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Brief Report of the Project of the Second Boat of King Khufu

Sakuji Yoshimura and Hiromasa Kurokochi
Waseda University and NPO Institute of the Solar Boat

Abstract

This brief report summarizes the investigation of the second boat of King Khufu at Giza from 1987 to the present. In the late 1980s the Institute of Egyptology at Waseda University began preliminary investigations, including the first sampling of timbers from the boat. Based on the results of these surveys, plans for safeguarding the second boat were made and site facilities were prepared. In 2010 the pyramid enclosure wall standing over the pit of the boat was excavated, and in 2011 the cover stones of the pit were raised. In 2012 a second sampling of wood was undertaken, and now analyses of the condition of the wood and methods of consolidation are taking place.

In 1954, two boat pits were discovered along the south side of the Great Pyramid of King Khufu at Giza. A large wooden boat about 43 m in length, which had been dismantled and buried in the first pit, was excavated, consolidated, and reassembled by the Antiquities Service. A museum situated over the pit now exhibits the boat.

The pit of the second boat remained unexcavated (Figure 1). A joint Egyptian (Ministry of State for Antiquities) and Japanese (Institute of Egyptology, Waseda University) team is now implementing a project to safeguard the second boat of Khufu. This brief report presents an overview of this project thus far.

Preliminary Investigation

In 1987, an international team supported by the National Geographic Society made a small hole (about 10 cm in diameter) in one of the cover stones sealing the second boat pit and observed inside. This revealed timbers similar to those found in the first pit, and in 1994 a few small samples of wood were taken through this hole.

As a result of subsequent analysis, the following became clear:

a) The pit contained a large number of wooden timbers of a dismantled boat which are similar to those of the first boat.
b) The timbers are in poor condition; analysis revealed a serious decrease of cellulose.
c) The pit is not airtight; analysis confirmed the presence of contamination from the outside air.

The reason for the degradation of the timbers could not be identified, but traces of the inundation of a large amount of water could be seen on the side wall of the pit, and this, it was supposed, had promoted decay of the wood. Although steps were taken to prevent water from entering the pit from the surface, the structural condition of the lower part of the pit is not clear. It is possible that water may seep into the pit from cracks in the lower section. Furthermore, the deteriorated timbers are "laminated" in layers; the conditions of the lower layers of wood are assumed to be critical. Because leaving the timbers *in situ* would cause further decay and destruction, it was decided that the timbers had to be removed from the pit and conserved.

Facilities

In order to raise the timbers from the second pit, the following facilities were prepared.

"Large Hangar"

This tent warehouse, which is lightweight but structurally sturdy, stands over the pit to create a buffer zone (Figure 2).

Air Conditioners and Humidifiers

The humidity inside the pit is about 85 ± 5%. Because rapid drying of the environment will cause damage to the wood, two pairs of air conditioners and humidifiers have been installed to keep the temperature and humidity in the pit constant.

Gantry Crane

A self-propelled gantry crane was constructed over the pit for lifting up keystones and cover stones, which have a maximum weight of about 18 tons. The crane was covered with tent cloth and connected to both of the air conditioners and humidifiers to stabilize the environment in the pit during the opening.

"Small Hangar" (Double Hangar)

After the cover stones had been lifted, the pit was closed again with removable wooden boxes filled with insulators, and the gantry crane was moved aside. The small hangar was then constructed over the pit in order to more finely control the temperature and humidity.

Laboratory and Storage Room

For the conservation work and storing the timbers, a laboratory and storage room are now under construction within the large hangar.

Figure 1: The state of the second boat pit (in 1992)

Figure 2: The large hangar, 20 m in width, 44 m in length, and a maximum 10 m in height

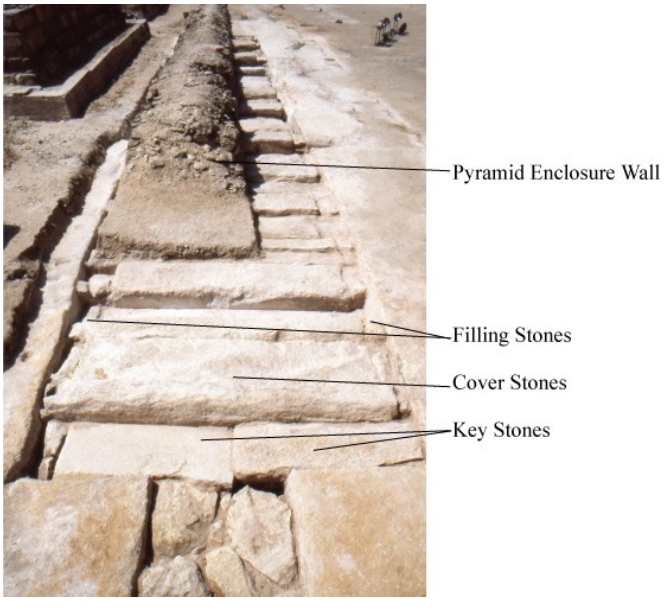

Figure 3: The pit, showing its architectural details and the overlying enclosure wall

Excavation of the Pyramid Enclosure Wall

Part of the original pyramid enclosure wall remained over the pit when the large hangar was constructed (Figure 3). From March to April 2010, this was measured, drawn, photographed, and scanned in 3D before being relocated outside the large hangar.

The Structure of the Wall

A layer of crushed limestone over the cover stones of the pit created a level horizontal surface on which the wall (consisting of layers of different composition) stands.

Figure 4: Diagram of the pit before removal of the cover stones

Finds

From the crushed limestone layer under the wall, a large number of small pieces of wood, charcoal, tiny pieces of copper, and hammer stones with copper on their surfaces were recovered. They are presumed to be discarded material and tools from the sharpening of chisels. The pottery found resembles examples from the Fourth Dynasty.

The wall itself yielded a variety of objects. Pieces of limestone relief probably came from mastabas in the surrounding cemeteries, a fragment of calcite with a hieroglyphic inscription was apparently part of a funerary object, and animal bones seemed to be offerings for the surrounding mortuary temples and tombs. Based on similar examples, the pottery found in the wall could be dated from the Fourth to the Sixth Dynasty.

Date of the Wall

In the previous studies the date of this pyramid enclosure wall has been determined to be between the Fourth Dynasty and the end of the Old Kingdom. No evidence to fix the date of the wall clearly was found in the project's excavation, but, judging by the pottery, the crushed limestone layer and the wall could be dated to the Fourth Dynasty and from the Fourth to Sixth Dynasty, respectively.

Graffiti

Graffiti written in red or black ink were found on the surfaces of 19 cover stones and a filling stone that filled the space between cover stones and bedrock. It is notable that among these was a cartouche with the name of Khufu in red ink, written on the upper surface of one of the cover stones. This is in contrast to the case of the first boat pit, in which 18 cartouches bearing the name of Djedefre were found, but none of Khufu.

The graffiti were preserved with a 5% acetone solution of Paraloid B72 by a conservator of the Ministry of State for Antiquities.

Lifting the Cover Stones

In May 2011, international specialists attended a workshop to discuss the method and equipment for lifting up the cover stones (Figures 3 and 4). Drawing from the suggestions of this meeting, from June to August of that year, Egyptian and Japanese stone masons lifted the cover stones and removed them from the large hangar (Figure 5).

The pit had been sealed in antiquity with two keystones at the eastern end and 39 cover stones (Figure 4). Spaces between the cover stones and bedrock were filled with filling stones (Figure 3). The gantry crane lifted the keystones and 35 cover stones, leaving 4 cover stones *in situ* at the eastern end as original samples. After the cover stones were lifted, the pit was closed again with 60 wooden boxes, each 4 m in length, 50 cm in width, and 15cm in height. These were filled with insulation, and their faces were treated with a fungicide to prevent contamination of the timbers below.

During the lifting, a survey of each cover stone, filling stone, and pit was done. Graffiti classified as follows was found on the surfaces of removed keystones, cover stones, and 193 filling stones:

a) graffiti that included a name of a king: 4 of Khufu, 11 of Djedefre (these graffiti were painted on the surfaces of the cover stones);
b) year in the reign, season, month, and day;
c) measurement of the stone;
d) signs and marks;
e) reference line for construction.

The Second Sampling and Analyses

In February 2012, a second sampling was conducted to obtain specimens from the upper layer of timbers (Figure 6), so that analysis of the condition of the wood could be performed in detail and methods of consolidation could be tested. This work was undertaken in both Egypt (primarily at the Grand Egyptian Museum Conservation Center) and Japan (at the Gangoji Institute for Research of Cultural Property).

After removal of the gantry crane to the western end of the pit, the "small hangar" was built over the pit to control the environment when it was opened. The second sampling was performed in this small hangar. Before the sampling, the original situation in the pit was recorded by 3D scanning and photography of the upper layer of timbers.

Samples were taken from 22 loci. The specimens were 15 pieces of wood from 15 different loci, 5 pieces of mortar from 2 loci, 2 pieces of textile from one locus, 2 pieces of rope from locus, and one piece each of metal, cloth, and insect nest, each from a different locus.

Subsequent analysis of the wood includes: identification of species; determinations of compressive strength, moisture content, specific gravity, and composition (cellulose, hemicelluloses, lignin, and ash); X-ray diffraction; Fourier transform infrared spectroscopy (FT-IR); microbiological analyses; C14 dating; tests for consolidation; and so forth.

Afterword and Acknowledgements

Now preparation for publication of the detailed data and results of the study is underway. In November 2012, an international seminar was held at the Grand Egyptian Museum Conservation Center to discuss the results of the analyses and future plans for the project. It is hoped that there will be an opportunity to report the results of the seminar.

We would like to extend our deep thanks to the Egyptian authorities whose gracious cooperation facilitated this project: Ahmed Khadry (Secretary General of Egyptian Antiquities Organization during the preliminary investigation in 1987), Mohammed Ibrahim Bakr (Secretary General of Egyptian Antiquities Organization during the preliminary investigation in 1992-93), Zahi Hawass (Secretary General of the Supreme Council of Antiquities during the preparation of facilities, excavation of the pyramid enclosure wall, and lifting up the cover stones in 2008-11), Mohamed Ibrahim (Minister of the Ministry of State for Antiquities during the second sampling and analyses in 2012), and Mustafa Amin (Secretary General of the Supreme Council of Antiquities during the second sampling and analyses in 2012).

Figure 5: Lifting a cover stone

Figure 6: A view of the timbers inside the pit, February 2012

We were pleased to be a joint team with the following Egyptian colleagues, who have made important contributions to the project: Ali Asfar (Director of Giza Inspectorate), Afifi Rohim Goneim (Chief Inspector of Giza, Project Leader for the Egyptian side), Hussein Bassir (Director General of Grand Egyptian Museum Conservation Center), Eissa Zidan Abd el-Badea (Grand Egyptian Museum Conservation Center), Ayman Hamed (Engineering Consultant), Hany Hanna (Engineering Consultant), and Diaa el-Din Ahmed (Inspector of Giza).

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Additional Information

Further information may be found at the website of the Nonprofit Organization Institute of the Solar Boat: http://www.solarboat.or.jp/index_e.html.