Strange & Beautiful

Termites or gophers: Who made the mima mounds?

These strange hillocks might be the work of gophers, termites, or something else entirely

Presented by
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Standing in a native prairie near the city of Olympia, Washington, the view resembles an expanse of giant grass-covered bubble wrap. Broad, metre-high hillocks stand in formation, in line but not touching, across more than 600 acres of land, providing an oasis of green in the otherwise shrub-infested grasslands.

These humps are called mima mounds and they're believed to have dominated the landscape for thousands of years. Charles Wilkes, a US naval officer and explorer, thought they were ancient Indian burial mounds when he first encountered them in 1841, but when he ordered his men to dig up three mounds they found no bones, only a "pavement of round stones". Native American legends say a falling star dropped them like pebbles onto the earth and modern day urban myths say they are the work of aliens.

Over the last 150 years, the explanations have become less fanciful but no more conclusive. Mima mounds continue to mystify natives and scientists alike.

Mima mounds, mima mounds everywhere (Credit: Morgan Davis, CC by 2.0)

While the mima mounds in Washington draw tourists in hordes, they're far from unique — similar formations exist in other US states and on every continent except Antarctica. They are known as hogwallow mounds in California and Oregon, prairie mounds in New Mexico and Colorado, and pimple mounds in the southeastern states. The South Africans call their sandy hill-like features "heuweltjies", or little hills, and the Brazilians call the places they occur "campos de murundus", or mound fields.

> *They are a really important part of the ecosystem*

So when is a mound a mima mound?

"Mima mound refers to very specific features that we find in the western US, one or two metres high, about seven to 10 metres wide, very circular, very symmetrical and when you find them there are thousands of them," says **Emmanuel Gabet**, a geomorphologist at San Jose State University in California.

Scientists call other larger, broader, flatter, less circular and more dispersed mounds mima-like mounds.

No mere curiosity, these puzzling mounds create their very own ecosystem. In the western US, for example, fresh water pools known as vernal pools collect between them, allowing a variety of endemic animals and plants to thrive.

On the plains of South Africa, millions of mima-like mounds that cover a vast area are home to distinctive flaura and fauna. "If you consider that many of our landscapes here are very nutrient-poor, you have these landscapes that are occupied by the mima mounds that are relatively nutrient-rich," says **Michael Cramer**, a biologist at the University of Cape Town in South Africa. "So they are a really important part of the ecosystem."

Birth of a hummock

But while scientists agree on the ecological importance of the mounds, they don't necessarily agree on their origins. Multiple theories have been proposed, including **earthquakes**, **glacial flooding**, gas venting, whirlpools, and the shrinking and swelling of clays. Some suggested causes have persisted since the late 19th century, such as the idea that gophers or **termites** created them or that they are formed by the accumulation of wind-blown sediments around clumps of vegetation.

"One of the challenges with mima mounds is that, in many cases they are actually very old, and that makes it very difficult to work out what might have been going on," Cramer says. Scientists estimate that **some of the mounds could be as much as 30,000 years old** with an undisputed slow growth rate that presents a challenge for traditional field experiments.

"The difficulty here is thinking of a way to test any of these ideas," says Cramer. "What experiments are you going to be doing? What are the measurements that you should be taking to determine whether it is actually gophers or termites or plants that are causing these mounds?"

A Mazama pocket gopher (Credit: Washington Dept of Fish and Wildlife, CC by 2.0)

It's a problem that Gabet decided to try to overcome from the comfort of his desk. Rather than heading to the fields to observe the mounds grow at glacial speed, he created a **computer model** to create a virtual "mima mound world". His starting point was a **study** by George W. Cox of San Diego State University in 1987. Cox believed that pocket gophers — burrowing rodents that weigh less than a quarter of a pound (100g) and sport fur-lined "pockets" in their cheeks — were pushing soil uphill to create the mounds. To test the theory he seeded the soil with metal tracers in a mima mound field in San Diego. Using a metal detector, Cox found that the soil moved uphill. Assuming gophers were doing the moving, this implied they were purposefully building them.

Why would animals that typically only leave piles of earth in their wake bother with such a giant construction project?

Gabet used information from Cox's study, building information about soil conditions and gopher behaviour into his model. "It basically simulates the gophers searching for the nearest high spot and then pushing of the soils towards that high spot," he says.

Gabet then pushed the "time machine button", sat back, and watched what would happen in the decades and centuries to come. "The first time I ran it, the mounds were starting to emerge. I was just stunned."

The mounds built by the digital gophers bore a striking resemblance to the real thing in terms of height, width and spacing, Gabet says. But why would animals that typically only leave piles of earth in their wake bother with such a giant construction project?

"The idea is that the gophers are more likely to build up these habitats where the soil would be less saturated," says **Sarah Reed**, an environmental scientist at the University of California, Berkeley.

A Botta's pocket gopher (Thomomys bottae) (Credit: John Cancalosi / Alamy)

Gophers are half blind and avoid going above ground because of the threat posed by predators, Reed says. But as landscapes age the habitable soil layer becomes thinner and the foundational

layer hardens to the point where, when it rains, the topsoil becomes saturated. This leaves the soil levels in which the gophers live without sufficient oxygen.

"These gophers spend 99% of their lives underground so they are very easily affected by any changes in the soil," Reed says. The theory is they build up the mounds to get above the water table.

Hard work

Faced with skeptics who suggested gophers were incapable of summoning the energy to build the humps, Reed designed a **model** to estimate how much energy it would take for one of them to dig through the soil and push it uphill to create a mound. She then balanced this effort against its energy intake. "I found from an energetic perspective it is entirely feasible," she says.

Gabet is certainly confident the mystery is solved. "The gold standard for any scientific theory is: Does it match the facts and the observations?" And so far the gopher theory does that at least on the west coast, according to Gabet. "So I feel like we've nailed it, but as far as mounds forming elsewhere, it could be other burrowing animals or it could be a plant-based theory."

Termites (Macrotermes bellicosus) building their nest (Credit: Ingo Arndt)

Where does that leave those trying to explain similar features in other, gopher-less places? In drier climates the prevailing theory has been that termites build them, much like the African *Macrotermes* termite species that **build large conical structures up to nine metres high**.

How could a colony of termites move that amount of soil into a central place?

"These termites do different things in different environments," says **Joe McAuliffe**, an ecologist and research director at the Desert Botanical Garden in Phoenix, Arizona. "Sometimes they'll build very small conical nests no more than a metre high, almost as hard as concrete. It is a protective because all kinds of animals, including aardvarks, will have them as their dinner."

It was a theory Cramer didn't question until he went on a tour of the mima-like mounds near Cape Town. "I noticed that there were quite big rocks on the surface of the mounds," he says. "It was kind of hard to explain how the rocks would get onto these mounds courtesy of a termite."

McAuliffe is also skeptical because the amount of soil in a mima-like mound two meters high and 30 metres wide would be immense. "It is massive and how could, even over thousands of years, a colony of termites move that amount of soil into a central place?" he asks.

Maybe it's all about plants putting down roots (Credit: Anna Levinzon, CC by 2.0)

Interest piqued, **Cramer then developed a hypothesis** based on earlier research done in the US and inspired by the regular pattern of the mounds in the landscape. His idea was that individual

plants, or clumps of plants, spread their roots and drained the surrounding soil of water and nutrients. As the plants competed for resources, the emerging landscape was one of vegetation clumps at regular intervals — not so close to run dry of water or nutrients, but close enough to make best use of the soil's assets.

> *Termites probably do play a very important role*

These plants spurred the creation of nutrient-rich islands surrounded by barren soil that encouraged tall, thick vegetation and attracted opportunistic animals such as termites and porcupines. According to Cramer, one of two processes might then be responsible for the formation of mima-like mounds: as the wind whips across the desert, the plants either protect their island from erosion, leaving a standing butte-like mound, or they capture wind-blown sediment which accumulates over time.

McAuliffe believes in the latter theory. "The dense, tall vegetation reduces wind velocity and causes the windblown it is carrying to drop," McAuliffe says. "So that occurs over hundreds and thousands of years and you eventually have a two metre high little hill."

And rather than discounting the termites, McAuliffe believes they play a critical role in the process by bringing in plant nutrients and helping to build up the vegetation. "You have to go past some critical point where you can have a flush of vegetation so the wind breaks are there," he says. "So termites probably do play a very important role in how this whole thing gets moving."

"You mean I did all that digging for nothing?" (Credit: All Canada Photos / Alamy)

Cramer, with his colleagues at the University of Cape Town, plans to investigate where stone layers occur in the mounds as an indication as to whether the mounds have been deposited by the wind or not, and also to look more closely at what causes their regular spacing.

"One of the questions that we are wrestling with is what actually drives that spacing," Cramer says. "Is it just competition between plants or is there more to it?"

One solution fits all?

So could the vegetation-wind theory be behind North America's mima mounds too?

"Hills of dirt are a fairly generic feature and part of the confusion comes about from trying to state that all these different types of features are formed by the same process," Gabet says. "So the ones found on other continents, those are probably not strictly mima mounds."

Mima mounds in Thurston County, Washington State (Credit: We Shoot / Alamy)

But other researchers believe mound-like formations across the globe at least partially share common causes.

"I think there is more than one thing going on, and in particular I think there is an interplay between erosion and deposition," Cramer says. "I think those two things might play out differently in different circumstances, but I am pretty convinced that vegetation patterning is at the heart of it."

And while Reed is a strong believer in the gopher hypothesis, she recognizes it is far from proven.

"Part of the intrigue of the mima mounds is the controversy," she says. "There has been more than a century of controversy, and I don't think there is enough evidence to immediately stop the controversy at this point in time."

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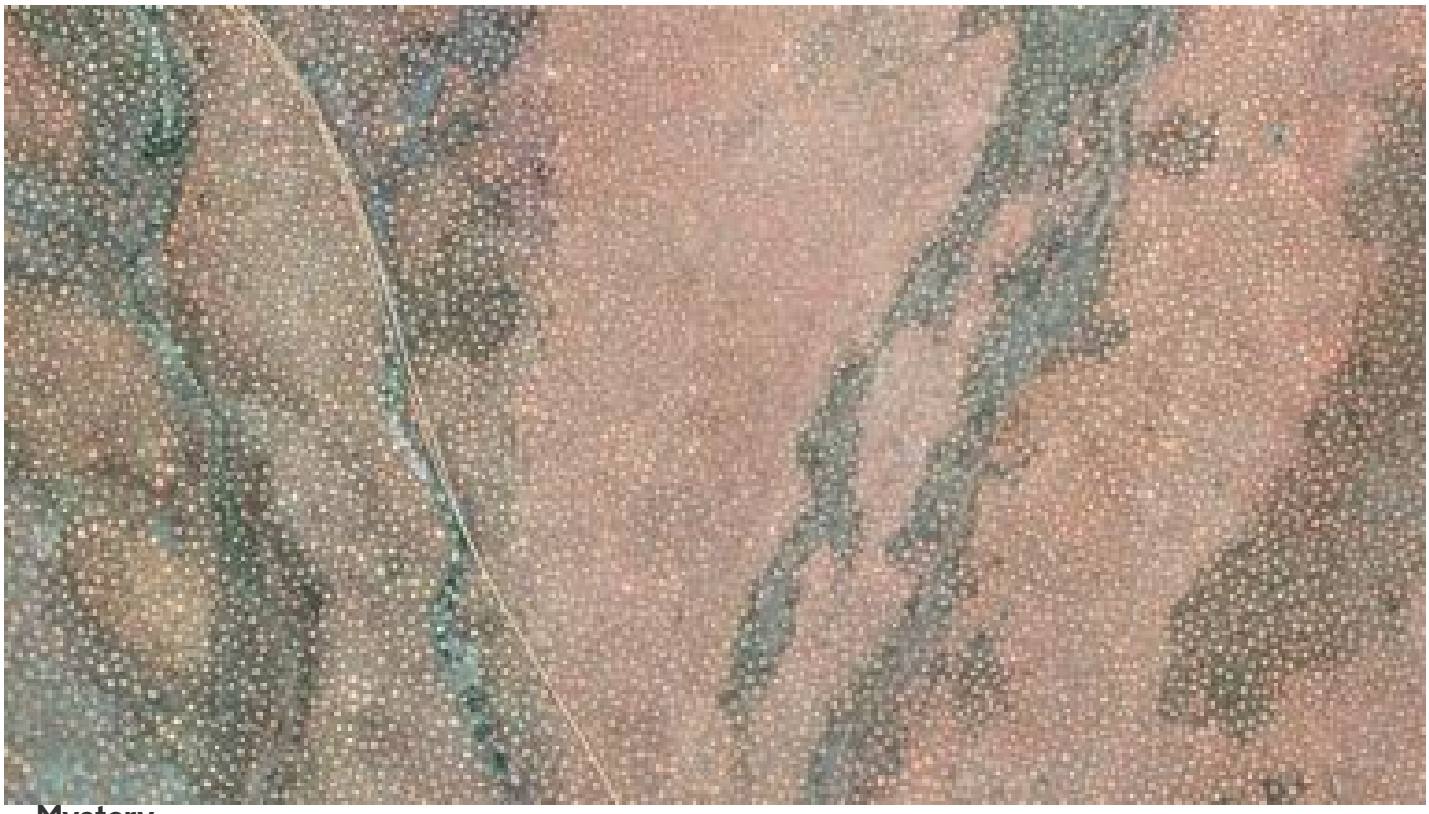

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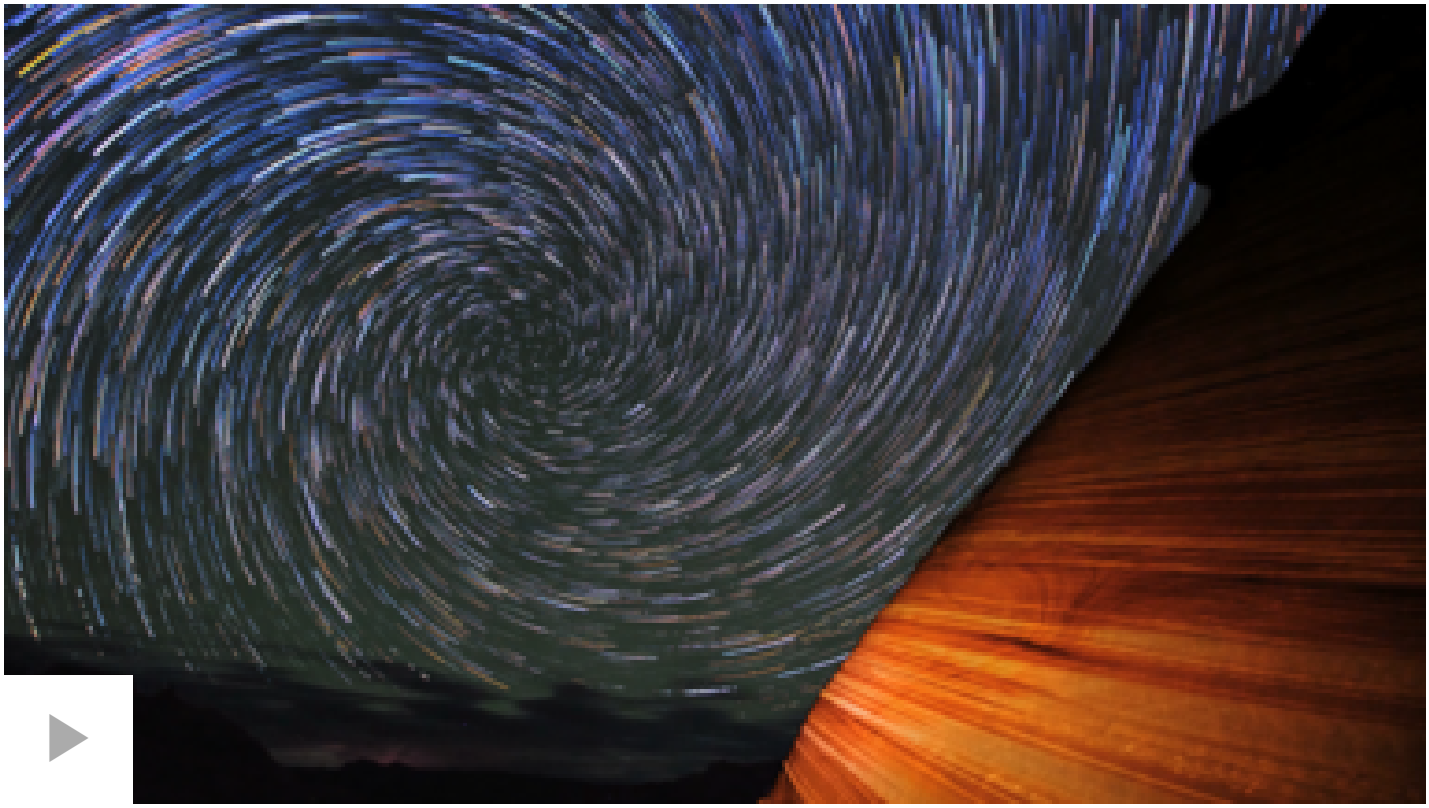

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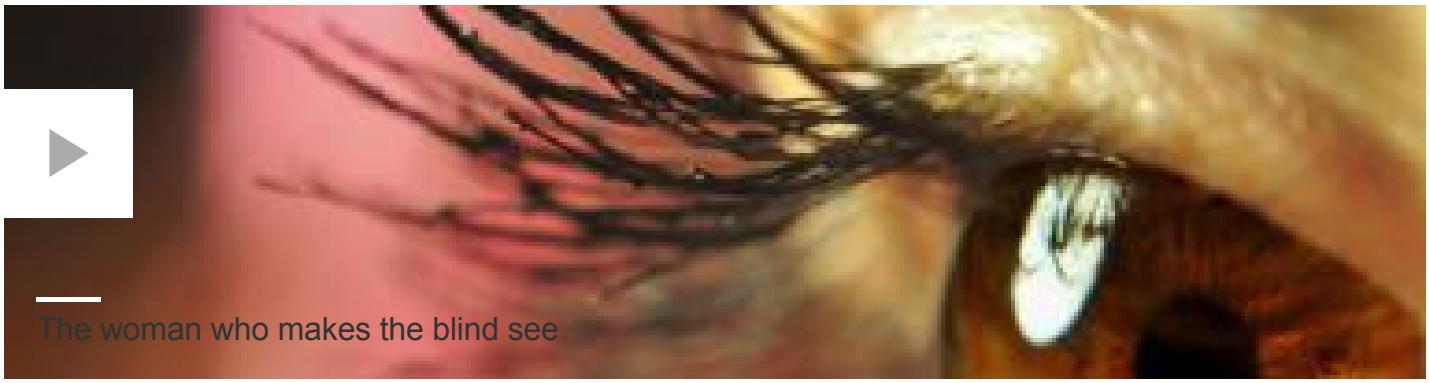

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