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GIZA PLATEAU MAPPING PROJECT

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Following the successful start of a 3D laser scanning program on the Giza Plateau in 2023, Ancient Egypt Research Associates (AERA) continued work in two sessions in 2025 led with Dr. Søren Sindbæk of Aarhus University and his team from the Organization of Danish Museums. The goal was to survey the bedrock floor along the eastern, northern, and western sides of the Great Pyramid, along with the two Khufu boat pits on the pyramid's southern side. This work included scanning the cover blocks of the eastern boat pit still located at the pyramid, as well as those from both pits now on display at the Grand Egyptian Museum (GEM). During a short fall 2024 season, we also continued analysis in the AERA field lab, a Ministry of Tourism and Antiquities (MoTA) magazine near the Great Pyramid, on the everyday material-culture remains retrieved by our excavations at the Giza Plateau.

GREAT PYRAMID BUILDERS' MARKS: 3D SCANNING

In 2023, the MoTA gave AERA permission to survey the floor to the south of the Great Pyramid (fig. 1). This area became available for study after the Khufu boat museum—built above the eastern pit in the 1970s to house the boat reconstructed from pieces interred in it—was removed from the site in 2021 and the boats themselves were moved to the GEM for permanent display. That survey complemented and completed our 2015–16 survey of more than 2,900 builders' marks and other features cut into the bedrock floor on

Figure 1. In-progress laser scanning survey of the southern pavement of the Great Pyramid in 2023. View to the west.

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the other three sides, an undertaking that was part of a collaboration between AERA and the Glen Dash Foundation Survey project.

In January 2024, the Danish team used a Trimble SX10 scanning total station to scan and compile a 3D record of millions of points on features of the southern floor related to the landscaping, leveling, and layout of the base of the Great Pyramid by Khufu's builders. These features include lever sockets, rock-cut holes, quarry channels, and emplacements for slabs fitted together in jigsaw patterns to pave a court encircling the pyramid on all sides, in addition to more modern features. The data preserve a facsimile of the features and enable us to visualize how the pyramid builders leveled and shaped the building site. The 2024 work showed the potential of the scanning to capture even barely visible features that are exposed to intense tourist traffic, sand and wind erosion, and maintenance operations at the plateau. The success of the 2024 scanning prompted our return to survey the floor on the pyramid's three other sides in February 2025 to enhance the record compiled in 2015–16. In advance of this endeavor, AERA's workers cleared sand and debris from the Great Pyramid's floor to the east, north, and west to expose the structure's foundation platform, remaining casing, pavement, and bedrock floor to a width of more than 10 m from the pyramid's baseline, taking in the court and the foundation of its enclosure wall (figs. 2–3).

In connection with the survey, a special effort was made to scan the so-called trial passages on the eastern side of the pyramid (fig. 4). These passages, cut in bedrock, are thought to have been carved as a test or model for the juncture of the ascending passages, horizontal passage, and grand gallery built in masonry in the interior of the pyramid. The trial passages exhibit cross-section dimensions, alignment, and angles exactly like the passages inside the pyramid. During our Great Pyramid Temple Project (2020–22), we surveyed these passages as part of our documentation of Khufu's pyramid complex. Our laser scan of the passages

Figure 2. Sayed Salah Abd el-Hakim and Sarah Qvistgaard preparing to scan. View to the south.

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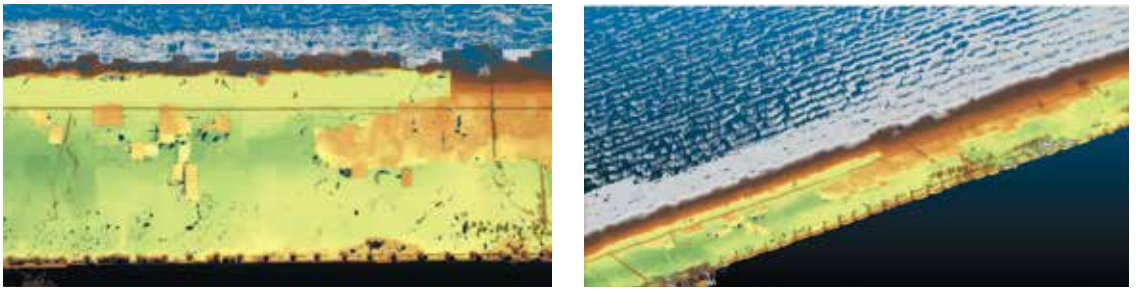

Figure 3. Left: A section at the middle of the western side of the Great Pyramid. The pavement is colorized to emphasize height differences between 59.5 m and 62.0 m above sea level (green and brown, respectively). This colorization highlights the subtle sculpting of the bedrock to drain rainwater toward the corners of the pyramid (deep green), as well as the level of individual slab sockets (light green) and surviving slabs (light brown) from the pavement. Unprocessed point cloud data. Right: Bird's-eye view of the middle section of the western side of the Great Pyramid. The pavement is colored as in the left image. Unprocessed point cloud data.

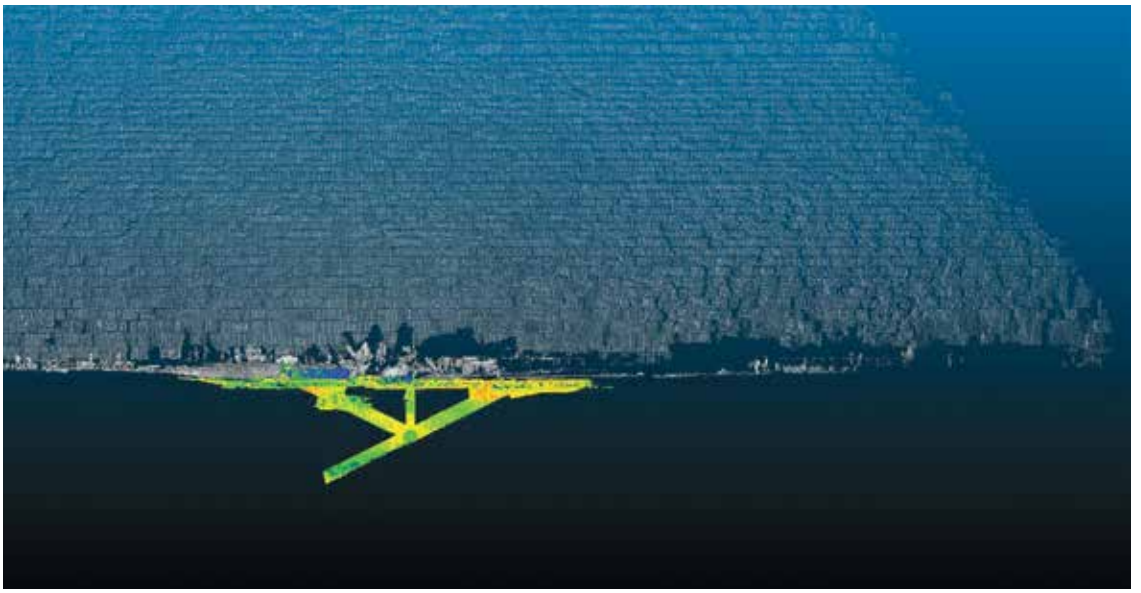

Figure 4. Scan of the subterranean "trial passage" on the eastern side of the Great Pyramid. Unprocessed point cloud data.

this season built on that work and, for the first time, resulted in a 3D view of these intriguing subterranean corridors—a model of ancient engineers' planning and procedure.

KHUFU BOAT PITS: 3D SCANNING

During a second period of work in May and June 2025, we returned for further scanning of Khufu's two boat pits and their cover blocks (figs. 5–7). These prominent features are located immediately outside the pyramid court and enclosure wall. An ancient, secondary wall of broken stone ran over the covered pit. AERA team members scanned these features in collaboration with Dr. Eissa Zidan, Director of MoTA Conservation, and Ms. Samar Mahmoud, Senior Archaeology Consultant at the GEM. The goal is to produce a 3D model of the boat pits and their cover blocks, as well as an animation that shows the blocks in

Figure 5. Khufu boat pit scanning team, June 2025. View to the west.

Figure 6. View of the two boat pits on the southern side of the Great Pyramid, June 2025.

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Figure 7. Location of the two boat pits and the eastern boat pit cover blocks stored at the plateau (some blocks are also still in situ over the pit, and some have been moved to the GEM for display). Image by Rebekah Miracle, AERA GIS.

their original positions (guided by ancient graffiti in red and black paint, some giving directions), for the display of the Khufu boats in a special GEM exhibit hall. Visitors will be able to see the original positions of the blocks, how they were removed, and how the boats were buried and uncovered.

After a thorough cleaning (fig. 8), we used a Trimble X9 laser scanner to map the pits and their cover blocks. The Trimble X9 is a high-speed laser scanning system operated remotely with a tablet that allows the subject scanned to be seen in real time. In addition to laser scanning, the machine also photographs the scan area. We completed scans of the cover blocks on display at the GEM as well (fig. 9).

KHUFU BOAT PITS: GRAFFITI AND BUILDERS' MARKS

As part of the boat pit work, Dr. Aurore Ciavatti (Institut français d'archéologie orientale) examined the builders' marks in the eastern boat pit and on its associated cover blocks. The discovery and exploration in 1954 of the eastern boat pit revealed numerous marks both on the faces of the cover stones and on the walls of the pit. These data were documented at the time of their discovery, and an extensive publication of them was initially planned, but much of the data remain unpublished; in 1971, Abdel Moneim Abubakr and Ahmed Youssef Mustafa published only nineteen of the builder's marks. Even though these marks are laconic, they provide valuable information about the logistical organization of the workers and the construction process of the pyramid complex. They also tell us about the chronology of the sealing of the pit, which took place at the same time as Khufu's funeral. These red and black inscriptions are extremely vulnerable to natural erosion. Many of the inscriptions on the cover stones have disappeared or become barely legible, so there was an urgent need to document the remaining inscriptions accurately to preserve the information

Figure 8. Our team cleaning the eastern boat pit, May 2025. View to the east.

Figure 9. Mohamed el-Sayed scanning the boat pit cover blocks on display at the GEM, June 2025. View to the north.

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Figure 10. Unpublished inscriptions on the underside of the cover blocks in the eastern boat pit.

Figure 11. Left: Cover stone E38 on display. Center: Image of cover stone E38 produced using DStretch software, which highlights pigments that are sometimes imperceptible to the naked eye. Right: Inscription on cover stone E38 as published by Abubakr and Mustafa in 1971 (*Beiträge zur ägyptischen Bauforschung und Altertumskunde* 12, 11 fig. 6e).

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and ensure their publication in the future. The cover stones of the eastern boat pit are kept in three locations: the boat pit itself, on display nearby to the southeast, and at the GEM, where some blocks have been arranged above a tunnel so visitors can see the graffiti on the undersides (figs. 6–9).

We gathered all the published epigraphic data (facsimiles, photographs, and lists) so that the inscriptions could be identified on the cover stones and the original numbering of the stones reestablished, as twenty-eight of forty-one stones had been moved (twenty-three for display nearby and five to the GEM). We were able to establish the locations of only eight of the nineteen inscriptions that Abubakr and Mustafa published in 1971 (three of the eight have fully disappeared), in addition to ten triangular marks on the south wall of the pit. The inscriptions on the in situ cover stones (fig. 10) are all unpublished, and Dr. Ciavatti plans to issue a full epigraphic catalog in the future.

To complete this documentation, we first took photos of all the accessible stones to identify the faces likely to contain an inscription, even if imperceptible, by using DStretch software, which highlights pigments that cannot be seen by the naked eye (fig. 11). We then carried out a new photographic and photogrammetric survey of the potentially inscribed stones. Using photogrammetry and textured 3D scanning, technical indications painted on the pits' walls (triangular markers with measurements and guidelines) were also documented. This photogrammetry complements the textured 3D scan of the pits and cover stones.

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AERA field lab team members who participated in the study season included Claire Malleson, lab director; Sarah Hitchens, assistant lab director; Emmy Malek, assistant lab director (and objects); Anna Wodzińska and Mahmoud el-Shafey (ceramics); Johanna Sigl and Mariam Adel (animal remains); Samar Mahmoud (lithics); Nisha Kumar (faience); and Manami Yahata (plaster). We also thank MoTA conservator Mohammed Kamal Sayed.