --> 00:23:30,990

Greg Schmidt: You don't need to get a moon  
bulldozer and . . .

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00:23:30,990 --> 00:23:32,009

Host: And drill [crosstalk].

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00:23:32,009 --> 00:23:34,139

Greg Schmidt: That's right, that's right.

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00:23:34,139 --> 00:23:37,220

And so that's something that we're looking  
at pretty seriously.

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00:23:37,220 --> 00:23:38,220

Abby Tabor: That will simplify [crosstalk].

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00:23:38,220 --> 00:23:39,220

Jim Green: But you know it has some challenges.

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00:23:39,220 --> 00:23:40,220

I'm sorry.

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00:23:40,220 --> 00:23:44,659

Abby Tabor: Well, it would simplify living  
there maybe quite a bit if we don't have to

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00:23:44,659 --> 00:23:45,850

construct habitats, but . . .

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00:23:45,850 --> 00:23:47,600

Jim Green: Correct, but it has another challenge.

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00:23:47,600 --> 00:23:48,600

Abby Tabor: What's that?

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00:23:48,600 --> 00:23:55,980

Jim Green: Some of these drops down to the surface might be 100 meters.

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00:23:55,980 --> 00:23:57,440

And we don't have a ramp.

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00:23:57,440 --> 00:23:58,870

We can't just drive down into it.

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00:23:58,870 --> 00:24:04,779

We haven't found one yet that really . . . There might be some hints of a couple that have

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00:24:04,779 --> 00:24:08,789

that feature associated with them.

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00:24:08,789 --> 00:24:13,409

So many of them are just the collapse of the roof, and so then you have to be able to get

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00:24:13,409 --> 00:24:14,570

down to them.

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00:24:14,570 --> 00:24:17,720

Now, scientifically these are incredibly exciting.

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00:24:17,720 --> 00:24:21,340

And they are because you see the stratigraphy.

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00:24:21,340 --> 00:24:29,710

As you can go down the sides, you can see the layers that we can't get into from surface

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00:24:29,710 --> 00:24:30,980

missions.

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00:24:30,980 --> 00:24:36,970

And those layers are -- you know, that's the geological book of the moon: how old they

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00:24:36,970 --> 00:24:43,850

are and what are they made of and how they evolved on an airless body over 4 billion

474

00:24:43,850 --> 00:24:44,850

years.

475

00:24:44,850 --> 00:24:50,600

And then when you get into the bottom part of that, we don't know what the cave structure

476

00:24:50,600 --> 00:24:55,110

or cavern structure or lava-tube structure really looks like.

477

00:24:55,110 --> 00:25:00,419

We don't know how far it goes or where it goes, but it's a different environment because

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00:25:00,419 --> 00:25:03,450

it's been sheltered all this time.

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00:25:03,450 --> 00:25:05,539

We don't know what we're going to find in there.

480

00:25:05,539 --> 00:25:06,539

Host: Nice.

481

00:25:06,539 --> 00:25:07,780

Is that exciting?

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00:25:07,780 --> 00:25:08,780

Yeah, well --

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00:25:08,780 --> 00:25:09,780

Male Voice: Folks, we have Reiner Gamma, one of the swirls.

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00:25:09,780 --> 00:25:10,780

Greg Schmidt: Oh, yes.

485

00:25:10,780 --> 00:25:11,780

Host: Oh, wonderful.

486

00:25:11,780 --> 00:25:12,780

Yeah, let's take a look at that.

487

00:25:12,780 --> 00:25:20,610

Jim Green: So another site, another one of the sites that are really exciting that could

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00:25:20,610 --> 00:25:26,989

be considered for human exploration, are locations on the moon where the remnant magnetic field

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00:25:26,989 --> 00:25:32,690

. . . That means the field . . . The magnetosphere of the moon, which it must have had early

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00:25:32,690 --> 00:25:35,490

on in its life, has gone away.

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00:25:35,490 --> 00:25:37,049

The core is now solid.

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00:25:37,049 --> 00:25:38,270

It's probably not liquid.

493

00:25:38,270 --> 00:25:42,190

It's not circulating to generate a magnetic field.

494

00:25:42,190 --> 00:25:48,159

And so the rocks that were molten at the time,  
as they solidify they take that field.

495

00:25:48,159 --> 00:25:52,659

They take ownership of that field, and then  
the background field goes away.

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00:25:52,659 --> 00:25:56,740

And here's an area, these are called swirls.

497

00:25:56,740 --> 00:25:59,200

This is really huge.

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00:25:59,200 --> 00:26:07,499

The central feature off to the left, that's  
probably 150 kilometers in size.

499

00:26:07,499 --> 00:26:15,039

And then you have what looks like a snaky  
feature off to the right.

500

00:26:15,039 --> 00:26:18,700

That's also trapped magnetic-field material.

501

00:26:18,700 --> 00:26:24,019

And we now know, based on our knowledge of  
our earth's magnetosphere, how the magnetic

502

00:26:24,019 --> 00:26:27,539

field of our earth has protected us over time.

503

00:26:27,539 --> 00:26:30,899

And so we want to be able to drive into these  
areas.

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00:26:30,899 --> 00:26:36,220

We want to be able to see how that magnetic

field interacts with the solar wind, what

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00:26:36,220 --> 00:26:42,030

happens when coronal mass ejections hammer the moon and hits a swirl like that, and how

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00:26:42,030 --> 00:26:44,590

we could be protected because of that field.

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00:26:44,590 --> 00:26:49,130

Now, that field has to be intense for us to be able to make a measurement of it.

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00:26:49,130 --> 00:26:50,130

Greg Schmidt: That's right.

509

00:26:50,130 --> 00:26:51,159

Jim Green: But we could measure it from orbit.

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00:26:51,159 --> 00:26:53,809

Well, geez, that's fantastic.

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00:26:53,809 --> 00:27:01,809

So as you can see, the discoloration on the surface -- as you see the light and dark areas

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00:27:01,809 --> 00:27:03,350

-- this whole area is just flat.

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00:27:03,350 --> 00:27:10,090

And the difference is how the regolith is organized or how it has been exposed to the

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00:27:10,090 --> 00:27:13,679

solar wind and changes in it over time.

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00:27:13,679 --> 00:27:17,549

And so all that stuff is really fascinating.

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00:27:17,549 --> 00:27:23,350

It enables us to look at how the solar wind has impinged itself in the moon and locked

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00:27:23,350 --> 00:27:28,549

into the moon in certain regions but has not done so in these swirls.

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00:27:28,549 --> 00:27:29,559

That's why they're all white.

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00:27:29,559 --> 00:27:30,559

Abby Tabor: Yeah.

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00:27:30,559 --> 00:27:31,759

Jim Green: But that whole area is just flat as a pancake.

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00:27:31,759 --> 00:27:33,350

Abby Tabor: It's good you say that because I thought it was ridges.

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00:27:33,350 --> 00:27:34,350

Jim Green: Right.

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00:27:34,350 --> 00:27:35,350

You think it's ridges, but it's not.

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00:27:35,350 --> 00:27:36,350

Greg Schmidt: Yeah.

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00:27:36,350 --> 00:27:37,350

Yeah.

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00:27:37,350 --> 00:27:38,350

It looks that way, yeah.

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00:27:38,350 --> 00:27:39,350

Jim Green: It's just a discoloration of the surface.

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00:27:39,350 --> 00:27:40,350

Abby Tabor: Huh.

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00:27:40,350 --> 00:27:43,779

Greg Schmidt: And there's a lot of disagreement now on some pretty fundamental aspects of

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00:27:43,779 --> 00:27:46,990

it: What are the details of the magnetic field?

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00:27:46,990 --> 00:27:50,940

The material that you see that's light -- is that fresh material?

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00:27:50,940 --> 00:27:52,389

Some people think it is.

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00:27:52,389 --> 00:27:57,169

One of the foremost scientists that works with our institute, actually -- Carle Peters

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00:27:57,169 --> 00:28:02,499

at Brown University today -- said she doesn't think so.

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00:28:02,499 --> 00:28:06,960

And quite honestly, I love it when science is like that, when there's a lot of disagreement,

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00:28:06,960 --> 00:28:09,679

because that means that we're going to find new things.

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00:28:09,679 --> 00:28:12,929

And that means that we send a mission there to find it.

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00:28:12,929 --> 00:28:14,730

Jim Green: Well, and it won't be just any old mission.

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00:28:14,730 --> 00:28:18,509

It's got to be something that can translate across that and make measurements.

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00:28:18,509 --> 00:28:19,509

Greg Schmidt: Yep.

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00:28:19,509 --> 00:28:21,380

Jim Green: And so that would be a rover.

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00:28:21,380 --> 00:28:22,380

Greg Schmidt: Yeah.

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00:28:22,380 --> 00:28:27,139

Jim Green: So as the commercial groups are planning to land on the moon and look around

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00:28:27,139 --> 00:28:32,690

and have resources -- some will be landers and some will be rovers -- we want to be able

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00:28:32,690 --> 00:28:37,369

to say: "Hey, these are sites that if you go there, we want to go with you.

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00:28:37,369 --> 00:28:40,070

We want to participate in that grand adventure."

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00:28:40,070 --> 00:28:45,309

We want to be able to make measurements that not only are important to them but revolutionize

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00:28:45,309 --> 00:28:49,110

our science and our understanding of our closest neighbor, the moon.

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00:28:49,110 --> 00:28:50,110

Greg Schmidt: Yep.

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00:28:50,110 --> 00:28:53,960

Host: So to pivot over to the chat because they were right: It has been blowing up.

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00:28:53,960 --> 00:28:58,429

We've been saving as many questions as we possibly can.

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00:28:58,429 --> 00:29:04,379

A while back we had V1K1337, [who] said: "If you read this message out loud, I will be

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00:29:04,379 --> 00:29:05,960

so happy."

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00:29:05,960 --> 00:29:06,990

So there you go.

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00:29:06,990 --> 00:29:08,179

[General applause]

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00:29:08,179 --> 00:29:10,499

Host: And then not only that.

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00:29:10,499 --> 00:29:11,950

Jim, you were getting some love from S4D.

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00:29:11,950 --> 00:29:14,169

[Panda Ah] says: "I love Jim, man."

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00:29:14,169 --> 00:29:15,169

We all do.

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00:29:15,169 --> 00:29:18,179

Jim Green: Thank you very much.

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00:29:18,179 --> 00:29:22,909

Host: But I want to go to [Lucciador 90],  
who is asking: "Would the moon be a good place

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00:29:22,909 --> 00:29:25,580

for a telescope since there's no atmospheric  
distortion?"

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00:29:25,580 --> 00:29:26,580

Greg Schmidt: Oh.

564

00:29:26,580 --> 00:29:27,580

Yeah, yeah.

565

00:29:27,580 --> 00:29:30,320

Well, I'd like to talk a little bit about  
that.

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00:29:30,320 --> 00:29:38,090

So one of our investigators, one of our scientists  
at my institute is Jack Burns at University

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00:29:38,090 --> 00:29:39,090

of Colorado.

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00:29:39,090 --> 00:29:40,240

He wants to do just that.

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00:29:40,240 --> 00:29:44,620

But the kind of telescope that he wants to  
put up there is a little bit different than

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00:29:44,620 --> 00:29:47,990

what most people might be thinking of.

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00:29:47,990 --> 00:29:54,559

He wants to put a series of di-pole radio

antennas.

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00:29:54,559 --> 00:29:57,080

And so you might think: "Well, why the heck do you want to do that?"

573

00:29:57,080 --> 00:29:59,639

Why don't you just do that here?"

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00:29:59,639 --> 00:30:04,649

The problem is we all have our devices and all sorts of --

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00:30:04,649 --> 00:30:05,749

Jim Green: Phones.

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00:30:05,749 --> 00:30:11,590

Greg Schmidt: -- phones, you name it, that are completely contaminating the electromagnetic

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00:30:11,590 --> 00:30:15,390

spectrum and the radio region.

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00:30:15,390 --> 00:30:24,630

And it turns out that the far side of the moon, since it's always opposed to Earth,

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00:30:24,630 --> 00:30:30,999

is one of the most radio-quiet areas in the Solar System -- the quietest in the inner

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00:30:30,999 --> 00:30:31,999

Solar System.

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00:30:31,999 --> 00:30:32,999

Abby Tabor: Wow.

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00:30:32,999 --> 00:30:37,950

Greg Schmidt: And the thing is, okay, then

you think: Well, what's so interesting about

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00:30:37,950 --> 00:30:39,850

this frequency range?

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00:30:39,850 --> 00:30:48,080

As it turns out, you can hear echoes of the formation of the first stars by putting telescopes.

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00:30:48,080 --> 00:30:49,100

This is what we think.

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00:30:49,100 --> 00:30:54,539

We've never done it before, but it's quiet enough that we think we're going to be able

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00:30:54,539 --> 00:30:56,260

to observe that.

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00:30:56,260 --> 00:30:59,409

And this is what Jack and what we want to enable.

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00:30:59,409 --> 00:31:00,409

Host: So --

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00:31:00,409 --> 00:31:01,409

Jim Green: And sci-- oh, I'm sorry.

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00:31:01,409 --> 00:31:02,409

Host: Oh.

592

00:31:02,409 --> 00:31:03,409

No, no, no.

593

00:31:03,409 --> 00:31:04,409

Go ahead, go ahead, go ahead.

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00:31:04,409 --> 00:31:08,519

Jim Green: Scientists look at various parts of the electromagnetic spectrum and, from

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00:31:08,519 --> 00:31:15,490

that, we make all kinds of new and neat discoveries and look at the universe in new ways.

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00:31:15,490 --> 00:31:20,259

Our atmosphere has prevented us from doing a lot of that, and that's why our spacecraft

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00:31:20,259 --> 00:31:21,259

are so valuable.

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00:31:21,259 --> 00:31:27,970

That puts our eyes above the atmosphere which then prevents these wavelengths from making

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00:31:27,970 --> 00:31:28,970

it to the ground.

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00:31:28,970 --> 00:31:35,020

And the radio area is just like any other part of the electromagnetic spectrum.

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00:31:35,020 --> 00:31:40,429

If there's a region we haven't been able to look at and explore, that's the new frontier.

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00:31:40,429 --> 00:31:41,429

Host: Nice.

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00:31:41,429 --> 00:31:42,429

Abby Tabor: Wow.

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00:31:42,429 --> 00:31:48,620

Jim Green: And in the 20-megahertz to couple-hundred-megahertz range, even though those radio waves do make

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00:31:48,620 --> 00:31:52,620

it down to the ground because of the radio interference that we have today, we have to

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00:31:52,620 --> 00:31:54,570

go someplace else.

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00:31:54,570 --> 00:32:00,499

And the far side of the moon is a great opportunity to be able to put something there and explore

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00:32:00,499 --> 00:32:03,230

a brand-new region of the electromagnetic spectrum.

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00:32:03,230 --> 00:32:05,159

Host: So we had a question a while back.

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00:32:05,159 --> 00:32:09,860

And then somebody, this is VT Whiplash, asked: "How bad is the latency from the moon to the

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00:32:09,860 --> 00:32:10,860

earth?"

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00:32:10,860 --> 00:32:12,640

But then there was another question that scrolled through too quickly.

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00:32:12,640 --> 00:32:17,249

I did not see the name on it, but they were like: "If you did a Twitch stream from the

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00:32:17,249 --> 00:32:20,929

moon to the earth, how bad would that latency be?"

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00:32:20,929 --> 00:32:21,929

So . . . ?

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00:32:21,929 --> 00:32:23,701

Greg Schmidt: So round-trip time is about three seconds or so.

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00:32:23,701 --> 00:32:24,701

Host: So not that bad.

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00:32:24,701 --> 00:32:25,701

Greg Schmidt: Yeah.

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00:32:25,701 --> 00:32:26,701

Host: It could be worse.

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00:32:26,701 --> 00:32:32,360

Greg Schmidt: So when President Nixon talked with Neil Armstrong and Buzz Aldrin, when

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00:32:32,360 --> 00:32:37,299

he said "Hello," it took a second and a half or thereabouts, a little bit less, to get

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00:32:37,299 --> 00:32:38,299

there.

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00:32:38,299 --> 00:32:43,090

Then even if they responded right away, right back, it would take another second and a half

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00:32:43,090 --> 00:32:44,090

to get back.

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00:32:44,090 --> 00:32:46,679

And so round trip it's at three seconds, yeah.

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00:32:46,679 --> 00:32:51,289

Abby Tabor: Okay, so a Twitch stream from the moon sounds entirely do-able.

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00:32:51,289 --> 00:32:53,000

Greg Schmidt: Yeah, yeah.

628

00:32:53,000 --> 00:32:56,590

But controlling a robot or something like that, maybe not so much.

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00:32:56,590 --> 00:32:57,590

Abby Tabor: Yeah.

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00:32:57,590 --> 00:32:58,590

Is that a big challenge?

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00:32:58,590 --> 00:33:00,320

Greg Schmidt: Yeah, it is a big challenge.

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00:33:00,320 --> 00:33:05,340

At my institute a few years back, we had hosted a centennial challenge.

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00:33:05,340 --> 00:33:11,660

It was called the Lunar Regolith Excavation Challenge, and we got eight tons of regolith

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00:33:11,660 --> 00:33:15,490

stimulant in what we finally called the Dirt Box.

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00:33:15,490 --> 00:33:16,490

Host: Nice.

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00:33:16,490 --> 00:33:20,960

Greg Schmidt: And various teams, most of them college teams, got to make robots.

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00:33:20,960 --> 00:33:21,960

Abby Tabor: Cool.

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00:33:21,960 --> 00:33:25,820

Greg Schmidt: And they couldn't be . . . The operators couldn't be right there with the

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00:33:25,820 --> 00:33:26,820

robots.

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00:33:26,820 --> 00:33:28,730

They had to be in another room.

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00:33:28,730 --> 00:33:33,289

And what they did is they actually put that same latency in, that three-second round-trip

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00:33:33,289 --> 00:33:34,289

latency.

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00:33:34,289 --> 00:33:35,289

Abby Tabor: Yeah, it would be realistic.

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00:33:35,289 --> 00:33:36,289

Greg Schmidt: Yeah, yeah.

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00:33:36,289 --> 00:33:37,289

Uh-huh.

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00:33:37,289 --> 00:33:40,759

And so they had to develop systems that would take care of that.

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00:33:40,759 --> 00:33:42,090

But you know what?

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00:33:42,090 --> 00:33:43,090

They figured it out.

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00:33:43,090 --> 00:33:44,779

Host: In fact, they're still using that [bed].

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00:33:44,779 --> 00:33:48,259

And so that's a shout-out for people if they go to [facebook.com/nasaames](https://facebook.com/nasaames).

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00:33:48,259 --> 00:33:49,730

Greg Schmidt: Yeah.

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00:33:49,730 --> 00:33:53,940

Host: We did a Facebook Live a while back where they're using this now for experiments

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00:33:53,940 --> 00:33:59,230

of the light: how the whites are super-bright and the darks are super-dark and [how] that

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00:33:59,230 --> 00:34:00,770

means for autonomy and rovers.

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00:34:00,770 --> 00:34:01,770

Greg Schmidt: Yeah.

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00:34:01,770 --> 00:34:02,770

Yeah.

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00:34:02,770 --> 00:34:06,679

Host: So if anybody wants to go dig through, that was a couple months ago, people can go

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00:34:06,679 --> 00:34:11,260

through and get a firsthand -- well, secondhand they can see people talking about it.

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00:34:11,260 --> 00:34:12,260

Abby Tabor: No, that was awesome.

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00:34:12,260 --> 00:34:13,260

That was -- sorry.

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00:34:13,260 --> 00:34:16,980

Greg Schmidt: Well, we were interested in that because the lighting is like polar lighting.

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00:34:16,980 --> 00:34:17,980

Jim Green: Yeah.

663

00:34:17,980 --> 00:34:21,079

Greg Schmidt: And the poles are super-interesting in terms of the moon.

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00:34:21,079 --> 00:34:25,730

That's one of the places we really want to go because of the resources that are there.

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00:34:25,730 --> 00:34:28,409

We talked about water a little bit earlier.

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00:34:28,409 --> 00:34:33,470

You're not going to find it on the equator, where every day it would just evaporate.

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00:34:33,470 --> 00:34:39,040

There are these regions called permanently shadowed regions on the moon that haven't

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00:34:39,040 --> 00:34:42,220

seen sunlight for a billion years.

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00:34:42,220 --> 00:34:47,230

Now, how water got there, there's a lot of debate about that.

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00:34:47,230 --> 00:34:48,230

Jim Green: Yeah.

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00:34:48,230 --> 00:34:53,210

Greg Schmidt: There's probably multiple processes, perhaps comets landing and things like that.

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00:34:53,210 --> 00:34:54,210

But nonetheless, we --

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00:34:54,210 --> 00:34:56,369

Jim Green: Of course, they didn't go like this.

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00:34:56,369 --> 00:34:57,369

They really impacted.

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00:34:57,369 --> 00:34:58,369

Greg Schmidt: That's right, that's right.

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00:34:58,369 --> 00:34:59,369

[Unintelligible].

677

00:34:59,369 --> 00:35:00,369

That's a good point, Jim.

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00:35:00,369 --> 00:35:01,560

This wasn't a soft landing.

679

00:35:01,560 --> 00:35:03,839

Jim Green: Yeah, it wasn't a soft landing.

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00:35:03,839 --> 00:35:08,000

And then that material, if it wasn't in the pole in the beginning, actually migrates --

681

00:35:08,000 --> 00:35:09,000

Greg Schmidt: That's right.

682

00:35:09,000 --> 00:35:10,819

Jim Green: -- because it's a cold area, a very cold area.

683

00:35:10,819 --> 00:35:11,819

It's called a cold trap.

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00:35:11,819 --> 00:35:12,819

Greg Schmidt: Yeah.

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00:35:12,819 --> 00:35:13,819

Yeah.

686

00:35:13,819 --> 00:35:16,700

Jim Green: And so indeed, that sort of attracts that stuff after the impact.

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00:35:16,700 --> 00:35:17,700

Greg Schmidt: It does.

688

00:35:17,700 --> 00:35:18,700

It does.

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00:35:18,700 --> 00:35:19,700

Abby Tabor: What is it that migrates?

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00:35:19,700 --> 00:35:20,700

What migrates?

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00:35:20,700 --> 00:35:21,700

Greg Schmidt: The water.

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00:35:21,700 --> 00:35:22,700

Abby Tabor: The water does?

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00:35:22,700 --> 00:35:23,700

Jim Green: Water.

694

00:35:23,700 --> 00:35:24,700

Water will migrate.

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00:35:24,700 --> 00:35:25,700

Greg Schmidt: Yeah.

696  
00:35:25,700 --> 00:35:26,700  
Yeah.

697  
00:35:26,700 --> 00:35:27,700  
Uh-huh.

698  
00:35:27,700 --> 00:35:28,700  
Abby Tabor: Huh.

699  
00:35:28,700 --> 00:35:29,700  
Greg Schmidt: That's right.

700  
00:35:29,700 --> 00:35:30,700  
It evaporates, and then it goes down when  
it's cold.

701  
00:35:30,700 --> 00:35:33,339  
And once it goes down in one of these permanently  
shadowed regions, that's where it stays for

702  
00:35:33,339 --> 00:35:34,380  
a billion years.

703  
00:35:34,380 --> 00:35:35,410  
Abby Tabor: That's incredible.

704  
00:35:35,410 --> 00:35:40,630  
Host: And so -- well, we showed it up on the  
screen, what Brian is working on.

705  
00:35:40,630 --> 00:35:42,079  
We can go to the cloud cam.

706  
00:35:42,079 --> 00:35:47,421  
And so folks, I can introduce Brian Day, the  
guy . . . Oh, we'll go to the cloud cam, the

707  
00:35:47,421 --> 00:35:48,421

other one.

708

00:35:48,421 --> 00:35:50,100

There we go.

709

00:35:50,100 --> 00:35:51,931

Oh no, not that one.

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00:35:51,931 --> 00:35:52,931

Abby Tabor: There he is.

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00:35:52,931 --> 00:35:53,931

Host: Hey!

712

00:35:53,931 --> 00:35:54,931

The best beard in Silicon Valley.

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00:35:54,931 --> 00:36:00,059

So folks, if you want more on Brian Day, we have a podcast that we did with him a couple

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00:36:00,059 --> 00:36:01,059

months back.

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00:36:01,059 --> 00:36:02,059

So you can look at that.

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00:36:02,059 --> 00:36:05,410

But he's been showing a program called Moon Trek.

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00:36:05,410 --> 00:36:11,640

You can literally type into Google or the search engine of your choice "Moon Trek NASA,"

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00:36:11,640 --> 00:36:14,040

and you'll find exactly what Brian is looking at.

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00:36:14,040 --> 00:36:17,210

But Greg, hey, do you just want to talk a little bit about what Moon Trek is, how that

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00:36:17,210 --> 00:36:18,210

came about?

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00:36:18,210 --> 00:36:21,220

And then you wanted to show us some stuff, some of the landing sites.

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00:36:21,220 --> 00:36:23,040

Jim Green: Sure.

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00:36:23,040 --> 00:36:24,260

Sure, indeed.

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00:36:24,260 --> 00:36:30,161

Many years ago, as we were contemplating leaving lower-earth orbit, moving out into the Solar

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00:36:30,161 --> 00:36:35,020

System -- and the moon was a potential target, of course, and we're still hanging onto that

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00:36:35,020 --> 00:36:42,980

idea as we move out -- we realized that our data sets -- and we've been launching spacecraft

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00:36:42,980 --> 00:36:51,230

and orbiting the moon and even some of the old lunar-mapping missions that the Apollo

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00:36:51,230 --> 00:36:56,670

era used -- that data is becoming now more available to us because we're digitizing it

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00:36:56,670 --> 00:37:00,680

and putting it into these kind of frameworks.

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00:37:00,680 --> 00:37:07,450

We decided we needed to be able to bring this data together, co-register it such that it's

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00:37:07,450 --> 00:37:15,190

all connected to the right coordinate system, and then allow us to peer at the moon in different

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00:37:15,190 --> 00:37:20,040

wavelengths and in different temperatures and, really, in different altitudes.

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00:37:20,040 --> 00:37:22,521

You can see the variation in heights.

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00:37:22,521 --> 00:37:28,750

And that tells us all kinds of things about the structures, a little bit about how they're

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00:37:28,750 --> 00:37:35,660

put together and what they're made of, and then of course looking for safe landing spots.

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00:37:35,660 --> 00:37:41,310

So that particular system we've been working on for quite a few years, and we made the

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00:37:41,310 --> 00:37:47,940

decision early on that we were going to make it network-accessible so that not only can

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00:37:47,940 --> 00:37:53,460

any scientist get access to it or any of the other space agencies that are looking for

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00:37:53,460 --> 00:37:56,210

how to use LRO data to be able to land.

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00:37:56,210 --> 00:37:58,653

But also everybody in the public can take a look at it.

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00:37:58,653 --> 00:38:01,950

Host: Even video-game companies can grab this and use real data.

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00:38:01,950 --> 00:38:02,950

Jim Green: Yeah.

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00:38:02,950 --> 00:38:03,950

Right, absolutely.

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00:38:03,950 --> 00:38:05,510

Greg Schmidt: And anyone who's watching this right now, actually, yeah.

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00:38:05,510 --> 00:38:08,450

Abby Tabor: We could just go bring it up and look at it [on a phone]?

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00:38:08,450 --> 00:38:09,450

Greg Schmidt: Yeah.

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00:38:09,450 --> 00:38:10,450

Oh, absolutely.

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00:38:10,450 --> 00:38:11,450

Yeah, yeah.

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00:38:11,450 --> 00:38:12,450

Abby Tabor: Awesome.

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00:38:12,450 --> 00:38:17,390

Jim Green: Well, we did see that [Flash Stop] was a fabulous cratered system in the southern

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00:38:17,390 --> 00:38:21,710

hemisphere, and you can tell by . . . Now  
this is a different view.

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00:38:21,710 --> 00:38:24,460

Male Voice: [Where do you want it]?

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00:38:24,460 --> 00:38:25,640

Jim Green: Oh.

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00:38:25,640 --> 00:38:26,640

Oh, oh.

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00:38:26,640 --> 00:38:31,309

Let's go to . . . We can go to Schrödinger,  
or you can go to --

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00:38:31,309 --> 00:38:32,420

Greg Schmidt: Yeah.

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00:38:32,420 --> 00:38:33,900

Schrödinger, or Tycho maybe.

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00:38:33,900 --> 00:38:37,410

Jim Green: Well, Tycho is not quite in the  
polar region.

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00:38:37,410 --> 00:38:38,410

Greg Schmidt: No, no.

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00:38:38,410 --> 00:38:39,410

Uh-uh.

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00:38:39,410 --> 00:38:40,410

Abby Tabor: No, of course not.

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00:38:40,410 --> 00:38:41,410

Of course not.

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00:38:41,410 --> 00:38:42,410  
Host: Who wants to go to Tycho?

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00:38:42,410 --> 00:38:43,410  
Greg Schmidt: Oh.

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00:38:43,410 --> 00:38:44,589  
Well, Tycho, yeah.

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00:38:44,589 --> 00:38:46,500  
[Crosstalk] the central peak.

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00:38:46,500 --> 00:38:49,460  
Jim Green: This is Tycho Brahe.

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00:38:49,460 --> 00:38:55,460  
So this is a shout-out to what he has done  
for us, as we talked a little bit about.

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00:38:55,460 --> 00:38:58,109  
Host: Brian will give us a shout-out when  
he's ready to go.

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00:38:58,109 --> 00:38:59,579  
Abby Tabor: Yeah.

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00:38:59,579 --> 00:39:03,550  
Jim Green: But those regions are just really  
exciting.

772  
00:39:03,550 --> 00:39:05,099  
But they're challenging.

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00:39:05,099 --> 00:39:09,030  
Not only [are they] on the moon, but it's  
dark there.

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00:39:09,030 --> 00:39:12,300  
And so if we've got a spacecraft that moves

in there that wants to make measurements,

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00:39:12,300 --> 00:39:15,530

we're going to have to either bring our own  
light or it's going to have to feel its way

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00:39:15,530 --> 00:39:16,530

along.

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00:39:16,530 --> 00:39:17,530

Greg Schmidt: Yeah, yeah.

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00:39:17,530 --> 00:39:18,810

That's right, that's right.

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00:39:18,810 --> 00:39:23,960

And having mechanical components work in the  
cold like that is not so easy, too, because

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00:39:23,960 --> 00:39:26,670

we're talking really, really cold here.

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00:39:26,670 --> 00:39:27,670

Jim Green: Right.

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00:39:27,670 --> 00:39:30,730

As I said, that becomes a cold trap.

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00:39:30,730 --> 00:39:37,140

The temperature is very low because it doesn't  
get heated because of the sun angle and such.

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00:39:37,140 --> 00:39:41,609

And so consequently, we expect accumulation  
of ices.

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00:39:41,609 --> 00:39:46,849

Now, if it's cometary material, it's more  
than just water.

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00:39:46,849 --> 00:39:58,650

It's ammonia and other kinds of ices and methane and things that were probably in the original

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00:39:58,650 --> 00:40:03,109

collapsing cloud that formed the comets.

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00:40:03,109 --> 00:40:10,349

And so if we want to look at pristine material that's 4.5 billion years, this actually might

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00:40:10,349 --> 00:40:11,690

be the place to go.

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00:40:11,690 --> 00:40:17,320

Host: So while Brian is pulling that up, on the chat we have No Way Get Real, who asks

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00:40:17,320 --> 00:40:19,780

. . . I've got to love the Twitch handles.

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00:40:19,780 --> 00:40:21,460

It's pretty awesome.

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00:40:21,460 --> 00:40:23,940

"Are there different types of weather on the moon?"

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00:40:23,940 --> 00:40:28,481

I'm thinking the answer is just straight up "No," but I think there's probably something

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00:40:28,481 --> 00:40:29,559

more interesting than that.

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00:40:29,559 --> 00:40:30,559

Jim Green: Yes, there is.

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00:40:30,559 --> 00:40:31,559

Host: All right.

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00:40:31,559 --> 00:40:32,559

Jim Green: All right.

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00:40:32,559 --> 00:40:33,559

Host: Let's do it.

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00:40:33,559 --> 00:40:37,450

Jim Green: So it's not like the weather you're used to.

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00:40:37,450 --> 00:40:44,170

But because it doesn't have the atmosphere we know and love, it actually is exposed to

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00:40:44,170 --> 00:40:47,710

the solar wind two-thirds of the time.

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00:40:47,710 --> 00:40:54,180

And the other third of the time, it's exposed to interactions between the earth and its

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00:40:54,180 --> 00:40:56,270

magnetosphere and the solar wind.

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00:40:56,270 --> 00:41:00,520

In other words, the moon crosses the earth's magnetotail.

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00:41:00,520 --> 00:41:06,740

Now, when that happens, it is indeed a different environment.

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00:41:06,740 --> 00:41:13,609

But when it's outside the earth's magnetotail and in the solar wind, then it gets hammered

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00:41:13,609 --> 00:41:16,680

with the normal things that come from the sun.

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00:41:16,680 --> 00:41:19,400

The sun constantly outgases.

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00:41:19,400 --> 00:41:24,559

It's just like it exhales everywhere, and we call that the solar wind.

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00:41:24,559 --> 00:41:29,390

And it loses matter when it does that, and that material moves out.

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00:41:29,390 --> 00:41:32,690

So there's a constant stream of that.

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00:41:32,690 --> 00:41:39,070

And then sometimes things happen with the sun's magnetic field that envelopes a whole

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00:41:39,070 --> 00:41:42,250

section of it, energizes it, and throws it out.

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00:41:42,250 --> 00:41:44,320

And we call that a coronal mass ejection.

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00:41:44,320 --> 00:41:49,020

And that can hammer the moon just as well as it hammers the earth.

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00:41:49,020 --> 00:41:56,310

And when it hammers the earth and interacts with our own magnetic field, it produces aurora.

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00:41:56,310 --> 00:42:03,910

When it hammers the moon, that solar wind

gets embedded right into the soils and changes

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00:42:03,910 --> 00:42:12,380

its composition, changes its mineralogy and makes it a different set of material.

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00:42:12,380 --> 00:42:20,170

And on the swirls, these areas that have the remnant magnetic field actually probably protect[s]

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00:42:20,170 --> 00:42:22,040

the surface of the sun from that.

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00:42:22,040 --> 00:42:26,119

And that's another reason why we want to go there: We want to see what the pristine early

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00:42:26,119 --> 00:42:32,569

solar regolith, the soils on the moon look like by going in those areas.

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00:42:32,569 --> 00:42:33,980

Abby Tabor: There's so much going on on the moon.

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00:42:33,980 --> 00:42:35,640

Jim Green: There's a lot going on.

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00:42:35,640 --> 00:42:36,880

It's a cool --

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00:42:36,880 --> 00:42:38,119

Clive: [Crosstalk] Schrödinger.

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00:42:38,119 --> 00:42:39,789

Jim Green: Schrödinger has arrived.

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00:42:39,789 --> 00:42:40,789

Host: All right.

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00:42:40,789 --> 00:42:41,789

Well, there it is on our screen.

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00:42:41,789 --> 00:42:42,789

Abby Tabor: Yep.

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00:42:42,789 --> 00:42:43,789

Greg Schmidt: Yeah.

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00:42:43,789 --> 00:42:44,789

Host: All right.

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00:42:44,789 --> 00:42:45,789

Yeah, here we go.

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00:42:45,789 --> 00:42:46,789

Abby Tabor: Amazing.

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00:42:46,789 --> 00:42:47,789

Jim Green: Okay.

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00:42:47,789 --> 00:42:48,789

All right.

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00:42:48,789 --> 00:42:49,789

Host: Go on.

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00:42:49,789 --> 00:42:50,789

Abby Tabor: Tell us.

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00:42:50,789 --> 00:42:51,789

Host: Pray, tell.

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00:42:51,789 --> 00:42:56,190

Jim Green: Yeah, so this is just an absolutely spectacular crater.

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00:42:56,190 --> 00:43:02,490

You actually can see several features about it that you have to think about.

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00:43:02,490 --> 00:43:09,470

You see, normal smaller craters where there's an impact but no central peak, those typically

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00:43:09,470 --> 00:43:14,339

are maybe 5, 10 kilometers in size.

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00:43:14,339 --> 00:43:19,260

And then if you look real hard, you might see a crater that's bigger, that actually

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00:43:19,260 --> 00:43:21,319

has a central peak.

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00:43:21,319 --> 00:43:31,049

And then the new idea here is this crater is so enormous that it actually has two rims.

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00:43:31,049 --> 00:43:34,010

And so this is a tremendous impact.

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00:43:34,010 --> 00:43:39,410

Clive, correct me if I'm not right: This actually is one of the younger impacts at this size.

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00:43:39,410 --> 00:43:42,280

Clive: It's actually one of the older ones.

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00:43:42,280 --> 00:43:43,280

[Crosstalk] older ones.

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00:43:43,280 --> 00:43:44,280

Jim Green: All right, older ones.

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00:43:44,280 --> 00:43:45,280

Thank you.

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00:43:45,280 --> 00:43:46,280

Yeah, it's one of the older ones.

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00:43:46,280 --> 00:43:52,020

And so we want to get in it and we want to bring back material and age-date it and really

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00:43:52,020 --> 00:43:57,430

understand how old these structures are.

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00:43:57,430 --> 00:44:01,079

We also want to go to some of the newer craters and younger craters and examine those.

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00:44:01,079 --> 00:44:11,720

You can also see on the surface these features where there are gullies or look like gullies.

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00:44:11,720 --> 00:44:14,160

This crater is actually filled in with basaltic material.

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00:44:14,160 --> 00:44:22,579

That means that once you hit it, the molten rock underneath inside the moon bubbled up

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00:44:22,579 --> 00:44:25,040

and then started to fill in the crater.

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00:44:25,040 --> 00:44:26,040

Abby Tabor: Like lava?

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00:44:26,040 --> 00:44:27,040

Greg Schmidt: That's right, like lava.

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00:44:27,040 --> 00:44:29,809

Jim Green: And that's different than the . . . Yeah, like lava.

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00:44:29,809 --> 00:44:35,850

And this is a different feature if it was hit on the far side of the moon.

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00:44:35,850 --> 00:44:41,730

We don't see a lot of these huge regions that are old lava fields.

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00:44:41,730 --> 00:44:51,240

And that's because, we believe, the tidally locking part of the moon where we only have

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00:44:51,240 --> 00:44:58,349

one face actually pulls gravitationally the moon to the point where magma is much more

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00:44:58,349 --> 00:45:02,400

likely to flow on the near side than it is the far side.

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00:45:02,400 --> 00:45:08,430

And so a lot of the craters on the far side don't have floors of magma that have come

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00:45:08,430 --> 00:45:09,430

up.

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00:45:09,430 --> 00:45:10,430

Greg Schmidt: Yeah.

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00:45:10,430 --> 00:45:13,140

Host: So here's a question that came real quick from A Strawberry 2: "Is there any potential

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00:45:13,140 --> 00:45:15,500

for life to exist anywhere on the moon?

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00:45:15,500 --> 00:45:20,549

I know it couldn't live on the surface, but  
is it possible that it could be buried underground

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00:45:20,549 --> 00:45:21,559

or in polar ice?"

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00:45:21,559 --> 00:45:22,940

Jim Green: Or in the caves.

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00:45:22,940 --> 00:45:24,430

There's life in caves all over the place.

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00:45:24,430 --> 00:45:25,430

Host: In caves.

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00:45:25,430 --> 00:45:26,430

You have all kinds of extreme environments.

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00:45:26,430 --> 00:45:28,660

Jim Green: Now, I'm not starting speculation  
in that area.

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00:45:28,660 --> 00:45:29,660

Greg Schmidt: Yeah, yeah.

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00:45:29,660 --> 00:45:30,660

So probably not.

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00:45:30,660 --> 00:45:31,660

Jim Green: Probably not.

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00:45:31,660 --> 00:45:32,660

Probably not.

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00:45:32,660 --> 00:45:33,660

Greg Schmidt: Yeah, yeah.

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00:45:33,660 --> 00:45:34,660

Host: Sorry, guys.

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00:45:34,660 --> 00:45:37,750

Greg Schmidt: The problem is: How would it have evolved?

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00:45:37,750 --> 00:45:43,730

On Earth a long time ago, there were some very favorable conditions for that.

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00:45:43,730 --> 00:45:46,480

We had an atmosphere.

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00:45:46,480 --> 00:45:48,579

We had liquid water.

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00:45:48,579 --> 00:45:50,670

We had all of the organic ingredients.

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00:45:50,670 --> 00:45:57,619

We had this kind of pea soup that could result in life.

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00:45:57,619 --> 00:46:05,839

Now, are there places that could result in life that are completely different?

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00:46:05,839 --> 00:46:11,859

Some have speculated that maybe life could exist in the lakes of Titan, for instance.

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00:46:11,859 --> 00:46:16,890

I'm not one of those believers myself, necessarily, but I suppose it's possible.

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00:46:16,890 --> 00:46:19,810

Jim Green: Now, there's better places in the Solar System.

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00:46:19,810 --> 00:46:20,810

Greg Schmidt: There are.

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00:46:20,810 --> 00:46:21,810

Host: There's more interesting places.

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00:46:21,810 --> 00:46:26,660

Jim Green: But when the moon formed early, it also had a lot of organic material -- it

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00:46:26,660 --> 00:46:27,950

had to -- on its surface.

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00:46:27,950 --> 00:46:33,799

And that organic material was also brought to it by other impacts.

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00:46:33,799 --> 00:46:40,380

The detractor for the moon is that it's small in comparison to the earth; therefore, its

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00:46:40,380 --> 00:46:44,289

gravity isn't very big; and therefore, it didn't hang onto that.

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00:46:44,289 --> 00:46:51,210

And then the sun just ate that away, with the energy of the sun breaking up the organic

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00:46:51,210 --> 00:46:55,180

material and the solar wind then stripping that away.

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00:46:55,180 --> 00:46:59,200

So that really makes it tough.

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00:46:59,200 --> 00:47:03,930

Clive: That's why the polar regions with the

polar ices, they may contain the building

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00:47:03,930 --> 00:47:05,200

blocks for life.

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00:47:05,200 --> 00:47:09,360

Host: And I'm going to say: Eric, can you hear Clive on there, or do we need him to

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00:47:09,360 --> 00:47:10,360

move closer to the mic?

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00:47:10,360 --> 00:47:11,500

Eric: I can hear him, actually.

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00:47:11,500 --> 00:47:12,500

Host: Oh, awesome.

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00:47:12,500 --> 00:47:13,500

Good.

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00:47:13,500 --> 00:47:17,430

I didn't want our poor audio listeners to be like: "I can't hear Clive."

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00:47:17,430 --> 00:47:18,430

You're good, man.

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00:47:18,430 --> 00:47:19,430

Go for it.

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00:47:19,430 --> 00:47:24,490

Clive: Those ices may contain the materials that came to Earth, but they've not evolved

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00:47:24,490 --> 00:47:25,490

because it's too cold.

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00:47:25,490 --> 00:47:33,210

And that material may be what led to what you see on the screen right now, which is

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00:47:33,210 --> 00:47:34,270

scary.

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00:47:34,270 --> 00:47:37,460

[General laughter, crosstalk]

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00:47:37,460 --> 00:47:43,640

Clive: But that's why we want to go there in terms of science: to see, okay, are there

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00:47:43,640 --> 00:47:46,400

the pre-biology molecules there?

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00:47:46,400 --> 00:47:47,579

Jim Green: What did we start out with?

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00:47:47,579 --> 00:47:49,330

Clive: What did we start as?

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00:47:49,330 --> 00:47:52,220

What were the [unintelligible] the moon important?

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00:47:52,220 --> 00:47:55,630

But then those same molecules can be used to support life up there now.

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00:47:55,630 --> 00:47:57,170

You can get water.

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00:47:57,170 --> 00:47:59,279

You can crack the water into hydrogen and oxygen.

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00:47:59,279 --> 00:48:00,900

You can breathe the oxygen.

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00:48:00,900 --> 00:48:04,329

You can put the hydrogen back into the process, get more water.

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00:48:04,329 --> 00:48:05,329

You can drink it.

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00:48:05,329 --> 00:48:07,710

You can crack it again, use hydrogen and oxygen as rocket fuel.

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00:48:07,710 --> 00:48:14,540

So there's a way that the moon becomes very important as a refueling depot for exploration

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00:48:14,540 --> 00:48:18,890

but very important for understanding why we're here and how things started.

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00:48:18,890 --> 00:48:22,280

Greg Schmidt: Well, a lot of people are interested in these questions.

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00:48:22,280 --> 00:48:29,819

We have laboratories here at NASA Ames where we are using very, very cold temperatures

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00:48:29,819 --> 00:48:37,960

with some very raw pre-organic material, exposing it to ultraviolet light just like it would

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00:48:37,960 --> 00:48:43,000

be exposed to in deep space, and seeing what happens.

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00:48:43,000 --> 00:48:47,650

And there have been people here, such as Lou Allamandola and others, that have been doing

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00:48:47,650 --> 00:48:48,690

this for years.

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00:48:48,690 --> 00:48:59,000

And they've found that some pretty complicated things called PAHs and other compounds form

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00:48:59,000 --> 00:49:01,400

in a deep-space environment.

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00:49:01,400 --> 00:49:10,589

And so the question of how life originates and exactly where it originates is by no means

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00:49:10,589 --> 00:49:11,670

settled.

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00:49:11,670 --> 00:49:14,210

It's still an active debate topic.

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00:49:14,210 --> 00:49:17,210

Abby Tabor: Those are the building blocks of life, right?

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00:49:17,210 --> 00:49:18,220

Greg Schmidt: The building blocks, right.

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00:49:18,220 --> 00:49:22,160

Abby Tabor: Whenever we talk about organics, I'm afraid people might understand live organic

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00:49:22,160 --> 00:49:23,160

material.

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00:49:23,160 --> 00:49:24,950

But you're talking about molecules that can come together and . . . ?

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00:49:24,950 --> 00:49:26,180

Greg Schmidt: That's right.

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00:49:26,180 --> 00:49:33,270

Yeah, organics in a scientist's point of view are molecules that are made from carbon, basically,

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00:49:33,270 --> 00:49:34,270

carbon and other atoms.

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00:49:34,270 --> 00:49:35,270

But yeah, that's right.

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00:49:35,270 --> 00:49:36,270

Abby Tabor: Right.

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00:49:36,270 --> 00:49:37,270

Greg Schmidt: Huh?

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00:49:37,270 --> 00:49:38,270

Yeah.

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00:49:38,270 --> 00:49:39,270

Abby Tabor: Okay, cool.

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00:49:39,270 --> 00:49:40,270

Host: So I'm going to try to get to some more questions.

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00:49:40,270 --> 00:49:41,270

This is from a while back.

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00:49:41,270 --> 00:49:44,299

[Isutinos 749]: "What are the plans for this year's missions?"

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00:49:44,299 --> 00:49:46,299

Jim Green: Okay, so --

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00:49:46,299 --> 00:49:49,140

Host: How about the guy who holds all the money?

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00:49:49,140 --> 00:49:51,000

Go for it.

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00:49:51,000 --> 00:49:53,489

Jim Green: No, no.

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00:49:53,489 --> 00:49:54,710

That would be the worst thing to do.

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00:49:54,710 --> 00:49:55,710

Greg Schmidt: He gives it away.

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00:49:55,710 --> 00:49:56,710

Jim Green: I get it out.

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00:49:56,710 --> 00:49:59,460

Clive: This is being recorded, right?

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00:49:59,460 --> 00:50:00,691

Jim Green: I know.

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00:50:00,691 --> 00:50:01,691

I get it out, I get it out.

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00:50:01,691 --> 00:50:02,691

Host: Go ahead.

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00:50:02,691 --> 00:50:06,560

Jim Green: Yeah, so we have just an absolutely spectacular planetary program.

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00:50:06,560 --> 00:50:10,390

It's unbelievable the kind of things that we're doing.

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00:50:10,390 --> 00:50:18,190

Right now we've got LRO, as I mentioned, orbiting the moon, making spectacular observations.

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00:50:18,190 --> 00:50:22,881

We move a little further out into the Solar System, you go to places like Mars, we have

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00:50:22,881 --> 00:50:27,180

a set of spacecraft that are orbiting Mars right now.

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00:50:27,180 --> 00:50:33,349

One, the Mars Reconnaissance Orbiter, also could see a table about this size if it sat

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00:50:33,349 --> 00:50:35,210

on the surface of Mars.

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00:50:35,210 --> 00:50:39,349

So we have some similar things going at the moon as we do Mars.

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00:50:39,349 --> 00:50:43,440

And then, of course, on Mars we have two active rovers.

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00:50:43,440 --> 00:50:47,640

One is called Opportunity, and the other is called Curiosity.

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00:50:47,640 --> 00:50:53,540

Curiosity is making its way up Mount Sharp, and right now it's at a layer where there

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00:50:53,540 --> 00:50:54,650

were clays.

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00:50:54,650 --> 00:50:59,609

Now, clays were formed in water.

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00:50:59,609 --> 00:51:05,760

So now we know that whole area was just filled with water for a fair length of time.

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00:51:05,760 --> 00:51:13,849

And clays might be the perfect place for organic molecules to connect and start building structures

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00:51:13,849 --> 00:51:17,760

that could be of importance to life.

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00:51:17,760 --> 00:51:20,380

So that's an important set of observations.

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00:51:20,380 --> 00:51:22,349

We're going to be starting to make those.

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00:51:22,349 --> 00:51:27,579

As we move further out, into the asteroid belt, we have a spectacular mission.

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00:51:27,579 --> 00:51:29,510

It's called Dawn.

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00:51:29,510 --> 00:51:32,220

And Dawn is now orbiting Ceres.

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00:51:32,220 --> 00:51:33,970

This year we're going to change its orbit.

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00:51:33,970 --> 00:51:35,980

It's going to be a highly elliptical orbit.

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00:51:35,980 --> 00:51:40,820

It's going to get really close to the surface and make high-resolution imaging of certain

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00:51:40,820 --> 00:51:47,930

regions so that we get a better idea as to what Ceres is like, particularly in the future

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00:51:47,930 --> 00:51:51,170

if we want to be able to land and study that.

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00:51:51,170 --> 00:51:54,210

Also an asteroid mission called OSIRIS-REx.

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00:51:54,210 --> 00:51:55,210

Host: Nice.

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00:51:55,210 --> 00:52:04,000

Jim Green: This time we are getting very close to an asteroid called Bennu, and Bennu is

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00:52:04,000 --> 00:52:06,070

a carbonaceous chondrite.

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00:52:06,070 --> 00:52:10,799

It's kind of ball-shaped.

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00:52:10,799 --> 00:52:14,780

It has a fat little belly or equatorial band associated with it.

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00:52:14,780 --> 00:52:15,780

Host: Carbonaceous chondrite.

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00:52:15,780 --> 00:52:16,780

Jim Green: Yes.

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00:52:16,780 --> 00:52:17,780

Abby Tabor: I was waiting for that.

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00:52:17,780 --> 00:52:18,780

Jim Green: "What does that mean?"

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00:52:18,780 --> 00:52:19,780

Yeah, okay."

1012

00:52:19,780 --> 00:52:20,780

Host: Let's go for that.

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00:52:20,780 --> 00:52:23,569

Jim Green: So it's full of carbon --

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00:52:23,569 --> 00:52:24,569

Host: Yeah, that's what I was thinking.

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00:52:24,569 --> 00:52:27,079

Jim Green: -- and is just a nation to its own.

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00:52:27,079 --> 00:52:30,339

So it's carbonaceous.

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00:52:30,339 --> 00:52:37,640

And what that's all about is, because it's so rich in carbon, we think it has amino acids.

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00:52:37,640 --> 00:52:39,920

We believe it has a fair amount of water.

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00:52:39,920 --> 00:52:47,849

It had the early, early collapsing cloud material that things like it bombarded the earth and

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00:52:47,849 --> 00:52:53,750

brought those things to our planet that we believe potentially started and helped start

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00:52:53,750 --> 00:52:54,750

life on it.

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00:52:54,750 --> 00:53:00,842

And by going to Bennu, this primitive asteroid, we're going back in time and we're going to

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00:53:00,842 --> 00:53:04,770

really examine it in a way that we've never done before.

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00:53:04,770 --> 00:53:09,450

That's going to get to Bennu starting in August.

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00:53:09,450 --> 00:53:15,840

So in the next several months, Bennu is going to get closer and closer in view to us as

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00:53:15,840 --> 00:53:21,250

OSIRIS-REx comes up to it, and it's just going to be a spectacular set of observations.

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00:53:21,250 --> 00:53:23,660

We're just really waiting for that.

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00:53:23,660 --> 00:53:29,950

So then, as we go further out in the Solar System, we ran out of [Huygens]-Cassini.

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00:53:29,950 --> 00:53:35,740

It was down to the final few breaths, and we did ditch it into Saturn this last year

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00:53:35,740 --> 00:53:37,920

in a spectacular event.

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00:53:37,920 --> 00:53:45,109

We didn't want it flying into any of the really fabulous bodies like Titan we talked a little

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00:53:45,109 --> 00:53:48,260

bit about, or Enceladus.

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00:53:48,260 --> 00:53:50,990

And so we have nothing at Saturn at the moment.

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00:53:50,990 --> 00:53:58,029

But then, as we move much further out, we have a spacecraft racing its way out of the

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00:53:58,029 --> 00:54:00,160

Solar System called New Horizons.

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00:54:00,160 --> 00:54:03,119

It did a fabulous fly-by of Pluto a couple years ago.

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00:54:03,119 --> 00:54:12,510

And on January 1st of next year, 2019, it's going to fly by a smaller object beyond Pluto.

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00:54:12,510 --> 00:54:14,330

It's called a Kuiper Belt object.

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00:54:14,330 --> 00:54:20,650

This is also debris left over from the collapsing cloud that we've just now discovered.

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00:54:20,650 --> 00:54:25,230

So in our lifetime, we actually found these pieces out there.

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00:54:25,230 --> 00:54:28,260

There's probably tens of thousands of them out there.

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00:54:28,260 --> 00:54:34,109

These are building blocks of objects that become Pluto-like objects, and there's quite

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00:54:34,109 --> 00:54:37,760

a few of those bigger objects like that out there.

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00:54:37,760 --> 00:54:40,960

And so we're really excited about that flying by.

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00:54:40,960 --> 00:54:43,880

In fact, we now know that it may not be just one object.

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00:54:43,880 --> 00:54:45,510

It might be as many as three.

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00:54:45,510 --> 00:54:46,569

Voices All: Oh, wow.

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00:54:46,569 --> 00:54:47,569

Yeah.

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00:54:47,569 --> 00:54:50,410

Jim Green: And so it's going to be really exciting as we fly by it.

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00:54:50,410 --> 00:54:53,079

So we have quite a few things going on this year.

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00:54:53,079 --> 00:54:56,569

And then in May, in particular, the start of a new mission.

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00:54:56,569 --> 00:54:59,440

I talked about those missions that are active right now.

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00:54:59,440 --> 00:55:05,710

Our next start of a mission is on May 5th with the launch of Insight, and Insight is

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00:55:05,710 --> 00:55:07,160

going to Mars.

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00:55:07,160 --> 00:55:13,560

It's a unique platform that allows us to put  
down on the surface several important types

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00:55:13,560 --> 00:55:22,490

of measurements, one of which is a seismic  
system that will then really give us knowledge

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00:55:22,490 --> 00:55:26,109

about how Mars quakes.

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00:55:26,109 --> 00:55:27,630

And we know it quakes.

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00:55:27,630 --> 00:55:31,980

We see avalanches from space from the Mars  
Reconnaissance Orbiter.

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00:55:31,980 --> 00:55:32,980

Abby Tabor: Really?

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00:55:32,980 --> 00:55:35,359

Jim Green: Yeah, we caught them in progress  
-- you know, sides of the mountain coming

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00:55:35,359 --> 00:55:36,359

down.

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00:55:36,359 --> 00:55:37,359

Wow.

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00:55:37,359 --> 00:55:38,359

Something is happening.

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00:55:38,359 --> 00:55:39,920

Something is shaking there.

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00:55:39,920 --> 00:55:43,599

And Mars gets hit, too, gets hit by asteroids.

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00:55:43,599 --> 00:55:45,550

That causes quakes, too.

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00:55:45,550 --> 00:55:49,690

So the seismic measurements will tell us about the structure of Mars.

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00:55:49,690 --> 00:55:50,810

And we want to do that at the moon.

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00:55:50,810 --> 00:55:51,810

Greg Schmidt: Yeah.

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00:55:51,810 --> 00:55:56,839

Jim Green: We want to be able to think about how we can land things on the moon to make

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00:55:56,839 --> 00:56:01,869

those kind of measurements, and then that helps us understand the structure of these

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00:56:01,869 --> 00:56:02,890

terrestrial bodies.

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00:56:02,890 --> 00:56:08,760

We know the structure of Earth well because we have seismic measurements here now and

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00:56:08,760 --> 00:56:10,250

have for decades.

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00:56:10,250 --> 00:56:14,690

We're starting it on Mars, and we want to start that on the moon, too.

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00:56:14,690 --> 00:56:16,920

So Insight, Cinco de Mayo.

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00:56:16,920 --> 00:56:17,920

Host: Nice.

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00:56:17,920 --> 00:56:20,550

Jim Green: May the 5th it's going up.

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00:56:20,550 --> 00:56:23,790

And it lands on Mars also this year, in November.

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00:56:23,790 --> 00:56:30,190

Greg Schmidt: Well, and then we've been to places like Mercury, a little bit longer ago

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00:56:30,190 --> 00:56:31,190

Venus.

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00:56:31,190 --> 00:56:32,190

Jim Green: Yeah.

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00:56:32,190 --> 00:56:33,190

Greg Schmidt: Yeah, so . . .

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00:56:33,190 --> 00:56:37,170

Jim Green: Well, the United States has been first to every one of the planets, even Pluto.

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00:56:37,170 --> 00:56:38,539

Host: U.S.A.

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00:56:38,539 --> 00:56:39,920

[General laughter]

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00:56:39,920 --> 00:56:43,390

Host: Well, I'm looking at the chat.

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00:56:43,390 --> 00:56:46,450

I have so many questions, there's no way we're going to get to it.

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00:56:46,450 --> 00:56:48,849

We're going to wrap up in a couple of minutes.

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00:56:48,849 --> 00:56:52,280

I was going to try to do it at 3:00, but do you want to do a rapid fire on a couple of

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00:56:52,280 --> 00:56:53,280

these?

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00:56:53,280 --> 00:56:54,280

Greg Schmidt: Sure.

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00:56:54,280 --> 00:56:55,280

Host: Short, pithy things?

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00:56:55,280 --> 00:56:56,280

Try to get as many people involved as possible?

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00:56:56,280 --> 00:56:57,280

Jim Green: Sure.

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00:56:57,280 --> 00:56:58,280

Greg Schmidt: Yeah, absolutely.

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00:56:58,280 --> 00:57:01,089

Host: All right, so let's go with [Navi XP]:

"How long until we can put humans on Mars?"

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00:57:01,089 --> 00:57:04,000

What are some of the hurdles to building a colony there?"

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00:57:04,000 --> 00:57:08,940

Jim Green: So short and pithy.

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00:57:08,940 --> 00:57:14,860

So in my opinion, it's going to happen.

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00:57:14,860 --> 00:57:17,540

There's some technology things we're working on.

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00:57:17,540 --> 00:57:21,039

We know what we have to do and how we have to do it.

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00:57:21,039 --> 00:57:23,059

And so I don't think there's any show stoppers.

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00:57:23,059 --> 00:57:25,049

It's really all about will.

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00:57:25,049 --> 00:57:30,950

It's really all about the American people deciding that we want to move in this direction.

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00:57:30,950 --> 00:57:33,079

We're working hard with our international partners.

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00:57:33,079 --> 00:57:36,740

We know it's going to be of international activity.

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00:57:36,740 --> 00:57:41,619

And as we do that, I think that will hasten the opportunity.

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00:57:41,619 --> 00:57:48,019

I would like to see that happen, having humans on Mars, in my lifetime.

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00:57:48,019 --> 00:57:49,319

It's certainly viable.

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00:57:49,319 --> 00:57:55,700

Host: Let's go to [Dazzle Adorn]: "Astronauts returning from the moon to Earth went through

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00:57:55,700 --> 00:57:59,359

decontamination to make sure they didn't bring back organisms.

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00:57:59,359 --> 00:58:03,960

Did they do the same procedures before going to the moon to avoid contaminating it?"

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00:58:03,960 --> 00:58:04,960

Abby Tabor: Hmm.

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00:58:04,960 --> 00:58:05,960

Good question.

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00:58:05,960 --> 00:58:06,960

Greg Schmidt: No.

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00:58:06,960 --> 00:58:07,960

No, not that I'm aware of.

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00:58:07,960 --> 00:58:08,960

Jim Green: They took every organism they could get.

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00:58:08,960 --> 00:58:09,960

Greg Schmidt: That's right, that's right.

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00:58:09,960 --> 00:58:12,369

It's pretty much impossible to do that.

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00:58:12,369 --> 00:58:13,369

Host: Wow.

1123

00:58:13,369 --> 00:58:15,720

Greg Schmidt: The thing is we are ecosystems.

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00:58:15,720 --> 00:58:16,720

Host: Microbiome.

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00:58:16,720 --> 00:58:25,151

Greg Schmidt: We have more mass of other stuff with us than we do human mass, and we have

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00:58:25,151 --> 00:58:28,279

a tremendous variety of organisms on us.

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00:58:28,279 --> 00:58:32,799

We're actually really just learning about things like the gut biome and how much it

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00:58:32,799 --> 00:58:33,799

--

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00:58:33,799 --> 00:58:34,799

Jim Green: We need that.

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00:58:34,799 --> 00:58:35,799

Greg Schmidt: We do.

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00:58:35,799 --> 00:58:36,799

We do.

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00:58:36,799 --> 00:58:37,799

Jim Green: Yeah, got to have it.

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00:58:37,799 --> 00:58:38,799

Greg Schmidt: It's incredibly important.

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00:58:38,799 --> 00:58:41,980

And so no, we will never be able to sterilize ourselves.

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00:58:41,980 --> 00:58:47,500

Clive: The later Apollo missions, the astronauts didn't go through that contamination because

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00:58:47,500 --> 00:58:49,380

they knew they weren't bringing anything back.

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00:58:49,380 --> 00:58:50,890

Greg Schmidt: That's right, yeah.

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00:58:50,890 --> 00:58:52,370

Jim Green: Right, right.

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00:58:52,370 --> 00:58:55,720

Host: So [Soreth Avera]: "Would water from Moon be drinkable?"

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00:58:55,720 --> 00:58:58,720

Jim Green: Yeah, H<sub>2</sub>O is H<sub>2</sub>O now.

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00:58:58,720 --> 00:58:59,720

Host: Nice.

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00:58:59,720 --> 00:59:05,640

Jim Green: But I would say this: We would anticipate that what we would get when we

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00:59:05,640 --> 00:59:11,480

go to a permanently shadowed region and grab that material is a variety of things, a mixture

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00:59:11,480 --> 00:59:12,480

of things.

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00:59:12,480 --> 00:59:14,339

It wouldn't necessarily just only be H<sub>2</sub>O.

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00:59:14,339 --> 00:59:15,339

Greg Schmidt: Right.

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00:59:15,339 --> 00:59:17,450

Jim Green: There would be other volatiles in it.

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00:59:17,450 --> 00:59:20,270

As we mentioned, it could be a methane.

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00:59:20,270 --> 00:59:23,720

There could even be, perhaps, some ammonia in it.

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00:59:23,720 --> 00:59:25,660

Those are the kind of things that we see in comets, too.

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00:59:25,660 --> 00:59:28,519

Host: So all right, we'll grab one more before we wrap it up.

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00:59:28,519 --> 00:59:32,910

This is [Preto\_Naquo].

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00:59:32,910 --> 00:59:34,730

I'm totally butchering this.

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00:59:34,730 --> 00:59:39,420

"Can we eventually . . . " And they put it in all caps because they really mean it.

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00:59:39,420 --> 00:59:42,619

"Can we eventually terraform the moon?"

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00:59:42,619 --> 00:59:45,089

Greg Schmidt: The moon.

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00:59:47,170 --> 00:59:46,130

Wow.

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00:59:47,170 --> 00:59:49,150

I know people have looked.

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00:59:49,150 --> 00:59:51,970

People have looked at terraforming Mars for a long time.

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00:59:51,970 --> 00:59:57,350

Chris McKay, one of the experts on that, is right here at NASA Ames.

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00:59:57,350 --> 01:00:02,289

The moon, I'm not sure if the gravitational field is strong enough, quite honestly.

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01:00:02,289 --> 01:00:09,150

What you need to do to be able to terraform an object is have a planet or a moon with

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01:00:09,150 --> 01:00:17,960

enough gravity to hold in atmosphere and then be able to eventually have liquid water exist.

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01:00:17,960 --> 01:00:21,910

And below a certain pressure, that's not going to happen.

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01:00:21,910 --> 01:00:26,020

And so could you do it by impacting enough comets?

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01:00:26,020 --> 01:00:27,020

I don't know.

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01:00:27,020 --> 01:00:28,660

Someone has probably done the calculations.

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01:00:28,660 --> 01:00:30,289

I don't know what they are.

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01:00:30,289 --> 01:00:31,289

Host: Cool.

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01:00:31,289 --> 01:00:34,590

Well, so as we get ready to wrap up, a couple of plugs.

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01:00:34,590 --> 01:00:35,769

We have Gravity Assist.

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01:00:35,769 --> 01:00:38,069

I'll have to give the shout.

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01:00:38,069 --> 01:00:42,079

It was Sarah Noble who you had on the moon episode, which is already up online.

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01:00:42,079 --> 01:00:43,079

Jim Green: Yes.

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01:00:43,079 --> 01:00:44,079

Yes.

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01:00:44,079 --> 01:00:45,079

Host: People can go ahead and listen to that.

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01:00:45,079 --> 01:00:46,150

Which one do you have coming up?

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01:00:46,150 --> 01:00:50,079

Jim Green: Now, every Wednesday we put out one.

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01:00:50,079 --> 01:00:54,950

I think this week we did Linda Spilker on Saturn.

1180  
01:00:54,950 --> 01:00:56,069  
So that's been posted.

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01:00:56,069 --> 01:00:59,710  
We've got a couple more to go in this season.

1182  
01:00:59,710 --> 01:01:01,829  
After that I'm going to talk to Amy Simon, who's . . .

1183  
01:01:01,829 --> 01:01:02,829  
Host: Nice.

1184  
01:01:02,829 --> 01:01:03,829  
[General crosstalk]

1185  
01:01:03,829 --> 01:01:05,650  
Host: I have a cheat sheet over here, and he's like: "I've got it."

1186  
01:01:05,650 --> 01:01:07,090  
Jim Green: Yeah, yeah.

1187  
01:01:07,090 --> 01:01:08,090  
Yeah, yeah.

1188  
01:01:08,090 --> 01:01:10,700  
And she's going to talk about Uranus and Neptune.

1189  
01:01:10,700 --> 01:01:14,839  
Those are really huge planets.

1190  
01:01:14,839 --> 01:01:19,980  
We think of them as gas planets, gas giants, but they're very different than Saturn and

1191

01:01:19,980 --> 01:01:22,750

Jupiter.

1192

01:01:22,750 --> 01:01:28,339

So that's been really intriguing, and she's been studying those her whole scientific career.

1193

01:01:28,339 --> 01:01:31,480

And then we'll end this season with Alan Stern.

1194

01:01:31,480 --> 01:01:37,849

We're going to talk about Pluto, which is probably one of the most exciting places in

1195

01:01:37,849 --> 01:01:38,930

the Solar System.

1196

01:01:38,930 --> 01:01:43,440

I think when we flew by it, I just was absolutely shocked.

1197

01:01:43,440 --> 01:01:45,430

Greg Schmidt: What a surprise for everyone.

1198

01:01:45,430 --> 01:01:46,730

Jim Green: Oh, yeah.

1199

01:01:46,730 --> 01:01:47,730

Oh, man.

1200

01:01:47,730 --> 01:01:51,900

That body is much smaller than the moon but has an atmosphere.

1201

01:01:51,900 --> 01:01:56,599

Now, we just got done talking about no atmosphere on the moon, nor will it ever have it, and

1202

01:01:56,599 --> 01:01:57,599

Pluto has got it.

1203

01:01:57,599 --> 01:01:58,599

Greg Schmidt: Yeah.

1204

01:01:58,599 --> 01:01:59,599

And it's geologically active, too.

1205

01:01:59,599 --> 01:02:01,569

Jim Green: And it's geologically active.

1206

01:02:01,569 --> 01:02:04,140

Greg Schmidt: No one expected that.

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01:02:04,140 --> 01:02:12,750

Jim Green: It's got these nitrogen glaciers that move like toothpaste scouring the surface

1208

01:02:12,750 --> 01:02:15,440

and creating this beautiful heart-looking region.

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01:02:15,440 --> 01:02:17,369

And it just blew my mind.

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01:02:17,369 --> 01:02:18,650

Host: Excellent.

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01:02:18,650 --> 01:02:24,710

So as I was saying -- well, I always talk about, when talking about Gravity Assist,

1212

01:02:24,710 --> 01:02:26,720

this is the NASA in Silicon Valley Podcast.

1213

01:02:26,720 --> 01:02:29,940

Well, technically this is NASA in Silicon Valley Live.

1214

01:02:29,940 --> 01:02:30,940

But we're a podcast.

1215

01:02:30,940 --> 01:02:33,410

We're not the only NASA podcast.

1216

01:02:33,410 --> 01:02:34,410

Gravity Assist.

1217

01:02:34,410 --> 01:02:38,089

Houston We Have a Podcast is one that's out of Johnson Space Center.

1218

01:02:38,089 --> 01:02:40,279

We work a lot with them.

1219

01:02:40,279 --> 01:02:44,509

There's a YouTube and audio version of This Week at NASA.

1220

01:02:44,509 --> 01:02:45,509

They're still going.

1221

01:02:45,509 --> 01:02:48,510

It's shorter, four- or five-minute little segments.

1222

01:02:48,510 --> 01:02:50,770

So a lot of content out there for people to grab.

1223

01:02:50,770 --> 01:02:53,400

This has been the NASA in Silicon Valley podcast.

1224

01:02:53,400 --> 01:02:56,010

Huge thanks to Jim Green and to Greg Schmidt for joining us.

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01:02:56,010 --> 01:02:57,010

Jim Green: My pleasure.

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01:02:57,010 --> 01:02:58,010

Greg Schmidt: And my pleasure.

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01:02:58,010 --> 01:02:59,010

Abby Tabor: Thanks, guys.

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01:02:59,010 --> 01:03:00,010

Greg Schmidt: Thank you, yeah.

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01:03:00,010 --> 01:03:01,010

Host: And I would be remiss to . . . We have Eric, who's in our audio studio.

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01:03:01,010 --> 01:03:05,760

We have him on the Voice Of God over there.

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01:03:05,780 --> 01:03:11,980

And if we go to the cloud cam, over on the far left we have Jesse and Dave.

1232

01:03:11,980 --> 01:03:18,470

And you can't see Dominic who's sitting over there, Clive and Brian sitting there.

1233

01:03:18,470 --> 01:03:19,470

So huge thanks, guys.

1234

01:03:19,470 --> 01:03:21,339

This has been way fun.

1235

01:03:21,339 --> 01:03:24,410

For folks who are listening or watching on demand, or if you're listening to this on

1236

01:03:24,410 --> 01:03:27,440

your audio, too bad you can't see everybody  
wave.

1237

01:03:27,440 --> 01:03:30,519

But trust us that they are.

1238

01:03:30,519 --> 01:03:33,859

If you're watching on demand, we're on all  
the major social-media platforms under NASA

1239

01:03:33,859 --> 01:03:34,859

Ames.

1240

01:03:34,859 --> 01:03:36,900

We are using the hashtag #NASAInSiliconValley.

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01:03:36,900 --> 01:03:40,500

And we've gone analog, so we have a phone  
number.

1242

01:03:40,500 --> 01:03:44,200

If you have any comments, questions, you can  
also call 650-604-1400.

1243

01:03:44,200 --> 01:03:45,200

Call.

1244

01:03:45,200 --> 01:03:52,079

We're not going to answer the phone, but leave  
a comment or a question and then we'll try

1245

01:03:52,079 --> 01:03:56,560

to figure out how we can wrap that into an  
episode.

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01:03:56,560 --> 01:03:59,210

Huge thanks to everybody who participated  
live and participated in the chat.

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01:03:59,210 --> 01:04:04,839

We're going to keep doing this, not next Friday but the Friday after that.

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01:04:04,839 --> 01:04:09,950

We're working on a fun show where we're talking the early days of VR development.

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01:04:09,950 --> 01:04:14,390

Also autonomous-vehicle systems, stuff like that.

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01:04:14,390 --> 01:04:15,700

We're trying to solidify that up.

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01:04:15,700 --> 01:04:18,580

So not next Friday but the Friday after that.

1252

01:04:18,580 --> 01:04:23,839

If you haven't already, go ahead click "like," "share," "subscribe," every button on the

1253

01:04:23,839 --> 01:04:27,200

screen or podcast app that you can think of.

1254

01:04:27,200 --> 01:04:30,700

That's how you can find us.

1255

01:04:30,700 --> 01:04:36,930

And that is all of my plugs that I'm doing, but I also do need to give a shout-out to

1256

01:04:36,930 --> 01:04:38,140

the @NASAMoon.

1257

01:04:38,140 --> 01:04:40,220

There's a lot of moon activity happening at NASA.

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01:04:40,220 --> 01:04:41,390

We had the supermoon.

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01:04:41,390 --> 01:04:43,680

There was the blood moon, the eclipse earlier.

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01:04:43,680 --> 01:04:44,680

Greg Schmidt: Oh.

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01:04:44,680 --> 01:04:45,680

Yeah, yeah.

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01:04:45,680 --> 01:04:49,940

Jim Green: Well, we also, in October -- I think it's October 20th -- really promote

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01:04:49,940 --> 01:04:51,770

the international Observe The Moon Night --

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01:04:51,770 --> 01:04:52,770

Host: Nice.

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01:04:52,770 --> 01:04:56,619

Jim Green: -- where we get a lot of people out and we have opportunities to talk about

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01:04:56,619 --> 01:05:00,839

the moon as we see it from Earth but interact with a lot of subject-matter experts and a

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01:05:00,839 --> 01:05:07,170

lot of scientists that go to various places where many people are congregating to look

1268

01:05:07,170 --> 01:05:10,721

at the moon and really give you some great details about what's going on.

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01:05:10,721 --> 01:05:13,390

Greg Schmidt: I think the bottom line is this  
is your space agency.

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01:05:13,390 --> 01:05:14,390

Host: Exactly.

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01:05:14,390 --> 01:05:15,390

Greg Schmidt: So get involved.

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01:05:15,390 --> 01:05:16,390

Host: Absolutely.

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01:05:16,390 --> 01:05:17,390

Greg Schmidt: We want you.

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01:05:17,390 --> 01:05:21,390

Jim Green: And the moon we have is not any  
old moon.

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01:05:25,240 --> 01:05:23,720

It's our moon.

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01:05:25,240 --> 01:05:26,869

Host: And this is all . . . We're doing this  
on Twitch.

1277

01:05:26,869 --> 01:05:28,289

We're doing this as a podcast.

1278

01:05:28,289 --> 01:05:30,869

Notice there are no ads.

1279

01:05:30,869 --> 01:05:32,470

Don't give us any tips.

1280

01:05:32,470 --> 01:05:36,460

Pay your taxes -- this is how we survive.

1281

01:05:36,460 --> 01:05:39,750

So fortunately, we don't have to throw in ads or baked-in anything.

1282

01:05:39,750 --> 01:05:42,009

But thank you so much, everybody.

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01:05:42,009 --> 01:05:43,009

Thank you for making this possible.

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01:05:43,009 --> 01:05:44,009

Jim Green: Thank you.

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01:05:44,009 --> 01:05:45,009

Greg Schmidt: Thank you.

1286

01:05:45,009 --> 01:05:47,130

Host: Thank you, guys, for watching.

1287

01:05:47,130 --> 01:05:52,400

And we will see you in a couple weeks.