UT OF THIS WORLD

BY DAVID PESCI

Martha Gilmore not only teaches planetary geology, she practices it at the Jet Propulsion Laboratory, where she is helping to design missions to Mars.

Martha Gilmore is going to Mars. Again. In fact, this time she's not only responsible for helping pick a landing site, she'll be doing some of the driving on the red planet, too.

Gilmore, an assistant professor of earth and environmental sciences who frequently visits colleagues at the Jet Propulsion Laboratory (JPL), has been making the future motorized Martian rover more "intelligent." She is helping to select the landing site for the unmanned mission to Mars that will launch this spring. But that doesn't mean she has eyes only for interplanetary travel. She also has been looking at Connecticut and Long Island Sound, using satellite images to analyze plankton blooms and the spread of pesky purple flowers that choke local marshes. *Science* magazine has written about work she carried out with her students. Recently, she was selected to join the Committee on Planetary and Lunar Exploration under the aegis of the National Research Council.

For many researchers all this easily could be highlights from a long and distinguished career. But at 30 years old, Gilmore is barely getting started.

"I'm just having fun," she says, smiling, the enthusiasm in her voice rising. Gilmore talks about rocks and space flight the way 10-year-olds talk about Harry Potter. But then suddenly her voice dips slightly and her brow wrinkles.

"My only real frustration is that there's so much I want to do in so many areas. I'll never get to all of it."

Gilmore can trace her wide-ranging interest in geology to a single event: a trip to the State Museum of Pennsylvania she took with her parents when she was five years old. An exhibit on rocks and minerals captivated her.

"I was fascinated," she says, the enthusiasm in her voice growing again. "Rocks and geology immediately struck a chord inside me. We went back to that museum again and again, and every time I would just go over to that exhibit and stare. I knew that I wanted to be a scientist who studied rocks. From there everything just seemed to go."

"Go," yes, but at a rapid pace. Enrolled at the Program for the Exceptionally Gifted at Mary Baldwin College in Virginia, Gilmore skipped grades, read voraciously, and spent parts of her summers at various camps designed to cultivate inquiry and intelligence rather than athletic ability ("geek camps" she laughingly calls them). Along the way she became equally interested in astronomy. At age 14, with her high school equivalency in hand, she was already choosing a college and considering majors. She matriculated at Franklin and Marshall College, the only college to which she had applied, because it offered a major in geology and a minor in astronomy. It would be the first step toward a distinctive career in a new area—planetary geology.

Gilmore sailed through Franklin and Marshall and then went to Brown University to pursue graduate work under geology professor James Head, considered a leading authority on planetary geology. She loved the work but found her graduate studies were much more difficult than anything she had done up to that point.

"It was the first time where there were moments when I thought, Can I really do this? As an undergrad I thought I knew what research entails, but you really don't have an idea until you're challenged by a high-level graduate program."

She persevered. She led a team of scientists that was attempting to set the scientific objectives for an unmanned mission into the atmos-

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phere of Venus. Venus had become a specialty of hers, along with the study of Mars, and her work drew the interest of the Jet Propulsion Laboratory—the center for unmanned space flights in the United States. She finished her Ph.D. studies at the age of 24, delivering her dissertation, titled *Tessera Terrain on Venus: Style, Sequence and Duration of Deformation*, to rave reviews and earned herself an opportunity to work at JPL as an expert on Venus and Mars.

"Going to JPL was like a dream come true," she says. "I had spent some time there as a grad student, but going out to Pasadena and becoming really a part of all that was happening there was just so exciting!"

But it was also a very different type of work environment than what she had known in academia.

"The people at JPL are highly intelligent and very skilled, but the atmosphere and work ethic are completely different from what is typical in a university setting," she says. "At a university, I would make a decision to research one subject or look into another. At JPL, there's not a lot of research going on that doesn't have a direct effect on the task at hand. It is all very immediate and goal-oriented."

The work also has a political side, which can exact an emotional toll from researchers. Budget decisions, or even the prevailing whim of Congress, may suddenly result in the cutting of a project midway through. Often, the orders to cease work on a specific mission arrived with little or no notice.

"The first time I saw this happen, it was very unsettling," Gilmore says. "Someone I had been working with suddenly had his project canceled. I thought, he must be devastated. He was disappointed, but he quickly moved on. People just seemed to take these occurrences in stride. The mentality was more corporate, not something I was used to. After all, I had spent half my life in academia."

She got a firsthand taste of the sudden cut about a year after joining the JPL staff. She had been working with the lead scientist on a Mars mission set to fly in 2001, helping to coordinate the teams that were handling all the instruments for the spacecraft. But a mechanical glitch on the 1998 Mars Polar Lander mission caused it to crash to the surface. The ill-fated lander shared a chassis design with the lander Gilmore was working on, and it was feared the 2001 mission might suffer the same fate. This, coupled with the crash of the Mars Climate Orbiter a few months earlier (the result of engineers at Lockheed programming the orbiter's calculations in feet rather than meters), convinced NASA executives that they should hold back on the planned 2001 mission.

"When they told me our mission was canceled, I was very upset," Gilmore said. "I had spent more than a year of my life on that project. With the two crashes and now this decision, there was a feeling that NASA might reduce investment in Martian missions."

However, Gilmore and her team soon learned that quite the opposite was true. NASA was committed to Mars exploration and would increase the budget, despite the crashes.

"I realized pretty quickly that the instruments we were planning for the 2001 mission would be used on upcoming missions. So all our work wasn't in vain. Another lander would ultimately fly to Mars."

The 2001 Mars mission was not the only thing Gilmore was working on. She had devoted significant time to her favorite project at JPL: the Venus Surface Sample Return Study. Her task: work with a team of engineers to lay the foundation for an unmanned trip to Venus that would land on the planet, take rock and soil samples, and return to Earth.

"That was so much fun!" Gilmore says, her smile widening. "Basically, we were asked by NASA to do something no one had ever tackled before. It involved new ways of thinking and a variety of interesting challenges."

These included making recommendations for specific types of spacecraft, flagging possible landing sites, devising sampling and analysis techniques that would work in the 450-degrees Celsius weather on the Venusian surface, and designing a vehicle that would successfully return these samples to Earth. The project took more than six months to complete. When it was done, not only had the team created a comprehensive plan of execution, but also they were optimistic that the job could be completed on a $500-million budget—a figure NASA saw as reasonable for such a mission. The study is now in the hands of those at NASA who will decide if the mission will become a reality.

Gilmore remains involved with two other major projects related to upcoming Mars missions. She is on the site selection team for the mission launching in the spring of 2003, and she has been working with the rovers for that mission and another that will probably launch in 2008 or 2009.

"Site selection can be a tricky business," she says. "On Mars the challenge is dictated by the limits of our technology. Since NASA policy forbids use of nuclear power on the spacecrafts, the landers all rely on solar energy. This severely curtails the areas we can explore and spacecraft lifetime. This and constraints on elevation and rockiness of the surface mean about 70 percent

The Mars Orbiter Camera opened its fourth year orbiting the red planet with this mid-autumn view of three major valley systems. These valleys are believed by some to have been formed—at least in part—by large outbursts of liquid water some time far back in the Martian past, though there is no way to know exactly how many hundreds of millions or billions of years ago this might have occurred. Located around 40°S, 270°W, the picture covers an area approximately 800 km across and is part of the southern region of interest to Martha Gilmore.

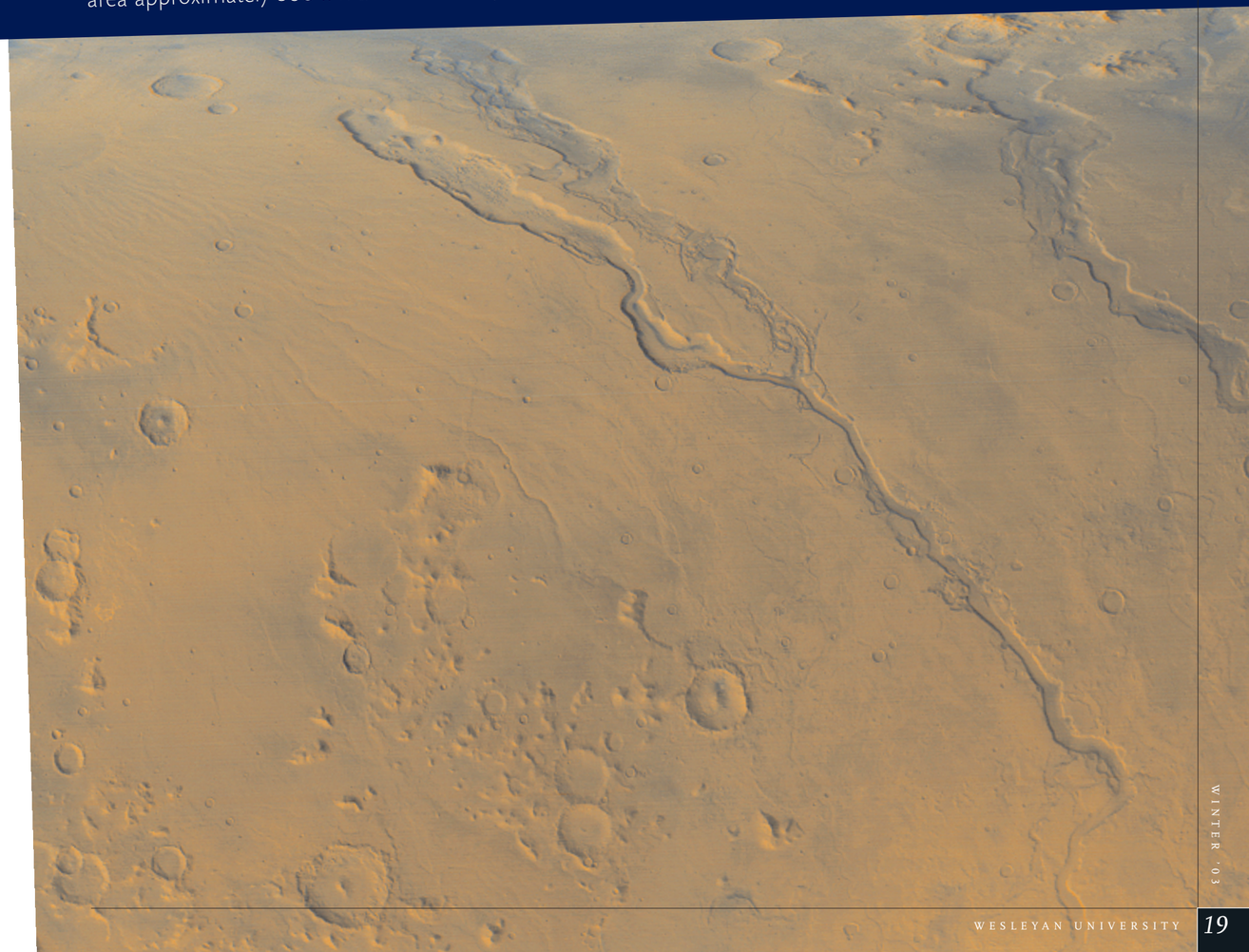
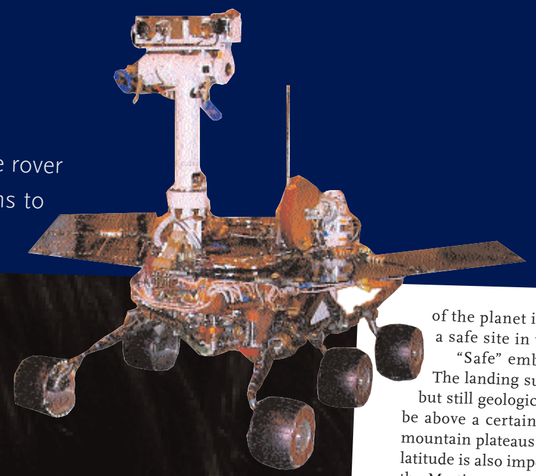


IMAGE CREDIT: NASA/JPL/MALIN SPACE SCIENCE SYSTEMS

To gather data and observe the craft's performance, Gilmore attended tests of the rover that will be used on the 2003 mission. She is on a team that will create programs to make the next generation of rovers more "intelligent."



of the planet is off limits. The trick is to find a safe site in what's left."

"Safe" embodies a variety of parameters. The landing surface needs to be relatively flat, but still geologically interesting. The site cannot be above a certain altitude (some of the Martian mountain plateaus exceed 30 miles in height). The latitude is also important: Flying a mission close to the Martian equator takes much less fuel. For the first time the site will be in the southern highlands.

"That's really exciting for us because all the work thus far has focused on Mars's northern lowlands," she says.

One site Gilmore is eyeing contains a Texas-sized area of hematite, a mineral that is often deposited by water runoff.

"That would be a very cool area to explore," Gilmore says, grinning.

Once the site is selected—a process that often continues well after the mission is launched—the rover will land with an airbag system.

To gather data and observe the craft's performance, Gilmore attended field tests of the rover that will be used on the 2003 mission. She is on a team that will create programs to make the next generation of rovers more "intelligent."

"The task of the rovers is to explore and sample," she says. "We want to teach them how to do this more efficiently and more effectively."

Up to this point, the rovers' mobile data sampling missions are slowed by having to wait for instructions from Earth. The new generation will be more mobile and able to sample a variety of data automatically. Gilmore's team is tasked with creating on-board programming that establishes a hierarchy of importance in the data that's collected.

"Basically, transmission of data can occur only when Mars and the Earth are in the proper position relative to each other; communication is limited," Gilmore says. "Some of the data we get is compressed by design, but our new algorithms will tell the rover that if it finds something we consider more interesting or unusual than what we've found so far, it is to give that sample priority and not compress the data, but rather send it to us in full as soon as possible. It's a much better way of doing research."

Gilmore's work at JPL has proved to be a tremendous benefit to her students at Wesleyan. After all, not many universities offer undergraduates direct access to professors with this type of experience or provide such courses as "remote sensing" and "planetary geology" taught by someone who has been directly involved in both subjects. In 2001, *Science*, one of the most highly regarded scientific journals in the world, reported on her preliminary findings of evidence of Martian water. Her coauthor on the article, Avi Stopper '01, was an undergraduate who had done what Gilmore terms graduate-level work helping her analyze satellite data. In late 2002, Gilmore and Eleyne Phillips '02 published a paper in *Geology* that provided further evidence that some Martian gullies had all the earmarks of those on earth cause by water flows. The paper also pointed out that some of this water may still be frozen deep within the gullies.

Turning their gaze earthward, Gilmore and Taras Gapotchenko MA '02 have used satellite imaging to examine plankton blooms in Long Island Sound over a three-year period. They are searching for correlations among input, temperature, and the recurring plankton blooms in the Sound. Another study has focused on the non-native marsh plant phragmites. The plant's purple flowers show up well on Landsat photography, which enables Gilmore and master's degree candidate Cheney Shreve to track the plant's spread across the state.

The Connecticut Department of Environmental Protection was so impressed with the results that Gilmore says the agency will be incorporating the use of more satellite image studies into future environmental analysis programs.

"I think this is an area where there are going to be some interesting opportunities," Gilmore says, knowing that she's started something with the DEP that may become a vital tool for statewide environmental efforts. "And the technology is only going to get better, which will open up more areas for Landsat studies."

Does that mean Gilmore will be spending more of her time on these earthbound studies?

"Perhaps," she says, considering. But then her smile widens. "There's just so much that interests me, it's really difficult to decide what specific direction I want to concentrate on," she says, her voice rising as she reels off possibilities. "The Landsat work is interesting, but the search for water on Mars is certainly something I am very devoted to. I think there are a lot of possibilities for water discovery on the exposed subsurface layers. Of course, I want to continue working on lander missions. And we have not even begun to talk about Venus!"

Gilmore goes on, talking excitedly about the possibilities of unmanned and even manned exploration of places like Mars, Venus, the moon, and Europa (a moon of Jupiter), her eyes nearly sparkling. She pauses and leans forward, her enthusiasm barely containable.

"I mean, come on!" she says, "It's all so cool!" W