

# Order of the Phoenix Visits Mars

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This last Memorial Day about two and one half months ago, while you were all barbequing and enjoying family, in that place called JPL, which is just a few miles from here, we were landing a spacecraft on Mars. What I am going to do today is give you an idea of why we explore, why we went to Mars, what was the challenge of actually landing a spacecraft on another planet and give you a preview of some of the early results that we're getting from that mission.

Many people ask me why we explore. There are a lot of problems here on earth, why don't we spend the money on solving those problems? Usually, I give two answers: one, which is more public-related, is that if Jefferson had decided not to send Lewis and Clark to the West because there were lots of problems on the East coast, we probably wouldn't be in California. They had lots of problems in England and if they did not send Captain Cook to explore, probably our knowledge would be much more limited. But here we had visionary people who were willing to invest and explore beyond what's in the horizon and that enriched all our lives. This does not include all the technological advances that have resulted from all that exploration. So, that's more the general explanation that I would give the public.

But on more fundamental level the way I explain it is that somehow about 13 billion years ago there was a big bang, now I don't know how actually it happened, but there was a big bang and that created a number of particles. Somehow those particles got together and they formed stars and galaxies and there are the billions of stars and galaxies in our universe. Then somehow around some of these stars there were planets, there was dust that formed around those stars and those dusts accumulated and they formed planets similar to the planets in our solar system. And then somehow on one of those planets was the right environment, it had the right chemistry on it and that led to some organic molecules and some cells, and somehow those cells got together and here you have this beautiful life that we have around us.

When you think about it, that's absolutely amazing. How did that happen? From that big bang and those particles we have smart people like you and I sitting down having a conversation today. So, what we're trying to do in exploration is basically provide the book of how did that happen? How did stars form? How did galaxies form? How did a planet like Earth form? Why is there life on it? Or is life common? If it's on Earth, is it everywhere in the Universe? Are there planets similar to our planet? If it's common that would be amazing and would completely change our thinking about our position in the universe. On the other hand, if we are unique that's equally amazing and when you look at the billions of stars in this universe why did life evolve only on this planet? So, what we're trying to do in our endeavor of exploration is to understand where we came from over a scale of billions of years.

Now, when we talk about exploring and looking if life is common or what led to life, people always think of Mars and the reason we think of Mars is that it's one of the nearest planets to us.

It is very similar in many aspects to Earth—the land surface on Mars is about the same as the land surface on Earth, if you take the oceans away, so, it’s a fairly big place. It has basically polar ice sheets similar to the ice sheets we have on Earth. There’s a North Pole and South Pole and you have ice sheets on the North Pole and the South Pole. They expand and shrink during the winter and summer. A year on Mars is equal to two years on Earth. A day on Mars is the same as one day on Earth, plus a little bit longer. It has an atmosphere; you see canyons on it. Here we have the Grand Canyon on Earth and there’s a similar canyon on Mars, except it’s the size of the whole United States. That said, we have a similar kind of geological phenomena which is happening on that planet. There are volcanoes on Mars similar to volcanoes on Earth. Mt. Olympus on Mars is larger than the Himalayas, it’s the largest structure in the universe. If you have been to Hawaii you see the calderas in the Hawaiian volcanic park. Mt. Olympus is very similar except they are extinguished at the present time. They were active sometime in the past, but not today.



Look at the surface if I take the titles away from the pictures—one is from Chile, one is from Mars you wouldn’t know which one is which. Clearly a lot of the phenomena are very similar.

When we look at the features on Mars we see what looks like rivers existed on that planet, what looks like drainage channels except that the water is not on the surface. It’s very similar if you have

flown over the dry areas of Egypt and you see the dry drainage channels. The water is not there, but there are indications that sometime in the past that surface was wet. You see sand dunes.



I would have thought this was a picture of Earth and you would have believed me but I can assure you that these are sand dunes taken on Mars.

What we have are a lot of similarities on the two planets, but there are some differences and what we have been trying to do over the last decade is understand how the geological evolution occurred on that planet, and particularly, was there water on the surface of Mars and did it stay for a long period of time. What are its oceans or rivers like? And then the next question is if there were oceans on Mars, did life evolve?

People don’t really appreciate that for the last decade our country has had so much presence on another planet. As of today, we have two space crafts which are orbiting Mars, we have two

rovers on the surface and we have one lander, which we landed a couple of months ago. We have robotic explorers which are effectively exploring another planet on our behalf for the last decade.

Geologists love craters, why do they like them? It's like you dig a deep hole in the ground that allows you to see what's below the surface, and that will allow us to see what happened in the past because the things on the surface are recent and as you go deeper and deeper there are older and older geologic formation. When you see the Grand Canyon I'm sure many of you have seen it, you see this laying. Basically what geologists look at is the layer which is on the top as more recent than the layer below and more recent than the layer below it and so on. So, by examining the composition of the layers from top to bottom, we can write the past history over billions of years. That's what we're doing on Mars. The rover has been driving around exploring and determining the composition of these different layers so that we can tell the history that has occurred in that area.

To make a long story short based on the two rovers that we have up there, Spirit and Opportunity, which have been exploring for four years, we do believe now that three to four billion years ago there were large oceans on the surface of Mars which lasted for a long period of time when the environment was warmer. Somehow, for some reason, three billion years ago all that water disappeared and then it became a very arid, very dry environment and a very cold environment. The key thing we want to understand is why that happened, and if life evolved at that time is there any remnant of it still on the surface of Mars? So, that's the kind of thing we're trying to understand with the different explorers that we have.

One of things that we wanted to do, I mentioned to you earlier there's a polar cap on Mars, we wanted to go closer to the polar cap and make a measurement of ice. And you say why is it interesting to do that? Because organic material tends to be preserved in ice, like you put it in your freezer. So what we wanted to do is to dig some of that ice and analyze it and see what kind of composition is in it that might be an indication of things which have been frozen in there for millions of years. What we did was decide to land the space craft very close to the pole. If you were on Earth it would be like we landed in northern Canada. If any of you were in northern Canada or Alaska there's a lot of perma frost and that's the kind of environment that is in the location that we decided to land.

We decided to land this space craft, very close to a large crater. Just to give you a couple of parameters. Imagine after we travel for about nine months to get to Mars, that's 420 million miles, we have to hit the top of the atmosphere of Mars within one hundred meters. The space craft has to come in at the right angle and, at the right location. Just to illustrate it for you, it's the same as if you go outside and hit the golf ball so that it lands in England and you have to land it straight in the cup. And, to make it a little more challenging that cup is moving at high speed and you still have to get it in the cup. So, don't try to come and play golf with me or people from JPL—we're very good at this stuff. That's challenge number one.

Challenge number two is you're coming at 12,000 miles per hour, that's the speed you're coming at, so you could go from here to Washington in about ten minutes. Within seven minutes we have to stop and land very softly on the surface.

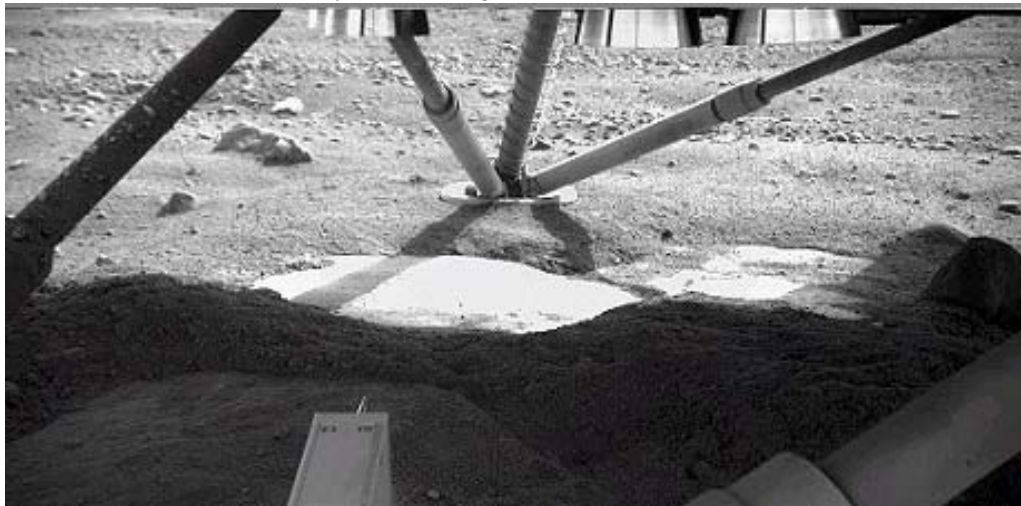
The third challenge is that you are doing all of this with all the networks looking over your shoulder to see what's happening. I told the employees on the team before we landed that there are two things which are sure: Number one, we are going to land but the question is we going to

land hard or soft? Number two, the following day we're going to be on every newspaper's front cover and the only question is we going to be heroes or bums?

Imagine that the team had worked six or seven years on that space craft and everything is coming in front of their eyes during those seven minutes [of landing]. All the efforts of six or seven years was either going to be a great success or not.

Let me tell you about some of the results. These are some of the first images that we got and as I mentioned to you earlier this surface looks very fractured because of the ice expanding and shrinking.

The space craft has an arm and at the end of the arm there is a camera. The arm has the same dexterity as your arm. So we basically took the arm and we looked under the space craft to see what was under it and that's what you're seeing here.



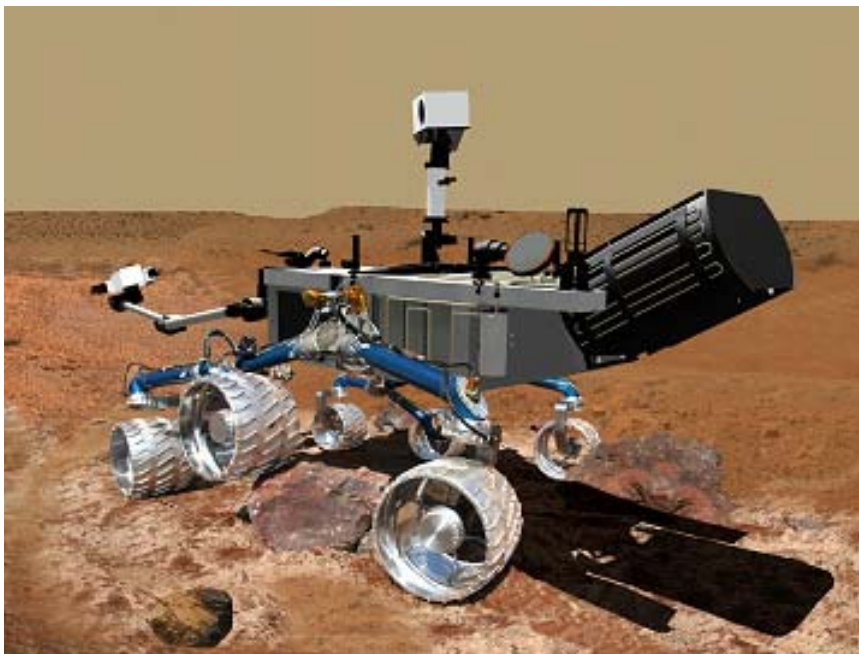
That's the landing pad here, these are the retrorockets which fired and as they fired they swept the surface under them and we see the ice which is exposed. You see the ice straight under these engines. What we found was literally solid ice and there was a thin layer in the dust or dirt sitting on top of it.

What we are doing with the arm is scooping soil and then putting it in an oven to heat it and see the composition of that soil.

This is one of the areas we are trenching. So you can see that's the trench, then you see this white stuff and that's the ice, which is below the surface.

Now let me describe to you some of the challenges. It takes 10 minutes for a signal to get from Earth to Mars, and 10 minutes to get one back. So you cannot joystick it. You cannot sit down and move the arm and joystick it. So the spacecraft has to be pretty smart. We send the command, we tell it what to do and it's pretty smart to move the arm, feel where the soil is, scrape the soil, pick up the thing, and drop the material inside that oven. That all has to be done autonomously by the spacecraft.

We have used two ovens, we have eight ovens on the spacecraft. In one of the experiments we actually measured water ice, which is literally H<sub>2</sub>O. On the other hand we got a big surprise, we also measured perchlorate, which is very oxidizing. So we have a little bit of a challenge because life or organic material wouldn't survive very well if you have a lot of perchlorate, but it will survive well if you have water. Our puzzle is why are these two different materials on the surface and what are the implications of them? We still have three months to complete the measurements in the different ovens. Come about November 2008 we get into the winter on Mars, a very heavy winter because we are very close to the pole. The sun will set completely and then for four months there is no sunlight. Most likely the Lander will freeze. We don't think it will survive, but in the meantime we might see frost starting to form on the spacecraft as we are watching that happen.



What's the next step? The next rover we are actually building as we speak. This rover is about the size of your car and basically it's like a roving chemist. What we want to do is be able to roam around, be able to sample rocks, put them inside the ovens and do the chemical analysis to see if we can detect carbon—that's the key ingredient for organic material. It has two cameras up here which are about

the height of a person. As it drives around it has an arm in front of it so we can touch rocks. It has a drill. It has a polishing kind of tool very similar to what your dentist uses to polish your teeth, except a lot more expensive. And then once we find something interesting we have a microscope to look at in detail. If we see something interesting we drill in it and then pull out samples, and put them inside the oven that we have on the spacecraft. It would be powered by a small nuclear generator so we don't have to depend on the sun and it can operate day and night. All the wheels are electric powered and each wheel is run completely independently of other wheels, so we can literally make a 360 degrees turn exactly where we're standing. So it has a lot of flexibility. We are designing it to survive for a couple of years, which most likely means it will survive for a decade. Then it will be able to drive many tens of miles on a regular basis. So in effect, we will have our explorer driving around Mars and exploring the surface.

To give you a feel of the size of it, this is the rover we sent about 10 year ago, called Pathfinder. This is the rover which is now on Mars, Spirit and Opportunity, which is about the size of your table. And that's this rover which is the size of a car. Now, the challenge we have here is how are we going to land it on the surface of Mars? If some of you remember when we landed the rovers we put them in big airbags. As we got close to the surface we deflated the airbags and we let them bounce on the surface. This one is too heavy to do that. So the way we are going to land it is we are going to come with a spacecraft and hover above the surface, but not land all the way down. Then, with a sky crane, dangle the rover as we're hovering over the surface. Once the rover touches the surface then we cut that cord. Then the spacecraft goes away and the rover is ready to move around. Very similar to when you sky crane Jeeps from a helicopter, except it's happening on another planet. And then, one other thing it has, in addition to the arm which has a camera and can take samples from it, it has a laser beam so that if there is a rock which is too far away or on a cliff we can actually shoot a laser beam and evaporate the rock and from the vapor coming from it actually determine the analysis of it. Very much like Star Trek, except it's real. So we we'll be walking around zapping. I'm sure kids will think this is pretty cool.

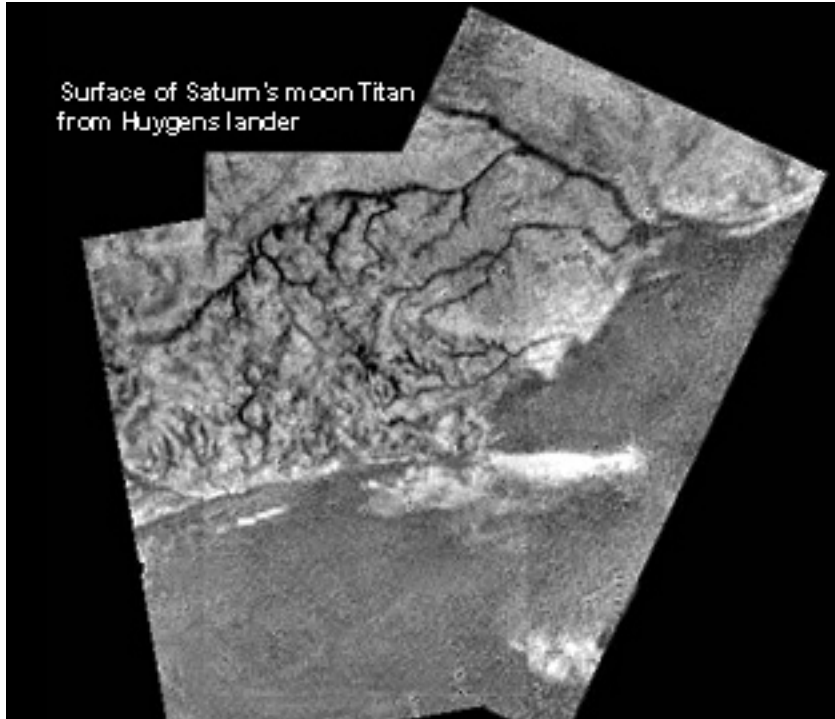
At the same time that we have a spacecraft on Mars, we also have a spacecraft which is exploring Saturn. Now Saturn is particularly interesting. One, it looks beautiful with all the rings around it, but there is a reason why we are interested in it. Because we believe that our solar system, when it formed, first the sun formed, there was a ring around it, then the dust in those rings accumulated then formed rocks which accumulated and formed a planet. And that's how our solar system was formed. Saturn is a miniature solar system that we are observing in front of us.

Now the rings, if you look at them in a telescope, look like they are a white solid ring, but in reality it is not. It is a bunch of small particles but from far away, it looks like a solid surface. When you look at it in detail you see that there are gaps in these rings and that's where little planets are actually forming. They are sweeping that dust and becoming larger and larger and forming a little planet. When you look at them edge on, these rings are paper thin. In one dimension they are a few hundred thousand miles, in another dimension they are less than a mile thick. These are some of the satellites which are forming in that area. And that's another example to show these rings and some of the satellites there in the background.

There are two satellites which are particularly interesting. One of them is Enceladus, which we know is made of ice. It's about the size of Great Britain, but what is particularly interesting is, and when we flew over we found that the temperature of the surface suddenly increased. After we passed, we looked backward and asked what's the reason for that temperature increase? And we saw geysers. It's exactly like Yellowstone. Here you have a planet and you have huge geysers which are sending up 50 kilometers of ice—which is coming from inside the surface of that planet. We believe that there might be an ocean below that surface. And then, because of the heat internal to that satellite, you have geysers like at Yellowstone. We actually had the spacecraft fly inside that plume and make measurements of the material in that plume, and we did detect organic material in it. We plan to fly it much closer down, flying through that plume and actually start taking samples and analyzing those samples.

The other satellite, which is particularly interesting, is Titan. That satellite is bigger than the moon. It has an atmosphere. The atmosphere is as thick as our own atmosphere. It has the same pressure. If you were on Titan, you would feel the same pressure you feel here, except there are two big differences. One, the atmosphere has a lot of methane, which is organic material. Number two, it's much colder than what we have here. There are clouds, so when we

dropped the probe in that atmosphere and took pictures we saw pretty much, the California coast. You have rivers; you have what looks like an ocean. We had the radar, which was in orbit take pictures and we saw lakes. These are about the size of the great lakes in the U.S. Now this looks exactly like our planet. We detected that there is a rain. You see rivers. You see lakes, except it's not water because it's so cold that water would not be flowing. It turns out that this is all methane, so it's similar to what you put in your car. So here we have a planet, which has the same hydraulic cycles as we have on our planet except its all organic material and it's all made of methane.



So if you were living on Titan you wouldn't worry about the price of gasoline, you just go to the nearest lake, put your pipe in and you get all the gas you want for free. On the other hand, if you light a match your planet will explode in one big poof.

So that gives you a flavor of the kind of thing we are exploring.

Thank you very much.

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