THE GREAT PYRAMID: THE INTERNAL RAMP THEORY

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Introduction

My involvement with the internal ramp theory is due to Jack Josephson, so I am delighted to be able to contribute this article to his Festschrift. Most of us think of Jack as an art historian, but he also has an engineering degree, and this is primarily an engineering story.

As is well known, the Great Pyramid of Giza is the only member of the Seven Wonders of the Ancient World that remains intact. Serious study of the Great Pyramid began in the seventeenth century, when the Oxford astronomer, John Greaves, visited the pyramid and in 1638 published the first book devoted to it. Greaves, like so many other earlier investigators, believed the Egyptians had advanced knowledge of all kinds of things and encoded this knowledge into the dimensions of the pyramid. During his visit to the pyramid, he took what he believed to be precise measurements (they were considerably off) and discovered the well-like chamber at the base of the Grand Gallery. Greaves’s publication stirred others to visit the pyramid, but the next important discovery was made more than a century later.

In 1765 Nathaniel Davison noticed a three-foot hole at the top of the Grand Gallery. When he climbed through it, he discovered the first relieving chamber above the King’s Chamber. He did not, however, realize that there were four other relieving chambers higher up.

The next discovery inside the pyramid came in 1835, when Captain G. B. Caviglia cleared both the descending passageway and the well discovered by Greaves and found that they connect. It is now generally agreed that the “well” was dug to provide air for the workers excavating the descending passageway. Colonel Howard Vyse conducted extensive explorations in and around the Great Pyramid from 1836-40, making the most important discoveries of the nineteenth century. Finding a crack in Davison’s relieving chamber, he blasted above it and discovered more relieving chambers that he named: Wellington’s Chamber, Lady Arbuthnot’s Chamber, and Campbell’s Chamber. In these relieving chambers, Vyse also found the now-famous graffiti associating Khufu with the pyramid. Also of great importance, he discovered beneath the rubble at the base of the pyramid two of the original casing stones and was thus able to determine for the first time the exact angle of the pyramid’s sides.

Probably the most eccentric of the nineteenth-century investigators was Piazzi Smyth, the Astronomer Royal of Scotland, who believed that the pyramid was basically a Christian monument whose measurements contained Biblical revelations. In spite of his extreme religious beliefs, Smyth was also a capable scientist and in 1864 conducted the most detailed survey of the pyramid up to that time. He even invented a miniature eight-inch camera so he could photograph in the smallest of crevices.

Smyth’s expedition was a remarkable combination of exacting science and delusion. When he first published his findings in 1867, they were universally rejected by the scientific community as the rantings of a religious fanatic. Still, his theory of revelations built into the Great Pyramid did not die easily, and the next surveyor of the Great Pyramid, Flinders Petrie, became interested only because his father was a believer.

Petrie’s father, a mechanical engineer, had read Piazzi Smyth’s book and became infatuated with the Great Pyramid and Smyth’s idea of divine inspiration. Young Petrie grew up hearing about his father’s plans to do a proper survey. For twenty years the father procrastinated, and in the

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1 J. Greaves, Pyramidographia (London, 1646).
meantime, Flinders became a proficient surveyor and conducted the first careful documentation of Stonehenge. In November of 1880, following in the footsteps of Smyth, 26-year-old Flinders Petrie embarked for Egypt accompanied by crates of scientific instruments.

Using a theodolite and a telescope, Petrie used the surveyor’s system of triangulation to take thousands of measurements all over the Giza Plateau. To ensure accuracy, he sometimes took the same measurement a dozen times. Inside the pyramid, he used a plumb line to determine the vertical and measured the walls at various heights to detect if there were even the tiniest of construction errors. Petrie was amazed at the precision of the Great Pyramid’s construction, and his measurements and observations are, until today, the basis of many discussions of the pyramid’s dimensions. Usually level headed, Petrie got carried away when he measured the granite sarcophagus inside the burial chamber. Because granite is so hard, and because the sarcophagus was so finely crafted, Petrie concluded that the ancients had drills and saws embedded with diamonds. Still, his survey is the foundation of much of the later work on the pyramid.

The Crane Theory

There are two basic theories of how nearly two million blocks of stone averaging two and one-half tons were raised during the construction of the Great Pyramid: cranes and ramps. The crane theory has its origins with Herodotus, who mentions that levers were used to raise the blocks. When this theory is discussed, something like the modern Egyptian shadouf is usually imagined. New Kingdom tomb paintings show farmers using shadoufs, so we know they were used in ancient Egypt, at least during the New Kingdom, and quite possibly in the Old Kingdom. However, there are several problems with the crane theory. It suggests that hundreds of these cranes were positioned at various levels of the pyramid to lift the blocks. One problem with this is that a tremendous amount of timber would have been needed for these cranes, and Egypt simply didn’t have forests to provide the wood. Large timbers for shipbuilding were imported from Lebanon, but this was a very expensive enterprise, so importing enough wood for hundreds of cranes would have been impractical. An even greater problem for the crane theory is that there would not have been adequate room on the pyramid to place all these cranes. The size of the pyramid’s blocks tend to decrease in size towards the top; towards the surface of the pyramid sometimes there is only 18 inches of standing room, certainly not enough space for a crane large enough to lift a two-ton stone. So the crane theory can’t adequately explain how the blocks were raised, and this takes us to the ramp theory.

The Ramp Theory

Diodorus of Sicily, writing three hundred years after Herodotus, said, “The construction was effected by means of mounds,” which is almost certainly a reference to ramps. Although Diodorus never suggested what the ramps might have looked like, Egyptologists have speculated about this for years. One version of this ramp theory is that a ramp was built on one side of the pyramid and as the pyramid grew, the ramp was raised so that throughout construction, blocks could be moved up the ramp all the way to the top (fig. 1). The ramp could have a maximum slope of eight percent, as this is about the limit for men hauling heavy blocks. With an eight-percent slope for the ramp and a height of approximately 480 feet for the pyramid, the ramp would stretch for approximately one mile. Although such a ramp is easy to imagine, there are three basic problems with this theory: 1) A mile-long ramp would have approximately the same volume as the Great Pyramid itself, nearly doubling the time needed to build the pyramid. Also, when the three sides of the pyramid that did not have the ramp were completed, then the ramp would have had to be dismantled, and finally, only after the ramp was dismantled could the face it rested against be completed. This too would add years to the project. 2) The pyramid is on a plateau, and it is not clear where one could put a mile-long ramp. 3) The remains of such a huge ramp have never been found. It is inconceivable that something almost as large as the Great

5 Herodotus, History (Cambridge, 1990), Book II, 125.