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# 3D Reconstruction and Virtual Modeling of The Ancient Khazarasp Monument

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**ABSTRACT**

***Objective:*** *This research focuses on identifying Khazarasp's architectural and construction traits during the Archaic and Antiquity periods to develop precise 3D models of this archaeological site.* ***Method:*** *Utilizing modern technologies like GIS and 3Ds Max allows for the creation of virtual museums and advances research in historical geography.* ***Results:*** *The city's early history is marked by cultural layers from the first half of the 1st millennium BC, featuring fortress walls with distinctive arrow-shaped loopholes, rectangular pilasters, and square towers. Given the high groundwater levels threatening its preservation, the paper argues that 3D reconstruction and virtual modeling are essential, non-invasive methods for conserving, studying, and showcasing this cultural heritage.* ***Novelty:*** *Khazarasp is one of Central Asia's oldest cities, strategically positioned along the southern border of the Khorezm oasis in Uzbekistan.*

## INTRODUCTION

Khazarasp is widely recognized as one of the five major ancient cities of Khorezm. Located on the right bank of the Amu Darya River, it held strategic importance for the entire Khorezm oasis, serving as a fortified eastern outpost. Known historically as the "Golden Gate of Khorezm," the "Fortress of Solomon," or the "Fortress with a Thousand Horsemen," its name comes from the Persian words "hazar" (thousand) and "asp" (horse) [1]. Khorezmian rulers kept an elite cavalry and infantry unit in this fortress, which also contributed significantly to regional trade and economic growth [2].

While the precise founders of the fortress are still debated academically, archaeological evidence confirms that the settlement was well-established by the 5th century BC, making it about 2,700 to 2,800 years old [3, 4]. Today, the site remains as a large kurgan (mound) on a flat terrain. The fortress's architecture is strongly influenced by local traditions, representing a period when Zoroastrianism was the main spiritual belief of the area [5, 6].

Although Khazarasp holds an important place in the region's cultural heritage and is linked to UNESCO World Heritage efforts, its physical remains are under serious environmental threats, especially from high groundwater levels. Protecting its ancient architecture, fortifications, and surrounding landscape calls for innovative solutions. This

study suggests using 3D modeling to virtually rebuild Khazarasp, helping to bridge the gap caused by physical decay and the need for preservation [7].

## RESEARCH METHOD

This study mainly draws on materials from the major archaeological excavations at the Khazarasp site, conducted during two key periods: 1958–1960 and 1996–1999. To determine the age of the city, its developmental stages, material culture, and the state of its defensive walls, archaeologists excavated stratigraphic trenches and pits at nine different site locations.

This research's methodological framework uses an interdisciplinary approach, blending traditional archaeological stratigraphy with cutting-edge computational and geospatial technologies.

Data acquisition relied on our empirical foundation, incorporating published reports, structural measurements, and artifact typologies from previous excavations.

Geospatial Mapping: GPS (Global Positioning System) and GIS (Geographic Information System) technologies were employed to illustrate the spatial distribution of the ruins, historical street layouts, and the 12 remaining towers.

3D Virtual Reconstruction: Using Autodesk 3ds Max, virtual models of the fortress – including walls, towers, gates, and internal features were created. The modeling process was primarily based on architectural extrapolation, drawing on ancient Khorezmian construction principles like pakhsa (rammed earth) and mudbrick.

## RESULT AND DISCUSSION

### *Results*

The stratigraphy of the archaeological trenches revealed three distinct construction periods, which serve as the chronological basis for the 3D modeling phases.

**The First Period (Archaic Era: 1st half of the 1st millennium BC)**

The lowest cultural layers identified at the site represent the early fortification of Khazarasp. Notably, excavations could not reach the absolute base (virgin soil) due to the intrusion of high groundwater [8, 9]. However, findings revealed formidable fortress walls intersected by arrow-shaped loopholes and decorated with rectangular pilasters. The exterior walls and corners were reinforced with square and rectangular towers. The 3D reconstruction of this phase emphasizes the rigorous geometric symmetry characteristic of early Khorezmian defensive architecture [10].

**The Second Period (Antiquity: 1st–4th centuries AD)**

During the second period, the entire fortress underwent a massive structural upgrade. The exterior was enclosed by a powerful brick "shell-wall," creating a robust plinth upon which a mudbrick superstructure was erected *(see Figure 1 and Figure 2)*[6]. The barrier wall continued to function effectively. Ceramic artifacts recovered from these horizons confirm its dating to the $1^{st}$-$4^{th}$ centuries AD, while broader archaeological finds indicate sustained interaction with the Achaemenid Empire and the Greco-Bactrian

Kingdom [11, 12]. The 3D models for this era focus on the enhanced fortification layers and the expanded urban footprint.

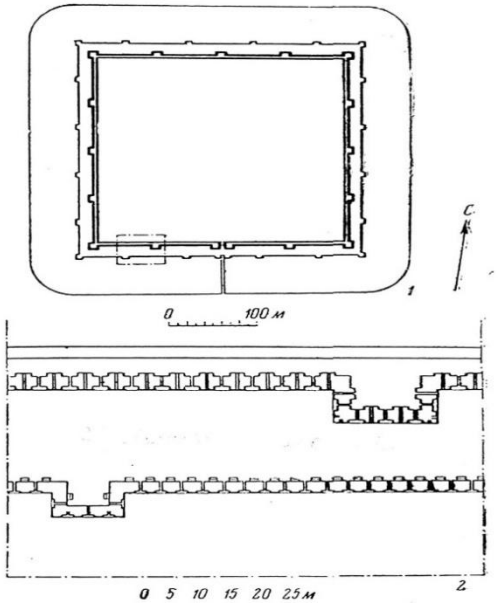


**Figure 1.** Plan of the early antique period fortress (1) and detail of the plan (2). Reconstruction

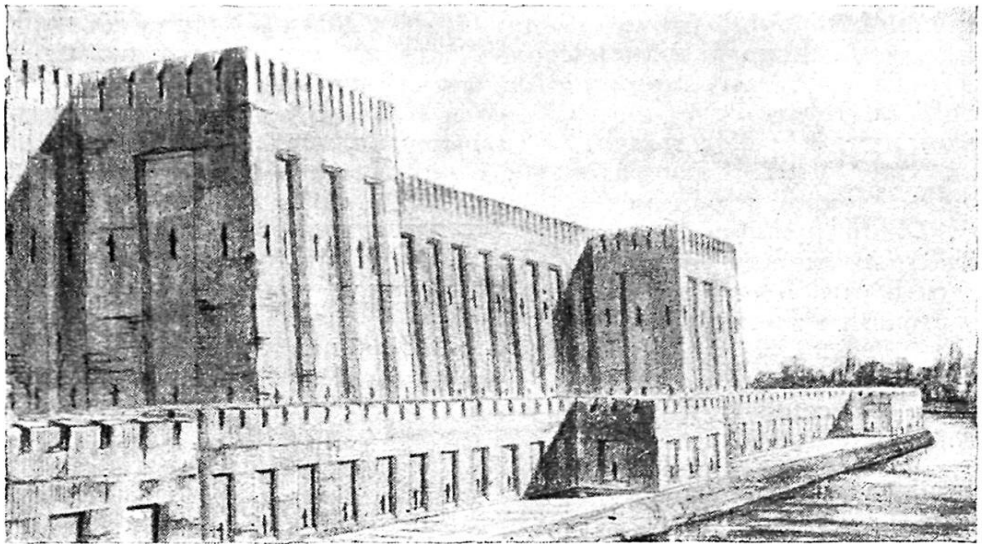

**Figure 2.** Fortress walls of Khazarasp of the early antique period. Reconstruction

**The Third Period (Middle Ages: 4th–12th centuries)**

Urban life continued intensely through the 4th and 5th centuries, especially near the gate areas. By the early 8th century, Khazarasp was recognized as one of Khorezm's three largest and most heavily fortified cities. Medieval builders built a new defensive perimeter on top of the ancient foundations, enclosing a rectangular area.

Today, 12 towers from this era remain, with the most notable being the 12-meter-high southeastern corner tower called Dev-Solgan. The city was encircled by an open rectangular moat, a remnant of the ancient canal system [13]. Excavations of layers from

the 11th–12th centuries revealed a detailed urban layout: streets connecting the western and eastern gates, craft districts such as jewelers and merchants, a central market covering over two hectares, residential houses, caravanserais, and bathhouses.

***Discussion***

Archaeological findings indicate that Khazarasp developed in an organized manner over many centuries, rather than chaotically. Encircled by pakhsa and mudbrick walls, it served both as a secure military fortress and a vibrant hub for artisans, as shown by the pottery kilns within the city walls. This ongoing urban development highlights Khazarasp as a unique example of a continuously evolving Central Asian cityscape [14, 15].

However, environmental factors, mainly the high groundwater level, severely hinder the physical conservation of Khazarasp, as it quickly damages mudbrick structures. Consequently, using 3D modeling is not just illustrative but essential for scientific preservation.

Reconstructing the Archaic and Middle Age periods using 3ds Max enables researchers to visualize undocumented historical and cultural processes. It offers essential data for interdisciplinary areas like historical geography, paleocology, and demographic mapping [16]. Additionally, 3D models of temples, caravan-serais, and nearby estates such as Sandiklitepe support a detailed reconstruction of the entire Khazarasp micro-oasis.

From both educational and economic standpoints, these 3D models are essential. They lay the groundwork for developing virtual museums, improving contemporary educational resources, and unlocking the region's untapped tourism opportunities.

## CONCLUSION

**Fundamental Finding:** Khazarasp exemplifies the architectural and urban ingenuity of ancient Khorezm, serving as a monumental testament. **Implication:** Creating a 3D model of Khazarasp offers a strong foundation for its preservation, detailed research, and worldwide promotion of this significant historical site. **Limitation:** Due to continual natural degradation threatening its physical remains, transitioning to digital preservation becomes essential. **Future Research:** To unlock this potential, we highly recommend starting and funding a core scientific project focused on detailed 3D mapping and virtual reconstruction of the ancient monuments located in the Khazarasp historical micro-oasis.

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