# Scientists reveal the magnificent complexity of the Alhambra

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Before a building can be properly restored, rebuilt or even maintained, architects need to have a good understanding of how it was constructed and what methods were used. That's especially true for historical

monuments with a unique type of architecture, like the Alhambra in Granada, Spain.

Ignacio Ferrer Pérez-Blanco and Marie-Pierre Zufferey, two scientists from the Laboratory of Numeric Cultures for Architectural Projects (CNPA) within EPFL's School of Architecture, Civil and Environmental Engineering (ENAC), have studied one of the Alhambra's main architectural features: muqarnas. These three-dimensional structures are made up of dozens of individual elements that can be arranged in an infinite number of ways. They were first used in the 9th century and have become a hallmark of Islamic architecture, found in Sicily, Iran, Morocco, Syria, Iraq and Egypt, as well as at the Alhambra in Spain.

## Using computer models to help preserve monuments

Despite how widely muqarnas were used, there's little information about them in the literature. Only a handful of reference documents—including two 17th century manuscripts (written by Fray Andrés de San Miguel and Diego López de Arenas) and a study published in 1842—contain descriptions of how their complex shapes, patterns and proportions were designed. However, in order to preserve these extraordinary structures, today's architects must be able to comprehend them fully and refer to documented research. "Just think about the monuments that were destroyed at Palmyra in Syria," says Prof. Bernard Cache, head of the CNPA. "We'll be able to restore only those for which computer models are available." Pérez-Blanco adds that the Alhambra complex is located in the most seismically active region in Spain.

## Combining ancient documents with digital technology

To identify the steps involved in building muqarnas and pinpoint which

data are needed, the EPFL scientists began by comparing the information in the two manuscripts with each other and with five of the muqarnas column capitals in the Alhambra. They visited the site in Granada and collected images with a 3D scanner, then developed computer models of the capitals using photogrammetric methods. Based on these computer models, they sculpted four of the muqarnas capitals out of stone in order to test out different methods. "The sculpting process was really important so we could understand all the different steps involved and the geometric problems the architects had to solve," says Pérez-Blanco.

## Astonishingly complex, with a previously unknown, asymmetric element

The scientists compared what they learned from the above process with the steps described in the manuscripts. They found that the manuscripts contained some information that was either incomplete, only partially right or entirely wrong. "We identified a total of 16 different 3D elements in the muqarnas, whereas previous research had described just seven," says Pérez-Blanco. "And we discovered a new asymmetric element that had never before been documented." The scientists had to use twice as many different elements as what was specified in the literature along with alternative proportions to sculpt the muqarnas capitals.

The five capitals they chose were just a small sample of the dozens of muqarnas—comprising thousands of individual elements—contained in the Alhambra, such as those in the Hall of the Ambassadors and the Hall of the Two Sisters.

The scientists' study showcases the muqarnas' complexity and documents their architectural elements, thereby enriching our knowledge of this

piece of world heritage. It also makes data available electronically for further research. Their method and findings, published in *Muqarnas*, can be used as a starting point for investigating more complicated patterns and better understanding the formal language expressed in the muqarnas of the Alhambra and other western monuments.

**More information:** StudyL brill.com/view/journals/muqj/3 … /article-p357_11.xml

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