

Survey and analysis of hieroglyphic inscriptions in the postern of Yerkapi – Hattusa

Giovanni Varriale*, Andreas Schachner**, Massimiliano Marazzi***, Vincenzo Morra*, Celestino Grifa****, Leopoldo Repola*

*Department of Earth Sciences, Environment and Resources, University of Naples Federico II, Via Cinthia, Naples, 80126, Italy,

**Deutsches Archäologisches Institut – Istanbul

*** Suor Orsola Benincasa University

**** Department of Science and Technology, University of Sannio, 82100 Benevento, Italy

Yerkapi is one of the most iconic monuments of the archaeological site of Hattuša (Schachner, 2024), the capital of the Hittite empire (17th-12th century BC), located approximately 200 km east of Ankara. It consists of a man-made hill up to 40 m high and almost 250 m long. The city wall, which runs over the rampart, has a gate that was originally decorated with four sphinxes. An underground tunnel, a so-called postern, runs precisely under this gate. The elaborate building, visible from afar, whose Hittite name is not yet known, was not used for defence purposes. Rather, it was most likely part of cultic ceremonies emanating from the temples located to the north in the city. The recent discovery of 249 painted hieroglyphs, found by Dr. Bülent Genç on the walls of the posterula (Schachner et al., 2023, pp. 58-79), led the international team of scientists from various disciplines, under the direction of Prof. Dr. Andreas Schachner from the German Archaeological Institute in Istanbul, to undertake further research. With the permission of the Ministry of Culture and Tourism of the Republic of Turkey, a team of architects and geologists from the Department of Earth Sciences, Environmental and Resource of the University of Naples Federico II and the Department of Science and Technology of the University of Sannio was assembled to develop a plan for digitisation and in situ mineralogical analysis. This was part of the international cooperation project 'Project Hattuša'. The objective of this multidisciplinary study is to develop a new methodology for the digitisation and detailed analysis of hieroglyphic inscriptions in artificial tunnels. This methodology will enable the interpolation of information from different fields of research into a single data management space, thus providing a profound understanding of complex architectural spaces.

The 3D digitisation campaigns at Yerkapi were conducted utilising a DJI Mini 3 Pro drone, TOF Riegl VZ 400 laser scanner and Artec structured light scanner. These activities covered the entire monument, the Sphinx Gate and the postern. The survey phases included the localisation of targets within the area (by means of a total station), in order to link the new models to the local reference system defined by the German Archaeological Institute. Subsequently, the data were imported into a specific 3D modelling software, where high-resolution polygonal models were produced. In this digitisation programme, the tunnel played a prominent role, with specific survey procedures being carried out. The initial acquisition phase comprised 13 scan positions, with the objective of aligning the data related to the wall structures and the Sphinx Gate. This was necessary in order to precisely locate the tunnel in relation to them and the related hieroglyphic inscriptions. A second, more detailed survey phase, with an acquisition sequence at intervals of 1-1.5 metres, enabled the postern blocks and their hieroglyphs to be precisely delineated in a single high-resolution model, with reduced shadow areas due to the considerable irregularity of the boulders. Furthermore, the presence of the 249 hieroglyphs in the postern necessitated the development of an articulated digitisation plan. The plan aimed to document the geometries and colours of the signs, the shape of the rocks on which they stand, the surface characteristics of the blocks, and to identify possible levels of preparation of the natural surfaces. Additionally, the mapping of the sequence of geoglyphics within the architectural space was also considered. Several 3D scanning of the areas in proximity to the hieroglyphs were conducted using a Artec structured light scanners. Photogrammetric data acquisition was also carried out using a Canon EOS camera with the objective of identifying the progression of the inscriptions on the orthophotos. The orthophotogrammetric models were then aligned by homologous points on the general reference model.

Furthermore, the hieroglyphs underwent diagnostic analysis for the study of geomaterials, with the objective of discerning the composition of the pigment utilized in their painting. Analyses were conducted on four sample inscriptions, which permitted the determination of the textural, mineralogical, and chemical characteristics of the red figures.

Each model, produced using a distinct instrument, was processed individually with a uniform methodology. The point clouds were initially meticulously segmented and manually removed of residual noise. Based on the specific point density of the analysed layer, filters were then employed to reduce the degree of noise that could not be removed manually and to reduce outliers. Once the digital models of Yerkapı's architectural features have been generated, they were imported into the CAD environment (Rhinoceros), where they were rendered and used for the production of drawings and analytical models necessary for the detailed study of the monument. With regard to the high-resolution 3D Artec models produced during the 2023 campaign, texture editing procedures were performed. The brightness, saturation, hue, contrast and gamma correction parameters were modified in a combined manner in order to better characterise the geometries of the hieroglyphs in false colours.

Images produced in orthophotogrammetric and perspective view (to facilitate the identification of the marks on the complex rock surfaces) were used as a basis for the vectorised representation of the painted figures. This approach enabled a comparative analysis of the curvatures on a mathematical basis (Marazzi Repola, 2024).

The digitisation of the architectural structures of Yerkapı, the tunnel and the inscriptions permitted the management of three-dimensional data at different levels of definition in a single virtual space. This enabled the hieroglyphs to be analysed and located with precision in the postern in relation to the Sphinx Gate above, through the use of special data management and visualisation procedures. This approach enabled the reading of certain hieroglyphic sign geometries that could not be visualised with the naked eye, and to associate them with precise petrographic analyses. A sequential interpretation of the hieroglyphs within the architectural context was conducted. The results of these investigations will be used to provide a new interpretation of the possible uses and symbolic meanings of the monument.

References

Marazzi M., Repola L. (2023). 'The New Painted Hieroglyphic Inscriptions of Hattusa: Overview and Status of Research', in: *News from the Lands of the Hittites*, Volume 7.

Schachner, A., Alparslan M., Bolatti Guzzo N., Genç B., Marazzi M., Repola L. (2023). 'Die Hieroglypheninschriften in der Poterne von Yerkapı – erste Ergebnisse', in: *Die Ausgrabungen in Boğazköy-Hattuša 2022*, AA 2023/1.

Schachner, A. (2024). 'A new look at an ancient city: An outline of the chronological and urban development of the Hittite capital Hattuša', in: *Anatolian Studies*, doi:10.1017/S0066154624000012