

# Muons to study the fortress wall of Xi'an, an ancient city in China

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**In news**– As per a new study, researchers are examining the fortress wall of Xi'an, an ancient city in China, by using tiny outer space particles called muons that can penetrate hundreds of metres of stone surfaces.

## **Key highlights of the study-**

- The study titled as 'High-precision muography in archaeogeophysics: A case study on Xi'an defensive walls', has been conducted by a team of scientists from Lanzhou University, China, and China Institute of Atomic Energy.
- **Xi'an's wall is 12 metres high and 18 metres thick. To analyse this 14 kilometres long rampart, researchers deployed a technique called muon tomography or muography, which uses muons to generate three-dimensional images of such large structures.**
- **These particles have helped them find small density anomalies,** which are potential safety hazards, inside the wall.
- Although muon tomography was first used in the 1960s, it has only recently found widespread utilisation among researchers, particularly in the field of archaeology.
- **With unique advantages, muography has gained increasing attention from archaeologists as a novel and innovative tool to investigate large-scale archaeological sites.**
- **This approach may be especially helpful for identifying endangered cultural relics and monuments.**

## **What are muons?**

- **Muons are subatomic particles raining from space.**
- They are **created when the particles in Earth's atmosphere collide with cosmic rays** – clusters of high-energy particles that move through space at just below the speed of light.
- About 10,000 muons reach every square metre of the Earth's surface a minute.
- **These particles resemble electrons but are 207 times as massive.** Therefore, they are sometimes **called "fat electrons"**.
- Because muons are so heavy, **they can travel through hundreds of metres of rock** or other matter before getting absorbed or decaying into electrons and neutrinos.
- **In comparison, electrons can penetrate through only a few centimetres. Muons are highly unstable and exist for just 2.2 microseconds.**

### What is muon tomography or muography?

- Muography is **conceptually similar to X-ray but capable of scanning much larger and wider structures**, owing to the penetration power of muons.
- As these high-energy particles are naturally produced and ubiquitous, all one needs to do is place a muon detector underneath, within or near the object of interest.
- The detector then tracks the number of muons going through the object from different directions, to form a three-dimensional image.
- The image is then compared with a muon image of the "free sky." This indicates how many muons have been blocked.
- The final picture is essentially a shadow of the object, in the light of cosmic muons.

### Muons and archaeology-

- **The technique was first used in the late 1960s**, when Nobel Laureate and US experimental physicist Luis Alvarez joined hands with Egyptologists to search for hidden chambers in the Pyramid of Khafre, Giza. Nothing was found at the time.
- However, in 2017, modern archaeologists repeated the experiment with more sophisticated and advanced muon detectors and stumbled upon a major finding.
- By placing several detectors in the queen's chamber and in an adjacent corridor within the pyramid and at its base on the north side, **the archaeologists were able to discover a previously unknown chamber at least 30 metres long.**
- **It was the first major inner structure to be found in the pyramid since the 19th century.**
- Much like the 2017 experiment, scientists of the latest study also used a muon detector, called CORMIS (Cosmic Ray Muon Imaging System), to examine the wall of Xi'an city.
- To collect enough data for scanning the whole structure, they deployed six detectors for a week at a time.
- The survey data are carefully processed with advanced statistical methods newly introduced in muography, and the results indicate density anomalies inside the rampart with unprecedented levels of precision.

### Uses of muography beyond archaeology-

- Apart from archaeology, muography has found use in **customs security, internal imaging of volcanoes and others.**
- Around 2015, **scientists used the technique to look inside the Fukushima nuclear reactors after the 2011 earthquake and tsunami in Japan.**
- As the site was highly radioactive, they put the two muon detectors in 10 centimetres thick boxes to protect them from radiation and then carried out the scanning.

- **Muography is also being used by researchers to analyse Mount Vesuvius, a volcano in Italy.**
- According to a 2022 study, with the help of this technique, researchers are trying to understand the finer details of the volcano's internal structure.