Planetary News: Phoenix (2008)
Phoenix Scientists Confirm Water-Ice on Mars

By A.J.S. Rayl
June 21, 2008

Phoenix has found the water-ice it came looking for in the north polar region of Mars, scientists announced during a press conference Friday, a finding that immediately began refueling excitement about the prospects for finding some kind of life on the desolate planet.

"With great joy we have found the proof that we have been seeking to show that this bright hard material is water-ice and not some other substance," said Phoenix Principal Investigator Peter Smith of the University of Arizona, which is leading the mission for NASA.

The evidence comes in the form of images taken less than one month after the lander set down near the Red Planet's north pole and six years after Phoenix mission co-investigator William Boynton, of the University of Arizona, and his team working with the gamma-ray spectrometer onboard the Mars Odyssey orbiter detected the presence of a hydrogen-rich subsurface layer, a telltale sign of water-ice, in this very region.

"We came to this site to find water-ice and we have found it," confirmed Mark Lemmon of Texas A&M University, lead scientist for the Surface Stereo Imager camera that sent home the photographic goods. "We have found what we were looking for."

"The Phoenix mission was inspired by the observation from Odyssey and modeled by the Odyssey scientists that there was ice in the northern plains of Mars," elaborated Smith. "Our mission was designed to land on that ice and in fact our landing site was carefully chosen as being a place where ice was very likely to exist under the surface. The Odyssey scientists and people who modeled dry soil to ice layer were correct and we are able to verify those predications with a lot of confidence."

The confirming discovery came despite some technical glitches, including an incident with Phoenix's onboard filing and data storage system that caused the lander to produce thousands of duplicate copies of file-maintenance data files and clog things up. The software issue was promptly diagnosed and should be "patched" no later than Tuesday, according to Barry Goldstein, Phoenix project manager, of the Jet Propulsion Laboratory (JPL).

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The Phoenix mission

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The Phoenix team had been keeping watch this past week on some little chunks that had been left at the bottom of a trench northwest of the lander, dubbed Dodo-Goldilocks, on Sol 20 (June 15, 2008), after Phoenix dug deeper to enlarge it. Many of the science team members had their suspicions. Then, when the lander imaged the trench on Sol 24, last Thursday (June 19, 2008), the chunks -- the largest was about 2/3 of an inch across -- were gone.

"They literally disappeared," confirmed Lemmon, who quickly turned the Stereo Surface Imager (SSI) pictures into a "blink" movie he posted yesterday. Presumably, they vaporized.

That disappearing act convinced even the few remaining skeptics among the science team that the chunks were

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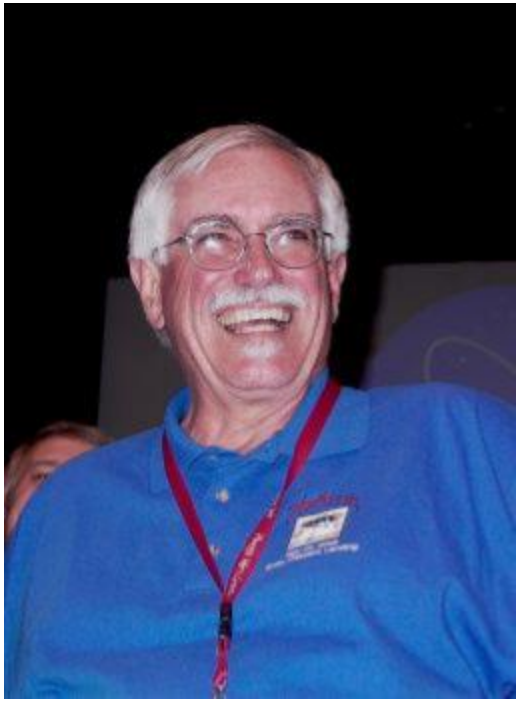
Disappearing act
Flipping back and forth between two color images captured by Phoenix on Sols 20 and 24 of its mission shows that some clods of bright material visible in the shadowed part of the trench on Sol 20 were no longer there on Sol 24. This is the evidence presented by the team indicating that the clods were, in fact, water-ice that sublimated into gas in the intervening sols.
Credit: NASA / JPL / UA / Texas A & M / animation by E. Lakdawalla



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Peter Smith

Peter H. Smith, a senior research scientist with the University of Arizona's Lunar and Planetary Laboratory, is the principal investigator of the Phoenix Mars Mission. He joined the faculty at the UA in 1978 and beginning with the Pioneer Venus mission that same year, his career took off for parts unknown. Since then, he has been participating in what have turned into landmark missions that have explored the solar system. Credit: The Planetary Society / A.J.S. Rayl

actually clumps of largely water-ice and not topsoil. Smith told reporters.

The team got the evidentiary photographs Thursday around 11 am or 12 pm (Pacific Daylight Time), said Smith. "It was the end of sol meeting and Mark [Lemmon] came rushing over with his computer and flopped it down to show us this blink movie he'd made."

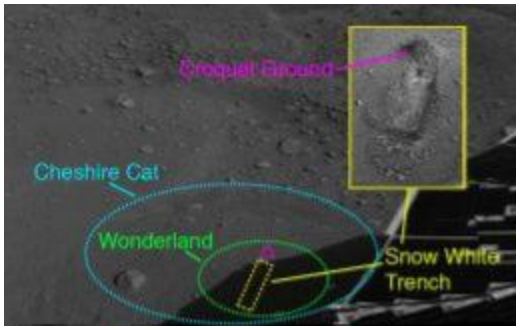
There in the animation [shown in this article] the image flipped between Sol 20 and Sol 24. In the first image, the chunks are there; in the next image, they're gone.

"It was so incredibly convincing," Smith said. "There was no argument to be made anymore. We all kind of just applauded."

"We believe these things are water-ice," Lemmon reiterated during the press conference. "In the course of sitting through the very cold but dry Martian environment and having sunshine on them in the morning, they sublimated. Salt does not behave like that." They couldn't have been carbon-dioxide (CO_2) ice at the local temperatures, because that material would not have been stable for even a day as a solid, he said.

Confirming the existence of water-ice in this region of Mars is a significant achievement and one that will definitely be noted in the space history books, not to mention the planetary exploration and Mars history books. Yet, the team seemed to take it so in stride, almost like another day at the office.

"It wasn't quite the celebration you'd imagine," admitted Smith. "There had been some question whether the bright material was salt , but people were kind of being pulled to this conclusion it was water-ice and the SSI images were the final evidence. These little clumps completely disappearing over the course of a few days is perfect evidence it's water-ice."



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Phoenix workspace

Phoenix took this image of its workspace on its Sol 22 (June 16, 2008) with a camera called the Stereo Surface Imager (SSI). It used its robotic arm to dig the trench, Snow White, near the center of a polygon called Cheshire Cat, in a digging site known as Wonderland. The pile from the dig is at the top of the trench, dubbed Croquet Ground. The fairy tale names help scientists keep mental track

"People here expected to see this," agreed Lemmon. "And when we started getting these extra images down -- literally while the data were still coming down -- we had enough in front of us to say there were significant changes" [with the chunks]. "Not long after that we had a movie to see how extensive the changes were. It was exciting, but frankly we just moved on with the rest of our day."

The definitive answers about the water-ice, its exact composition, for example, will come as the instruments churn out their analyses. "This [finding] tells us we've got water ice within reach of the arm, which means we can continue this investigation with the tools we brought with us," Lemmon said. "The real answers about the ice will come from the Thermal and Evolved Gas Analyzer (TEGA) and the Microscopy, Electrochemistry, and Conductivity Analyzer (MECA)."

Still, confirming the water-ice is, in fact, really there is pretty darn cool, a nice, big feather in an explorer's research cap and for Smith the finding is just a little sweeter. "I am absolutely overjoyed that we can make this statement based on imaging data, because I have spent a lot of my career building

fairy tale names help scientists keep mental track of the sites and studies.
Credit: NASA / JPL / University of Arizona

cameras very much like the SSI," he said. Smith spent nearly two years managing the building of the Mars Reconnaissance Orbiter's HiRISE camera for which Alfred McEwen, also of the UA, is the principal investigator.

"One of our great fears was that we would see ice under the lander and the arm wouldn't be able to reach it," he reflected later. "To find water-ice right within our digging area and to have the ability to reach to top of polygon and into the troughs between them, where we expect the ice will have a different character -- it does on Earth -- this is really beyond expectation and something wonderful. We thought polygons would be much bigger and expected that we'd land in the middle or on the edge of one. We didn't know we'd have *both* in reach."

Truth told, they were a little surprised to find ice this fast. "I was very surprised that the thrusters turned out to be our best digging tool and our best brush for cleaning off the ice layer," said Smith. "I was quite surprised to see that. I hoped that at the bottom of thruster pit we might see some hint of a flat surface, but I never thought we'd see what looks like almost like a billiard table that has been completely swept clean." It's why they called it Holy Cow. "And the ice was so visible to us -– that was quite a surprise -- and told us right away if that were ice we'd be finding it at about 5 to 6 centimeters," he said.

"It was a surprise to see something so bright and shiny and still dark compared to freshly fallen snow," added Lemmon. "But much brighter than the soil on Mars."

If the scientists seemed a bit nonchalant about their big, textbook changing, confirming discovery, they're really not. In part, living on Mars time is catching up with them and in part it's because they know their work has only just begun. "The big story is more personal to us perhaps -- but we can reach out and touch the ice on Mars now," Lemmon offered. "We can sample it and use our instruments to taste it and sample it."

Phoenix is equipped with a suite of sophisticated instruments to unravel the mystery behind the clumpy sticky topsoil, reveal the content and impurities or the water-ice, and determine whether the local environment just below the surface of the north polar region of Mars has ever been favorable for microbial life. "The truth we're looking for is not just in looking at ice," noted Smith. "It is in finding out the minerals, chemicals and hopefully the organic materials associated with these discoveries."

In addition to investigating the composition of the topsoil and water-ice and ice layer, they'll be looking to see if the water ever becomes available as a liquid and whether organic compounds are present that could provide chemical building blocks and energy for life. "The real answers about the ice will come from TEGA and MECA," Lemmon reminded.

Where there is water, there is life, at least on Earth. As part of NASA's ongoing expedition to 'Follow the Water,' Phoenix is looking for signs of habitable zones, not biological life per se. It does not have the equipment to look into the ice for microbial lifeforms.

Click to enlarge >
Holy Cow

Nevertheless, if any type of Martian lifeform existed that could be seen with the naked human eye, say a Martian beetle living under a rock, the lander could easily detect it and photograph it. And, there are a few intriguing rocks in the area that the scientists' have been eyeing. "There are rocks in our vicinity and I think half the scientists here are very curious to flip one over and see if there's anything living beneath it or if there's a salt concentration," acknowledged Smith.

But, as with all NASA missions, first things must come first, Smith said. "Our first and primary goal is to get a surface sample and a sample at the ice-soil boundaries."

Phoenix wasted no time this week. It dug another trench, this one to the northeast of the lander in the Wonderland site. "After finishing Goldilocks, we went to a new

Mark Lemmon
Mark Lemmon is the lead scientist on the Stereo Surface Imager (SSI) camera and a co-investigator on the Phoenix Mars Mission. He is an associate professor in the department of atmospheric sciences at Texas A&M University in College Station, Texas. There, his research interests focus on the development and application of cameras for planetary exploration, as well as aerosols in planetary atmospheres, atmospheric radiative transfer and numerical studies of light scattering by small particles. Credit: Texas A&M University

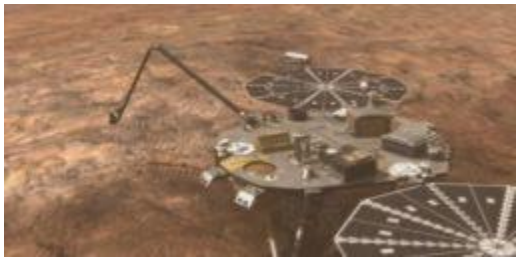
On Sol 8 (June 2, 2008) Phoenix used its robotic arm camera to acquire a set of images of Holy Cow, with a variety of exposure times. These images were merged, to permit better views on the possibly icy material found there, in both the shadowed regions under the lander in the foreground and sunlit regions in the background. The new images reveal that the flat layer continues underneath each of the lander thrusters, and that the thrusters have built a ridge of dirt between them.
Credit: NASA / JPL / UA

polygon in Wonderland -- more broadly Cheshire Cat -- our National Park system," said Phoenix 'dig czar' Ray Arvidson, of Washington University St. Louis, co-investigator for the robotic arm. "We decided to open [the National Park] up, because we wanted to dig right on top of that polygon."

On Sol 24 (June 19, 2008), Phoenix extended the first trench, Snow White, in the middle of that polygon, extending it and renaming it Snow White 1. Then, it dug another trench just to its right, Snow White 2. While digging, Phoenix hit a firm layer. After three attempts to dig further with its robotic arm and scoop, it stopped -- exactly what it's supposed to do when it hits a hard surface.

"The robotic arm stopped toward the end of the operations on Snow White 2, because it detected something hard," reported Arvidson. As programmed, it then dumped the soil and waited for further instructions.

The Phoenix science team spent all day Thursday analyzing new images from the new Snow White 2 trench and other data successfully returned from the lander earlier in the day. "Given the hardness, it looks like an ice layer and, from the point of view of the spacecraft telemetry, I think we have excavated with Snow White 2 -- the third exposure of ice," Arvidson said, which is "at the same depth as the ice layer" in the previous trench. "We have Holy Cow, the layers in Dodo-Goldilocks, and now Snow White 2."



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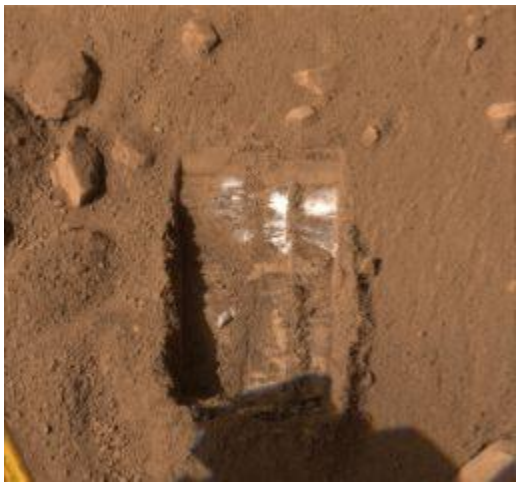
Artist's conception of Phoenix after landing
Credit: Phoenix Mars Mission, University of Arizona

As Mars missions go, Phoenix is soaring along and for the most part the mission has been has experienced very little turbulence. Technical "bumps," however come with the territory of space and the lander did suffer an information overload event earlier this week when it began duplicating file maintenance data.

"We now understand what happened and we do have that situation under control," assured Goldstein. "It's difficult to explain details of what happened, because it was really a delicate interaction between two problems, one of which we knew about and one of which we discovered was a consequence of the first problem," he said.

"Due to an issue we had in keeping the sequence counters aligned correctly across the boundaries, when we put the spacecraft into a sleep mode, another issue cropped up that basically forced the system into an infinite loop where it was generating this high priority but usually small number of packets of engineering," Goldstein explained.



Basically, that led Phoenix to generate "more than 45,000 high-priority packets" on Sol 22 (June 17, 2008). "It ended up "starving out or occupying all of the Phoenix's non-volatile memory, kind of like a thumb drive or flash drive you would used on your computer."

The spacecraft team at Lockheed Martin Space Systems in Denver and engineers at JPL are working now on two patches, "one to fix the bug we identified and the other to fix the consequence of the bug we knew about," Goldstein said. The plan is to uplink those patches to Phoenix by Monday or Tuesday and restore data operations to normal.

Despite the moments of downtime, Phoenix and its ground team kept flying -- and returned one of its prime directives to boot. The mission's three-month schedule has "30 days of margin" for situations just like this. So far, it has used only one contingency day out of 24 sols, Goldstein pointed out. "The mission is well ahead of schedule. We are making excellent progress toward full mission success."

Until those software patches get deliver early next week, the Phoenix science team must downlink all data on the day they collect it. It's really not that much of a restriction, said Goldstein, "as evidenced by this great discovery." By early next week, the restriction should be lifted and scientific data will again be able to be stored onboard overnight when needed, he added.

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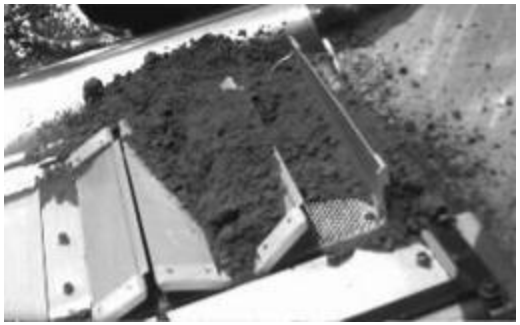
Sol 19 view of Dodo-Goldilocks trench site
For the first 21 sols of the Phoenix mission, digging activities focused on an area known as Dodo-Goldilocks, visible as the broad trench in this color view from Sol 19. The Dodo (on the left) and Goldilocks (on the right) were dug at the edge of one of the polygons that make up the polar region terrain. Samples from this area were delivered to TEGA oven #4 and to MECA's optical microscope. At the far end of the trench (top of the image) the scoop seemed just to clip some bright white material, which it turns out now is beyond all reasonable doubt icy in nature.
Credit: NASA / JPL / UA / Texas A & M

For the moment and the immediate future anyway, Phoenix isn't rushing to get deeper in the ice. "We're starting with surface samples," said Smith. "We would like to take time and be sure these remote control sequences are fully validated. We need to make sure when we go down to the ice layer, we're prepared."

The Baby Bear sample has been cooking in TEGA's oven #4, which, Boynton reported earlier in the week, "is working very well."

A TEGA analysis generally requires four heating episodes at different temperatures for different objectives. So far, Boynton said, they found some carbon dioxide released from the Baby Bear soil sample, but no water. "This is what we were expecting, because sample had been sitting out in the Sun," he said.

The TEGA team was still awaiting the results of the final bake yesterday. "Oven number four has endured a couple of delays because of the software difficulties and the final stage of the TEGA run may come down today or tomorrow," said Smith. Following that, he added, "there will several days for interpretation" before they can announce with confidence what Baby Bear is all about.



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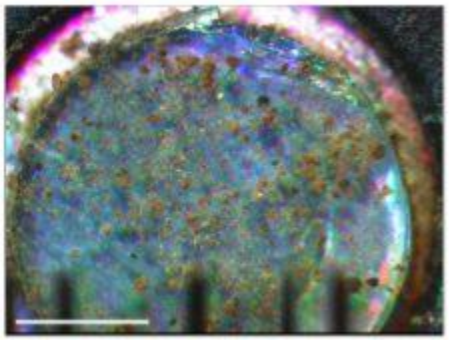
Attempt to open TEGA oven #5 doors
Two images were taken of the TEGA instrument on Sol 25 (June 20, 2008), before and after an attempt to open the doors of oven #5, adjacent to oven #4, which had been opened previously and used for the first sample. The left-hand door of oven #4 never opened properly. It now appears that neither door on oven #5 has opened properly.
Credit: NASA / JPL / UA / animation by E.Lakdawalla

Meanwhile, Phoenix's flight continues and its agenda is packed. On Friday, June 20, the lander was slated to gather samples for TEGA's oven # 5, open the doors to oven #5, deliver a sample from the Wonderland region to MECA's optical microscope, and prepare a sample for MECA's wet chemistry lab.

Images that were downlinked yesterday showed that the doors to the oven #5, like those on oven #4, only opened part way. The doors are not motorized. Rather, they are connected to springs and latches and, theoretically, should spring open completely when the latch is released. The springs on the doors are strong enough to push the doors open even when buried under a few centimeters of soil and the left-hand oven door has successfully thrown off nearly all the soil that covered it.

It is at the moment unclear what is preventing the doors from opening, but the instrument team is working to understand the consequences of this action, according to an official statement. In any case, it appears that the door opened part on oven #5 is enough to get a sample in and nothing it seems can stop this team now.



"Over the next two weeks or so, we'll be sampling soil just to left of Snow White, in area called Rosy Red," said Arvidson. "We will collect samples for three instruments, then go back into Snow White 2."

The plan for Snow White 2, the ice layer, is to hit is with Phoenix's "ice attack arsenal," he said. "We're going to groom it a little with backhoe, do some scraping experiments with scraper, and take our rasp, which is about size of your pinkie, and dig in. We'll try all those on this hard layer, which we're pretty convinced is a third exposure of ice."

The prospect -- and the public appetite -- for Martian life loom large and will not be ignored no matter how many times Smith, Arvidson, Boynton, et al., may say Phoenix carries no life-detecting equipment. And, to be sure, those tantalizing rocks nearby, which seem to beg to be lifted up, are on the Phoenix agenda.

"We're taking a deliberate path to meet our mission goals," Smith said. Once those objectives are met, however, the doors to other potential discoveries will open. "And we will be looking at other locations where people suspect

there may be different habitat possibilities, for instance, under rocks."

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Martian soil under the optical microscope

The particles in this image are scattered across a blue sticky silicone base just 3 millimeters (1/10 inch) across. The irregular, orange-ish particles, common across the image are actually clumps of even smaller particles that still look like unresolved specks even at this resolution. It is thought that these particles are clumping together in the same way as seen at much larger scales and which caused problems getting material into TEGA. Interestingly, the scale bar at the lower left is just 1 millimeter long, which is the same size as each hole in the TEGA screen.

Credit: NASA / JPL / UA