The Mysterious Roving Rocks of Racetrack Playa

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In a particularly parched region of an extraordinary planet, rocks big and small glide across a mirror-flat landscape, leaving behind a tangle of trails. Some rocks travel in pairs, their two tracks so perfectly in synch along straight stretches and around curves that they seem to be made by a car. Others go freewheeling, wandering back and forth alone and sometimes traveling the length of several football fields. In many cases, the trails lead right to resting rocks, but in others, the joyriders have vanished.

This may sound like an alien world, but it's actually Racetrack Playa in Death Valley, Calif. Since the 1940s, researchers have documented trails here and on several other playas in California and Nevada. Seventeen undergraduate and graduate students from the Lunar and Planetary Sciences Academy (LPSA) at NASA's Goddard Space Flight Center in Greenbelt, Md., traveled to the Racetrack and nearby Bonnie Claire playas this summer to investigate how these rocks move across the nearly empty flats.

Some rocks are thought to have moved nearly as fast as a person walks. But nobody has actually seen a rock in motion, and scientists haven't deduced exactly how it happens. The easy explanations—assistance from animals, gravity, or earthquakes—were quickly ruled out, leaving room for plenty of study and irresistible speculation over the years.

"When you see these amazing rocks and trails," says Mindy Krzykowski, an intern from the University of Alaska in Fairbanks, "you really get into coming up with your own ideas about what's going on."

Like being an explorer

After driving two hours from Beatty, Nev. (the nearest town with guest lodging), through the rugged mountains of the Amargosa and Panamint Ranges, the playa looks impossibly flat. This is the nature of a playa—a lake bed that is dry most of the time. A visitor can truly see for miles, because Racetrack rises only about an inch over its 4-1/2-mile length.

"Around you is hot white cracked clay in all directions (you're spinning to take it in)," wrote intern Emma McKinney of the Massachusetts Institute of Technology in Cambridge, Mass., in the blog for the LPSA trip. The mountains that hug both sides of the playa are so distant they look "like the backdrop to an old western [movie]…. No one speaks because they are a what-seems-to-be-a-million-miles-away-distance from you."

Sporting sunhats and carrying lots of water, the students arrived around 7 a.m. for their day of data collecting. They broke into five teams, each led by a Goddard scientist, and took out their maps. Then they packed their equipment and headed in different directions in search of rocks and trails. Justin Wilde from the University of Wyoming in Laramie says, "It felt like a treasure hunt."

For each rock and trail, the students recorded GPS coordinates and snapped photos. They dug up small sensors called Hygrochrons that had been buried (with the required permission of the National Park Service) three months earlier by Gunther Kletetschka, one of the trip leaders. The interns captured the electronically stored temperature and humidity data. They marked the trail boundaries by slipping colored pushpins into cracks in the clay and measured each track's length, depth, and width. They confirmed earlier observations that some of the big rocks have moved farther than the small ones.

The interns also found small mounds at the ends of some trails. People speculate these were formed when the rocks ploughed into the clay and came to rest. Quite puzzling were the mounds at the ends of trails that had no rocks.

The students checked for unusual or changing magnetic fields. (Nope, no evidence of that.) One student conducted radiation measurements. (Nothing strange there, either.) They pulled out small levels to determine if the rocks might be moving along trails tilted ever-so-slightly downhill. Instead, "the general trend is that they move uphill," as reported by Andrew Ryan of Slippery Rock University in Slippery Rock, Penn., in a talk that the LPSA group gave later at Goddard. "But the slope is so insignificant that we don't think it would influence this movement."

Two interns, Kynan Rilee from Princeton University in Princeton, N.J, and Gregory Romine, a graduate student at San Francisco State University, got the special assignment of photographing the playa's skyline and correlating these pictures with GPS coordinates. Rilee later fed this information into a model that can be used to determine where on the playa a photo was taken even if no GPS coordinates were documented. Soon, any visitor to Racetrack Playa will be able to upload photos for analysis at www.racetrackplaya.org .

Rilee estimates that the two of them walked 10 miles total—just two guys and their gear, the isolation occasionally broken by their walkie-talkie or by returns to the base to get more water. "Being out there was almost like being an explorer," he says.

Pondering the playa

The smorgasbord of data is needed because "what's happening on

Racetrack Playa is subtle and complicated. It's not obvious right away which data is going to be important," says Brian Jackson, one of the trip leaders. He and a colleague have been studying Racetrack Playa since 2006 and recently published a paper comparing the site to a dry lake bed on Saturn's moon Titan.

For a while, speculation was that the Racetrack Playa rocks have properties that help them move. But the rocks are just dark dolomite boulders that tumbled down from the mountain highlands. (That's not how the trails were made; those came after the rocks found a home on the playa.) "Dolomite is relatively common, and the rocks themselves are not unusual," explains Jackson. "It's where the rocks are located that makes them special."

Some of the rocks that have moved weigh less than a pound, but many are 25-30 pounds. One of the largest sliders, named Karen, has been estimated at 700 pounds. A powerful force is required to move rocks that big, and the obvious candidate is the fierce playa wind. "It's surprising when you see how big some of these boulders are," says Ryan. "You think, 'How can something that big get blown around?'"

Wind speeds of 150 miles per hour or more would probably be necessary to move most of the rocks. The wind speeds that graze the playa's surface are very fast, but not that fast, so the newer studies tend to ask how the friction between the rocks and the clay might be reduced.

The interns evaluated several hypotheses that have been offered over the years. "Within each group, we traded the data we collected and analyzed it together, though we also had our own ideas," Romine says.

"Teamwork is a key part of the program," notes Cynthia Cheung, the LPSA principal investigator. "The students come at this challenging problem with different strengths and from different directions. That's the way science is done."

Investigators have thought for years that the friction is somewhat reduced when the playa's surface gets wet and the top layer of clay transforms into a slick film of mud. Algae may lie dormant in the dry clay and bloom when the surface wets, further reducing the amount of friction. The students performed water-absorption experiments at Bonnie Claire Playa and found that the clay does get slippery. Even so, the students concluded that most rocks could not move without other help.

The aid probably comes in the form of ice—in this high desert, winter brings snow to the mountains. The meltwater washes downhill and collects in huge, shallow pools that spread across the playa and freeze at night. Decades ago, researchers proposed that big sheets of ice might envelop clusters of rocks, then catch the wind and drag the rocks around together. This might explain the cases in which two tracks run perfectly alongside each other.

When an experiment ruled out the possibility that this happens in all cases, the concept was refined. Now it's thought that collars of ice can form around the lower parts of the stones, probably because the mass of a rock retains the cold. When more water moves in, the collar helps the rock partially float, so even a heavy rock might slide when the wind blows. The presence of ice collars could explain why some trails start narrow and get wider: the rock gradually sinks into the wet clay as its icy lifejacket melts away.

The interns found that the Hygrochron sensors buried about three-fourths of an inch deep registered freezing temperatures in March, and those buried a little more than 3 inches down registered wet conditions almost continuously in March and April. This is evidence that conditions are right to form ice collars, reported Clint Naquin of Louisiana State

University in Shreveport and Devon Miller of West Virginia Wesleyan College in Buckhannon, in a talk presented on behalf of all interns.

Kletetschka is coordinating a research paper by the group that will present Hygrochron and other data and will suggest a slightly different mechanism for the rock movement. The rocks are still thought to be collared by ice, but the group has identified a new parameter that is critical in explaining why it is so easy to move the rocks and create trails. The paper will give the details, but the finding means that the wind speed doesn't have to be as great to move the rocks. "This idea would also explain the trails that don't have rocks," Kletetschka says. "The trails were made by rocks whose larger parts were made from ice."

The students also held an online event, coordinated by Goddard's Maggie McAdam, to talk about their NASA experiences with roughly 450 kids in Boys and Girls Clubs of America nationwide.

Problems still to solve

For some LPSA interns, the playa trip was their first exposure to scientific field work. "I learned that I prefer applied work," says Emily Kopp of the University of Wisconsin in Eau Claire. "I liked working with my hands, gathering my own data for my own research."

Students who had participated in previous field work appreciated their very large roles this time in collecting and analyzing key experimental data. "An intern can get stuck doing something like a cross between going to class and doing busywork," says Romine. "I feel like what I'm doing here is important."

Ryan, who is an environmental science major, plans to keep working on the Racetrack Playa mystery. He devised a test bed packed with mud from Bonnie Claire Playa that can be used to probe whether ice collars can form and make rocks buoyant under controlled laboratory conditions. His one obstacle: finding a freezer big enough to hold the setup. But he is not deterred. "I can take this home with me to finish the work if I need to," he says.

Leva McIntire from Seattle Pacific University, has another hypothesis to test. She postulated that the rocks are moving by regelation, a process usually associated with glaciers and mountains. Regelation is caused by a difference in pressure on the two sides of an object. Water on one side remains liquid and leaks around to the other side, trapping air bubbles on the second side, where ice forms. McIntire thinks this could happen on the playa. She notes that some students observed bubble-like formations in the clay next to certain rocks. "This theory might explain how the big rocks move," she says, "because it does not require floatation of the rocks."

In addition to the field work, LPSA interns worked closely with mentors on active research projects at Goddard, such as developing a "lunar dust buster" to remove sticky dust from astronauts' spacesuits, running Monte Carlo simulations of the atmosphere of Mercury and testing neutron and gamma-ray equipment that is designed to gather subsurface information about a planet without sample collection. The interns' results were presented in a campus-wide poster session.

"I came to the program liking engineering," notes Wilde, a chemical engineering major who explored possible pathways for forming water on the moon. "But I found the planetary research very enjoyable because I had so much liberty in my work."

"I've always been interested in the formation of stars and planets, and here, I've seen that there are still tremendous opportunities for research," says Krzykowski. "Not all the problems in planetary science have been solved."

Source: NASA's Goddard Space Flight Center

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