Study finds advanced 20th-century geometry in 15th-century tilings

23 February 2007

"We're finding widespread evidence for the same approach being used for 500 years across the Islamic world," says Peter J. Lu, a graduate student in physics. "Again and again, girih tiles provide logical explanations for complicated designs." Photo: Stephanie Mitchell/Harvard News Office

Intricate decorative tilework found in medieval architecture across the Islamic world appears to exhibit advanced decagonal quasicrystal geometry -- a concept discovered by Western mathematicians and physicists only in the 1970s and 1980s. If so, medieval Islamic application of this geometry would predate Western mastery by at least half a millennium.

The finding, by Peter J. Lu at Harvard University and Paul J. Steinhardt at Princeton University, will be published this week in the journal *Science*.

"We can't say for sure what it means," says Lu, a graduate student in physics at Harvard's Graduate School of Arts and Sciences. "It could be proof of a major role of mathematics in medieval Islamic art or it could have been just a way for artisans to construct their art more easily. It would be incredible if it were all coincidence, though. At the very least, it shows us a culture that we often don't credit enough was far more advanced than we ever thought before."

Breathtakingly elaborate geometric tiling is a distinctive feature of medieval Islamic architecture throughout the Middle East and Central Asia. Art historians have long assumed that simpler elements of the patterns were created with elementary tools such as straightedges and compasses. But there has been no explanation for how artists and architects could have created the unmistakably complex tile patterns adorning many medieval Islamic edifices.

"Straightedges and compasses work fine for the recurring symmetries of the simplest patterns we see," Lu says, "but it probably required far more powerful tools to fully explain the elaborate tilings with decagonal symmetry."

While it's possible to create these patterns individually with basic tools, they are incredibly difficult to replicate on a larger scale without generating extensive geometric distortions. The most complex medieval Islamic tilings have little such distortion, leading Lu to believe more is at play.

"Individually placing and drafting hundreds of decagons with a straightedge would have been exceedingly cumbersome," Lu says. "It's much more likely these artisans used particular tiles that we've found by decomposing the artwork."

These tiles, dubbed "girih tiles" by Lu and Steinhardt, consist of sets of five contiguous polygons (a decagon, pentagon, diamond, bowtie, and hexagon), each with a unique decorative line pattern. For medieval Islamic artisans, they may have represented a toolkit for generating huge numbers of distinctive tile patterns without the lengthy, painstaking, and often flawed process of creating each line segment individually.

These girih tiles may have been used to generate a wide range of complex tiling patterns on major buildings from medieval Islam, including mosques in Isfahan, Iran, and Bursa, Turkey; madrasas in Baghdad; and shrines in Herat, Afghanistan, and Agra, India.

In some cases, Lu found girih tiles used to create patterns of two distinct scales on medieval Islamic buildings. This approach generates infinite patterns with decagonal symmetry that never repeats -- also known as a quasicrystalline tiling, a phenomenon first described in the West in the 1970s by famed British mathematician Roger Penrose and more fully explained by Steinhardt and Dov Levine over the past 30 years.

In addition to examples on medieval structures that are still standing, Lu has been able to match his girih tiles with drawings in 15th-century Persian scrolls drafted by master architects to document their techniques.

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Source: Harvard University

APA citation: Study finds advanced 20th-century geometry in 15th-century tilings (2007, February 23) retrieved 25 May 2019 from https://phys.org/news/2007-02-advanced-20th-century-geometry-15th-century-tilings.html