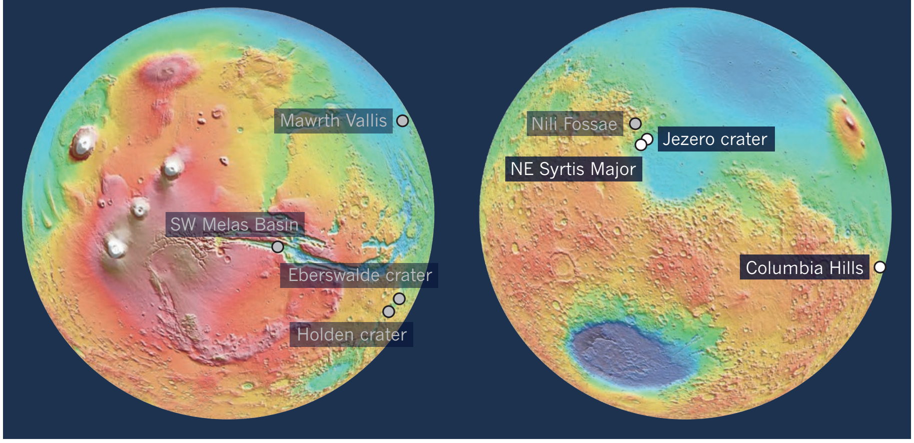
GETTING CLOSER

NASA has reduced its shortlist of eight landing sites for the Mars 2020 rover to three.



SOURCE: NASA/JPL

▶ Hills did not score highly in the community vote. And in another advisory report last week, a group of scientists on the 2020 project explicitly recommended against revisiting the site. That report argued that sending the 2020 rover to Columbia Hills was unlikely to resolve confusion over whether the site's silica rocks, which resemble hydrothermal deposits on Earth, could be linked to life.

But Matthew Golombek, a planetary scientist at NASA's Jet Propulsion Laboratory in Pasadena, California, says that Columbia Hills, like Jezero and NE Syrtis, presents a prime opportunity to explore possible past Martian life. The 2020 rover will carry scientific instruments that could tackle questions about the silica rocks there better than Spirit could, he says. "It's the only location on Mars that we know of that had a hot spring," says Golombek, who co-chairs the site-selection process. He notes that Columbia Hills also has a variety of other geological features nearby, such as an ancient lava flow from which samples could be dated to provide a much-desired absolute age for Martian rocks.

The Columbia Hills choice is likely to be controversial. Horgan says that she is "disappointed" that the site-selection committee went against the recommendations of the workshop and the advisory panel on Columbia Hills, although she is happy about the Jezero and NE Syrtis picks.

NASA wants a landing site where water once flowed, to increase the chance that the rover will discover evidence of any past life — such as organic compounds, biomarker molecules or even microfossils. But the site should also be easy to traverse, because the rover will need to begin drilling quickly to collect at least 20 rock samples in roughly 2 years. "We have to be able to get to the stuff," Abigail Allwood, an astrobiologist at the Jet Propulsion Laboratory, told the meeting.

That requirement, along with other challenges, knocked Holden crater off the list of possibilities. The rover would have had to drive large distances around that site to collect different types of geological samples. And as the southernmost location on the list (see "Getting closer"), it would have exposed sample tubes to strong sunlight and high temperatures, which could have compromised future tests.

LEFT BEHIND

Also out of the running is Eberswalde crater, which scored third in the community vote but is also far south and gets quite hot, Golombek says. Jezero crater offers the same sort of ancient-lake environment without the risk posed by high temperatures, he argues. And the community's fourth choice of Mawrth Vallis, although rich in clays, is not as clearly connected to a possibly once-habitable environment, he says.

Nili Fossae, where an orbiting spacecraft had seen methane rising from Mars, and Southwest Melas, another ancient lake, also fell off the list. Neither scored as highly as the top candidates for the potential for science return.

NASA has neither designed nor budgeted for how to get the Martian rock samples back to Earth. So the 2020 rover will drill and collect the samples, then lay them down on the Martian surface for an as-yet-unplanned mission to retrieve.

The European Space Agency is launching its own Mars rover in 2020, to Oxia Planum. China also plans to send one that year, when the alignments of Earth and Mars are favourable for launching missions between the two. ■

Additional reporting by **Erin Ross**.

PHILANTHROPY

'Riskiest ideas' on tap

Chan Zuckerberg Biohub gives its first US$50 million of grants to biologists, engineers and programmers.

BY AMY MAXMEN

The biomedical-research initiative created by Facebook co-founder Mark Zuckerberg and his wife, physician Priscilla Chan, has awarded its first science grants, on topics ranging from the genomics of obscure microbes to a memory-retrieval device.

Forty-seven investigators will receive up to US$1.5 million each in the next five years from the Chan Zuckerberg Biohub, a partnership between the couple's Chan Zuckerberg Initiative and three Californian universities: Stanford, the University of California, Berkeley, and the University of California, San Francisco. Together, the biohub grants announced on 8 February total more than $50 million.

"We told researchers, give us your riskiest ideas," says biohub co-leader Stephen Quake, a bioengineer at Stanford. Quake says that he and other grant reviewers favoured applicants who have impressive track records and bold ideas that lack preliminary evidence. "There is a creative anarchy in the atmosphere here in the Silicon Valley that we want to harvest," Quake says.

Jure Leskovec, a computer scientist at Stanford and chief scientist at the image-sharing company, Pinterest, won a grant even though his work has focused on analysing social networks rather than biological systems. Leskovec successfully argued that his approach to data could help biologists to understand the complicated interactions of genes and proteins exposed to drugs or disease.

"I don't think I'd get funding to pursue biological research through traditional funding sources because the grant reviewers would be sceptical," he says. "They'd say, oh, he's not one of us."

Other winners express the same sentiment, whether they are engineers who yearn to lead biology projects or biologists wanting to follow a hunch. The US National Institutes of Health (NIH) wants to see a lot of preliminary data, Quake explains: "We want to fund people so that they are more likely to get the NIH grant later." Sceptics have questioned whether the couple's money might be better spent by public institutions such as the NIH and the World Health Organization. But Quake says that the biohub seeks to complement those agencies.

Indeed, neither the biohub nor its parent initiative could replace government funding even if it wanted to. The initiative's $3-billion commitment — to science that aims to cure, manage or prevent all diseases — pales in comparison with the roughly $30 billion that the NIH spends annually on medical research.

The biohub's leaders hope to accelerate the rate at which its grantees' discoveries prove useful by requiring investigators to meet a dozen times each year. Recipients must also post their manuscripts on open-access preprint servers, such as arXiv, as soon as they submit the paper to a peer-reviewed journal. But researchers are permitted to file for patents, which would be owned jointly by the biohub and the scientists' home institutions.

Marc Kastner, president of the Science Philanthropy Alliance in Palo Alto, California, has advised Chan and Zuckerberg, among others. He applauds the biohub for selecting researchers who want to pursue non-traditional projects.

"If you're going to take a century-long view on curing disease," he says, "you need to emphasize basic research because you can't tell where breakthroughs come from." ■

GEOMETRY

Long-sought maths proof could shake up seismology

Solution to puzzle might allow Earth's structure to be determined from wave speeds.

BY DAVIDE CASTELVECCHI

Mathematicians say that they have solved a major, decades-old problem in geometry: how to reconstruct the inner structure of a mystery object '*X*' while knowing only how fast waves travel between any two points on its boundary.

The work has implications in real-world situations; for example, it could help geophysicists who use seismic waves to analyse the structure of Earth's interior.

"Without destroying *X*, can we figure out what's inside?" asked mathematician András Vasy of Stanford University in California, when he presented the work in a talk at University College London (UCL) earlier this month. "One way to do it is to send waves through it," he said, and measure their properties. Now, Vasy and two of his collaborators say that they have proved[1] that this information alone is sufficient to reveal an object's internal structure.

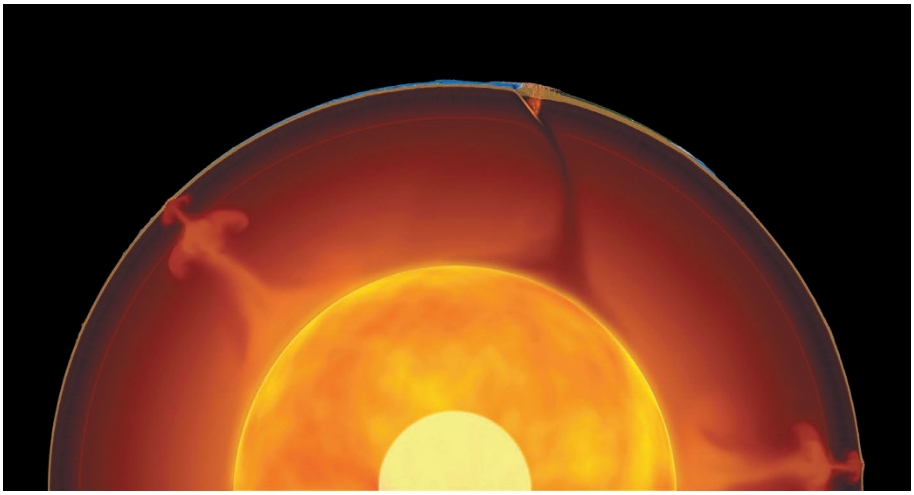
LOOKING INWARDS

The problem is called the boundary-rigidity conjecture. It belongs to the field of Riemannian geometry, the modern theory of curved spaces with any number of dimensions. Albert Einstein built his general theory of relativity, in which mass warps the geometry of space-time, on this branch of mathematics.

Mathematicians already knew that the way in which curvature varies from place to place inside a 'Riemannian manifold' — the mathematical jargon for curved space — determines the shortest paths between any two points. The conjecture flips things around: it says that knowing the lengths of the shortest paths between points on a boundary essentially determines the curvature throughout. The geometry is therefore said to be 'rigid'. So by measuring how fast waves travel inside a space, one could work out the shortest paths, and, theoretically, the overall structure.

The conjecture dates back to at least 1981, when the mathematician René Michel[2] formulated certain technical assumptions about the spaces for which it should be true. (It is not true for Riemannian manifolds in general.)

Vasy's co-author Gunther Uhlmann, a mathematician at the University of Washington in Seattle, had already solved it for two-dimensional manifolds — that is, curved surfaces[3]. Now, Vasy, Uhlmann and Plamen Stefanov, who is at Purdue University in West Lafayette, Indiana, have solved it for spaces that have three or more dimensions, as well.



Earth's inner structure could be revealed by the speed at which waves travel from one edge to another.

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LAYER BY LAYER

In Einstein's space-time, curvature produces gravitational lensing, in which the path of light bends around massive objects such as stars. Similar mathematics apply to conventional lensing, or refraction: light rays or sound waves shift direction when the medium through which they are travelling changes.

In the case of seismic waves — generated by events such as earthquakes — the differing properties of Earth at varying depths mean that the shortest path for such waves is usually not a straight line, but a curved one. Since the early twentieth century, geophysicists have used this fact to map the planet's internal structure, and this is how they discovered the mantle and the inner and outer cores.

Those discoveries were rooted in mathematical treatments that had some simplifying

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