Transcript: The Mars Exploration Rover: Spirit and Opportunity

Fraser: Welcome to Astronomy cast, our weekly facts-based journey through the Cosmos, where we help you to understand, not only what we know, but how we know what we know. My name is Dr. Fraser Cain, I'm the publisher [missing audio] today, and with me is Dr. Pamela Gay, a professor at Southern Illinois University at Edwardsville. Hi, Pamela, how are you doing?

Pamela: I'm doing well. It's snowing here!

Fraser: Yeah, and we are having the most horrible rainstorm ever — flood warnings.

Pamela: That's not good.

Fraser: Yeah, I'm really sick of the winters here on the West coast, I gotta say. Anyway, but let's think of another hostile environment.

Pamela: Exactly.

Fraser: So, the twin Mars Exploration rovers, Spirit and Opportunity, have been crawling around the surface of Mars since early 2004 – years longer than they were expected to live, and what they have discovered there on Mars has given scientists their best understanding of Martian geology over the last few billion years. Let's investigate these amazing rovers and their ongoing mission. You know, when we started this astronomy cast, we were amazed at how long the Martian rovers had been going, "Oh, it's amazing! It's been years and years!" That was in 2006. Now, we're in 2010 almost into 2011 – amazed at how long the Spirit and Opportunity have been going.

Pamela: Well, we might have actually lost Spirit. It's a sad, sad realization that has kind of gotten swept under the rug, but we may be down to one sad little rover.

Fraser: Well, let's go back then and talk about the history because it's an amazing, amazing mission.

Pamela: Well, these are part of the NASA Mars Exploration program. They're two cute little rovers. They're actually cute! They stare you in the eye with a panoramic camera with two lenses that actually look like eyes, and are spaced similarly to human eyes that give the rovers 3-dimensional vision, similar to human vision, but just make them very personable little robots.

Fraser: That is one of their most amazing things is that they look like people. They look very…you know I'm sure we anthropomorphize them – we look at them and say, "Aw, look at those adorable robots! Here's another billion dollars for future Mars Missions."

Pamela: Well, it's not quite "billion" dollar, it's more like "oh, here's another hundred million," which is at least an order of magnitude less.

Fraser: No no, I'm saying it's for the future, right? They make these ones cute, and that way the future missions will get funded.

Pamela: And well, Mars just does "cute" well because these missions build on the experience that we got from launching the Mars Pathfinder probe back in 1997, which was basically every little kid's Tonka truck come to life, roving around on the Martian surface.

Fraser: Yeah, absolutely. Well, we should put this all into context right because, you know, I mean, we've talked about this in other shows: that the NASA scientists, at least the international community of scientists, have been very careful and deliberate about how they've gone about researching. What's really the sweet prize in the end is the discovery of life on Mars. That's what they want, but they've actually really sort of stretched it out and gone after fairly incremental scientific discoveries, one after the other, and the Mars exploration rovers really fits into this structure quite well and really shows you how they're deliberately going about it.

Pamela: Right, so it really began back with the Viking missions back in 1976 when we landed less cute little landers on Mars and took pictures and took soil samples and started trying to figure out if there were organic compounds, if there were chemical reactions that resembled life. And it was inconclusive, so we figured out "OK, what do we need to do next?" And what we needed to do next was two things: one, be able to take samples of more than one location, there's places on earth that if you grabbed a handful of sand there'd be no evidence of life. And we also needed to have different chemical experiments, different imaging — different technologies on board. So, in 1997, we launched we very inexpensive little mission: Mars Pathfinder, which was basically a technology test. It was a child's 3-wheeled scooter-sized robot that roved around like an animated Tonka truck that took samples and took images and paved the way for the Mars Exploration rovers to get sent in 2003, and then land in January of 2004.

Fraser: Right, I mean this is a situation where you had a rover that you could remotely control, and it could drive around — not in real time — but you could say "go check out that rock," and it would drive over to that rock and examine it, and "go check out that rock," so you could see, and there also the technology — the whole landing technology — was really pioneered by what they did with pathfinder, where they had this airbag system, and you know, a much less expensive way of putting a payload onto the surface of Mars.

Pamela: Right, these are fabulous. These are the bouncy ball landing techniques, and it literally was drop something, have a parachute to slow it down, but recognize that you're not going to get it slow enough, but surrounded in airbags and let it bounce around until it settles down, and the Mars Exploration rovers were encased in these geometric containment vessels that had flaps that each individual flap was capable of flipping the entire lander if it needed to, so if it landed solidly on basically the roof, it could right itself and get the rovers upright and horizontal just be how it opened up the various flaps.

Fraser: So, why were there two rovers chosen?

Pamela: Well, it's a redundancy issue. Building two doesn't cost that much more than building one; you get all of the skills building one. It's sort of like with the Hubble space telescope. We actually built two of them and only launched one of them, so there's a tradition of "let's build two," and in this case "let's actually launch two." This gave us a chance to check out two very different parts of the Martian surface, and these were built not to look for life, but to go look for different signs of water, and so we wanted to be able to look on a part of Mars that looked like old shoreline, and to look in areas where we knew that there were minerals that could only be created in water environments, and so we chose two very different parts of the surface and dropped these two very identical little rovers, and sent them off on what we thought was a 90-day mission.

Fraser: Right, right. So the goal for these rovers was search for evidence of past water on Mars — so not life, not current water, but past water, and to really try to build up the history of when water appeared on the surface of Mars, how long it lasted, when it went away, and what kind of forms it took — you know, was it big nice warm lakes, of was it salty water brine hiding under rocks? And that's really what they were looking for.

Pamela: And the neat thing about these is because they have the ability to wander around, just like the Apollo astronauts on the moon, they can go from one place to another, grab a rock, sample it, figure out what it's made of, and use those samples from a variety of different locations. Now, admittedly, the greatest wandering they've done is only 20 km, but still, for a little robot, that's pretty good!

Fraser: It's amazing.

Pamela: So, grab these different rocks and calibrate the orbital information we have, so they're able to basically say, "OK, yes, Mars Reconnaissance orbiter detected [missing audio] in this location." Here are the rocks that correspond to this location, and yes things line up

Fraser: And so then, they had two very different landing spots

Pamela: Right, so we had one of them landed in Gusev crater, which is a nice, big crater that allowed you to — just like you might go up on the edge of a highway cut-out, look at the different layers in the terrain, and you could do similar sorts of things over in Gustav crater.

Fraser: Right, now this is a really big crater. I mean, you can't tell that it's inside a crater it's so big.

Pamela: Right, right. We started off with Spirit, and there's a great Twitter feed name called "Free Spirit." Spirit started out in Gusev Crater, and this area was selected in part because it had hematite noticed in the area, and hematite is a mineral that can only form in water, and it's a common rock that we have here on Earth. If you go to a mall that has a display of rocks that you can buy, the ones that kind of look like Mercury became a solid. Those are hematite.

Fraser: Right, right — kind of metallic, gray, shiny rocks — they polished them up.

Pamela: Yeah, they're pretty. So we sent Spirit into the Gusev crater following basically the traces of water, and went exploring and Spirit basically explored all around, and the most interesting area that it explored actually wasn't so much in Gustav crater, but once the escape took place. So, Spirit escaped and went to an area called home plate, and this is where a lot of interesting research ended up happening, where all sorts of mineral collections, all sorts of [missing audio], or dust devils, unfortunately, tied in with all of the exciting science. Spirit got stuck.

Fraser: And then there was a whole other mission too, so we're going to have to switch back and forth as we go.

Pamela: This is kind of schizophrenic – we have two robots!

Fraser: Yeah, yeah, "Now cut to Opportunity…"

Pamela: "Now cut to Opportunity…" Opportunity landed on (this is where I mispronounce something once per show) Meridiani Planum. It's a large, flat area, and it was thought to perhaps be an area that had formed as a seashore, and so this was selected as another place to be geologically interesting, to go and basically see what could be seen…looked for past water life, found what we think was signs of sedimentation, this is basically where all of the minerals come together and form a rock. You've probably seen this along the beach.

Fraser: What's the most amazing thing about Opportunity is that it landed in a crater — and not a very big crater. It landed in a very small crater it landed in a crater that's only a few meters across.

Pamela: Yes, Eagle Crater.

Fraser: So, when it landed in the crater, the scientists are like, "This is amazing. Uh oh, we're not even sure we're going to be able to get out of this crater." So, it was like a one in a million landing that then might have trapped the spacecraft for the rest of its mission. It couldn't go anywhere else except in this tiny crater, but in the end they were able to figure out a path to break it out.

Pamela: But while it was down there, it found all sorts of amazing geological structures because, in a way, a crater's a kind of cool place to land because you have all of these rocks that revealed right there right in front of you, and it was in this crater that they found something they dubbed "blueberries," and these are hematite spheres that are basically little tiny nodules that formed when the hematite formed.

Fraser: And this is that first real evidence of past water on Mars. Opportunity was the one that picked it up first, but it wasn't the only …

Pamela: No, no and what's amazing is that this little robot basically explored and explored and explored Eagle crater and then it did get itself out, and then it took off roving, and it made its way to Endurance Crater making it there four months after landing in late April of 2004, and there it kept looking at all the different layers of rocks. This one it circumnavigated, took lots of detailed images where you can see all of the cuts through the land.

Fraser: Right, so I mean up until this point, both of the rovers had been performing amazingly — already well beyond the expectations. They had discovered evidence of past water, thanks to Opportunity.

Pamela: And then Spirit had the Humphrey Rock as well, which was a rock that had minerals in it specific to water. Again, we have both of these suckers picking up rocks and finding indications of water.

Fraser: And different kinds, like you know, different chemicals, different deposits so it's just again and again and again discovering that there was water, and that there was probably large amounts of warm water, you know, liquid water on the surface of Mars, long enough to ideally to evolve life.

Pamela: and NASA's not quite willing to go that far, but yeah, there was water and Humphrey Rock actually is a rock that formed from magma, so we know there's volcanism, we know there's water all at the same time, and that's one of the models we have for how life formed on earth: take volcanoes, insert water, add lightening.

Fraser: We hope, we think.

Pamela: We have no idea.

Fraser: Right. Now, up until this point it was, you know, like I said, it was baffling, both rovers way beyond their expected life span, but, you know, it couldn't last forever.

Pamela: No, and in 2005, Opportunity decided to, well, do what many of us have done with cars and that is to dig itself into the sand. It was happily exploring more than a year after its launch. And it found itself in what mission planners called Purgatory Dune. They ended up having to do simulations. There are actually twins to both Spirit and Opportunity here on Earth, so we have two that we can literally…NASA scientists take these suckers out to sandboxes trying to figure out how to free them. And after getting stuck in April, they managed to get poor little Opportunity free in 2005, June and get it roving again and get it onto firmer ground, and they took off roving again, this time off to yet another crater.

Fraser: And I remember they were running different simulations on you know how can you make it work with only 5 wheels, 4 wheels, or how can you make it walk? They test and then they had to re-upload all this code to teach it how to get itself out of these situations but spirit had its own problem, too.

Pamela: Spirit took a little longer to get stuck. Spirit got stuck on Home Plate, which is an interesting place to say that a rover got stuck. In 2009, Spirit was roving along and hit a sand dune and hasn't quite figured out how to get out of the sand dune, and so that's been a great issue, and in January of 2010, after months of attempting to free the rover, they basically gave up, and NASA said we're going to turn it into a stationary mission platform. And this is the awesome thing is even after Spirit has basically gotten itself stuck to the point that the best rover drivers couldn't figure out how to unstick it and they tried all sorts of crazy stuff. If you've ever gotten your car stuck, you know how you do all the crazy "OK, wheels right, gently touch, wheels left touch hard" – all of that craziness

that you do — they did it with the rover, couldn't get it out, so they figured out "OK, so we still have working cameras, we still have lots of working cameras. They, of course, examined everything they could reach, but it was sand. They turned it into basically an observing platform to observe the stars, to figure what is the wobble of the planet, to observe the weather. It's kind of neat to think that basically Spirit for a while was a weather station. If we're ever going to start getting human beings living on Mars, we really need to get the weather in detail. You only have so many things you can look at and if it's a choice of terrain or clouds, most scientists are going to say give me those pictures of the landscape. And for a while Spirit helped us understand the weather and helped us understand planetary wobbles by just looking at how the stars positions change.

Fraser: But I think the most interesting part of probably the whole mission was Opportunity's sort of roving up to the edge of the Victoria Crater and then crawling down inside because I know that right before Opportunity got to Victoria, there were a lot of dust storms and all of its solar panels got covered with sand, and so they weren't sure that it was going to have enough power to get down into the crater, and then you get the dust storm and then you get these dust devils which was totally surprising

Pamela: 2007 (the latter half of 2007) was kind of a scary time for Mars scientists because both rovers got fairly covered in dust, and that was the original dust scenario for these two little guys. They'd get covered in dust and wouldn't get enough solar power to keep themselves warm and that's what kills the rovers is if their batteries get too cold. They just can't keep going. They also have to keep their joints warm. There is a problem with the shoulder in Spirit where its shoulder froze up, but there always was that one gust of wind that came along and cleared off the solar panels, but in 2007, if the clouds of dust are so great that sunlight can't reach the rovers, it really doesn't matter how little or how much dust is on the rovers themselves, and these dust clouds just never seemed to end, and they went through all sorts of crazy "OK, we're going to re-program the rovers to do this instead of what we'd originally intended in hopes that by doing this slightly different shutdown scenario that we can keep them going," and they managed to keep them going through the dust storms.

Fraser: And so this is a really special place. Victoria crater is a pretty big crater where you know a space rock had carved out enough of the landscape that you could really look back in time — it was like a time machine that you could do, but once again scientists were unsure if they could get opportunity even into the crater, and then if they could get it in, could they even pull It back out again.

Pamela: And what is amazing is that they pulled out both. So, it got to Victoria Crater in 2006, started figuring out how to get back down in 2007. At the beginning of the year they also had a software problem, where Spirit went into basically "freak-out mode" for a little while and they had to figure out how to re-program the memory on both spacecraft. [Spirit] survived the software upgrade (and if you've upgraded a computer, you know how scary that is), survived the dust storms of June 2007 and onwards, and then just explored all over inside of Victoria crater. There's an area called Duck Bay that in late 2007 Opportunity went down and was able to look at all the cuts of the inner slope and examine all of the different layers. It exposed years and years of sedimentation,

and in mid-2008, Opportunity climbed back out and is now on a massive 12-km trek to get to the 22-km-wide Endeavor Crater, which is an even more interesting crater to try to explore.

Fraser: And sort of when Opportunity was doing this work around Victoria Crater, that's when the Mars Reconnaissance arrived in orbit around Mars and so you get these amazing pictures of Opportunity perched at the rim of the crater and you can see its tracks as it's moving around, you know. I highly recommend you search for those photographs. We had them on the show once. It's amazing! It really brings everything together because the photos are so clear and you can see exactly what Opportunity was staring at. You see the point of view from Opportunity looking at the rim of the crater, and then you see the images from the Mars Reconnaissance orbiter above. You can see what an amazing terrain it was. So, I guess, when recording the show right now (we;re in late 2010) Spirit is not moving.

Pamela: Probably lost.

Fraser: Probably lost, but Opportunity is still going, and it's going to hope to make it to Endeavor Crater.

Pamela: And it's stopping at all sorts of little craters or not-so-little craters along the way, so it's been a really interesting scientific journey, where even if it never makes it all the way to it's final destination, these missions are doing more science than anyone ever imagined they could do.

Fraser: So, put this into perspective then: where do you think this takes us along that continuum of the search for life on mars? That really is the goal.

Pamela: Well, with these missions, they were really the preliminary that led to Phoenix landing in the polar regions. They were sent to the equatorial regions where you had a lot more sunlight, they were sent to areas where we thought that there was past water, proved that yes, the mineralogy does indicate there was past water, and opened the door to say "OK, let's go find current water in the riskier land in polar regions." What they're doing now is just geologic gravy. They're basically getting to do the robotic equivalent of wandering around in the [missing audio] Zion area of the western United States and they're just looking out on these amazing vistas and examining what's in all of the cut-throughs down through the layers and layers of sedimentation. If they're mapping geology, I have to admit I'm an astronomer and I'm notorious for going to geology meetings and having to randomly ask people "what's this new vocabulary word?" and it's these missions that are forcing me to learn "why do people care about hematite?" It's shiny and pretty, but well, they care because it's filled with water, and they're doing all that cool geology.

Fraser: Yeah, and so the next big mission then is going to be the Mars science laboratory Curiosity. Yeah, and that's going to landing this year, right?

Pamela: It takes off this year, and then it takes a while to get there. That's a big heavy mission. It's not going to get bounced around on the surface.

Fraser: No, but it is an SUV-sized laboratory equipped with the stuff that could

detect life. I mean: this is it. This is serious.

Pamela: This is the [missing audio] Miami Hummer filled with equipment basically.

Fraser: …yeah, with arms, and its own nuclear reactor. Yeah, it's going to be quite the mission.

Pamela: But, I really do encourage all of you to go not just look at the Mars Reconnaissance orbiter mission images, but also look at all the vast panoramas that have been captured by Mars exploration rovers, and get yourself a pair of 3-D glasses.

Fraser: Yeah, they did a lot of stereo pictures because they had these two eyes. They could take these stereo images.

Pamela: And it looks just like it would look like for human beings because of the height of the eyes and the separation of the eyes, so you can actually see what it would be like to stand on the surface of Mars.

Fraser: Yeah, if you don't have a set of 3-D glasses — a lot of stuff sent over by NASA, a lot of the images — they'll release these 3-D images quite a bit, and it's great to have them, so have a set of 3-D glasses sitting beside your computer if you want to look at these kinds of photographs. Alright well, I think that was great, Pamela, and we will talk to you next week.

Pamela: Sounds good, Fraser, I'll talk to you later.