

# Machu Picchu: Ancient Incan sanctuary intentionally built on faults

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Detailed mapping indicates the World Heritage Site's location and layout were dictated by the underlying geological faults. Photo taken 5 Nov. 2010. Credit: Rualdo Menegat

The ancient Incan sanctuary of Machu Picchu is considered one of humanity's greatest architectural achievements. Built in a remote Andean setting atop a narrow ridge high above a precipitous river canyon, the site is renowned for its perfect integration with the spectacular landscape. But the sanctuary's location has long puzzled scientists: Why did the Incas build their masterpiece in such an inaccessible place? Research suggests the answer may be related to the geological faults that lie beneath the site.

On Monday, 23 Sept. 2019, at the GSA Annual meeting in Phoenix, Rualdo Menegat, a geologist at Brazil's Federal University of Rio Grande do Sul, will present the results of a detailed geoarchaeological analysis that suggests the Incas intentionally built Machu Picchu—as well as some of their cities—in locations where tectonic faults meet. "Machu Picchu's location is not a coincidence," says Menegat. "It would be impossible to build such a site in the high mountains if the substrate was not fractured."

Using a combination of satellite imagery and field measurements, Menegat mapped a dense web of intersecting fractures and faults beneath the UNESCO World Heritage Site. His analysis indicates these features vary widely in scale, from tiny fractures visible in individual stones to major, 175-kilometer-long lineaments that control the orientation of some of the region's river valleys.

Menegat found that these faults and fractures occur in several sets, some of which correspond to the major fault zones responsible for uplifting the Central Andes Mountains during the past eight million years. Because some of these faults are oriented northeast-southwest and others trend northwest-southeast, they collectively create an "X" shape where they intersect beneath Machu Picchu.



The Incas took advantage of pre-existing fractures in local stones to reduce the amount of energy needed to create their master stonework. Photo taken 21 July 2016. Credit: Terri Cook and Lon Abbott

Menegat's mapping suggests that the sanctuary's urban sectors and the surrounding [agricultural](#)

[fields](#), as well as individual buildings and stairs, are all oriented along the trends of these major faults. "The layout clearly reflects the fracture matrix underlying the site," says Menegat. Other ancient Incan cities, including Ollantaytambo, Pisac, and Cusco, are also located at the intersection of faults, says Menegat. "Each is precisely the expression of the main directions of the site's geological faults."

Menegat's results indicate the underlying fault-and-fracture network is as integral to Machu Picchu's construction as its legendary stonework. This mortar-free masonry features stones so perfectly fitted together that it's impossible to slide a credit card between them. As master stoneworkers, the Incas took advantage of the abundant building materials in the fault zone, says Menegat. "The intense fracturing there predisposed the rocks to breaking along these same planes of weakness, which greatly reduced the energy needed to carve them."

of the sanctuary in such a high perch also had the benefit of isolating the site from avalanches and landslides, all-too-common hazards in this alpine environment, Menegat explains.

The faults and fractures underlying Machu Picchu also helped drain the site during the intense rainstorms prevalent in the region. "About two-thirds of the effort to build the sanctuary involved constructing subsurface drainages," says Menegat. "The preexisting [fractures](#) aided this process and help account for its remarkable preservation," he says. "Machu Picchu clearly shows us that the Incan civilization was an empire of fractured rocks."

**More information:** Paper 148-9: How Incas Used Geological Faults to Build Their Settlements  
Abstract Link: [gsa.confex.com/gsa/2019AM/webp...ram/Paper330598.html](http://gsa.confex.com/gsa/2019AM/webp...ram/Paper330598.html)



Natural block in Machu Picchu Mountain. The local network of faults and fractures is visible in the blocks of rock integrated into Machu Picchu's structures. Photo taken 6 Nov 2010. Credit: Rualdo Menegat

Provided by Geological Society of America

In addition to helping shape individual stones, the [fault](#) network at Machu Picchu likely offered the Incas other advantages, according to Menegat. Chief among these was a ready source of water. "The area's tectonic faults channeled meltwater and rainwater straight to the site," he says. Construction

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