THE GREAT PYRAMID OF GIZA AS A CONSTRUCTION MINIMIZING THE FRICTIONAL DISSIPATION AND RELYING ON A LABOR CONCENTRATION CAMP.

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Abstract. The great pyramid of Giza as a construction minimizing the Frictional Dissipation and relying on a labor concentration camp. The present article is an attempt to give a significant input, from theoretical physics, into the construction of the great pyramid of Giza at different steps of its construction.

To find out precisely how the great pyramid of Giza was build, we assume that the construction of the great pyramid of Giza has reached a near optimum with respect to the technological level of the ancient Egypt civilization, with respect to the economic size of the ancient Egypt civilization and with respect to the minimization of the Frictional Dissipation during its construction.

With respect to technological level of the ancient Egypt civilization, the Frictional Dissipation is minimized with the following conditions :

01- In order to minimize the dry path length of the pyramid blocks, the water canals inside the mangrove swamps of the Nile Delta could be close as 550 meters from the the bottom of the great pyramid of Giza and only 42 meters lower than it. A raised road made of several rows of pyramid blocks can be used to transports the pyramid blocks from the water canals to the bottom of the great pyramid of Giza. The road elevation makes it possible to effectively counter the progressive covering of the road by sand and dust storms.

02- In order to minimize the dry path length of the pyramid blocks, most of the limestone quarries were close as 550 meters from the bottom of the great pyramid of Giza and only 42 meters lower than it. A raised road made of several rows of pyramid blocks can be used to transports the pyramid blocks from the water canals to the bottom of the great pyramid of Giza. The road elevation makes it possible to effectively counter the progressive covering of the road by sand and dust storms.

03- A regular grid of copper punches inserted between the pyramid blocks, which make up the raised road, and the transport of the pyramid blocks on huge copper sleds makes it possible to drastically reduce the frictional forces. Indeed, the frictional forces between two lubricated copper surfaces are very low : $5 - 15\%$.

Date: April 23, 2024.

04- Using a smooth side of the great pyramid of Giza itself as a ramp to climb the pyramid blocks with very long ropes from the bottom of the pyramid to the intermediate platform formed by the unfinished truncated pyramid. It minimizes further the dry path length of the pyramid blocks and the normal force from the pyramid blocks' weight thanks to a larger inclination angle. The inclination angle of the great pyramid of Giza is 51.8°. The total length of the very long ropes is 150 meters about. The smooth pyramid sides are made of white limestone casing blocks.

05- Using a smooth side of the great pyramid of Giza itself as a ramp to climb the pyramid blocks with very long ropes, from the bottom of the pyramid to the intermediate platform formed by the unfinished truncated pyramid. It minimizes the walking path of the slaves and it minimizes the lubricated needs. It makes also the labor of slaves and cattle much more efficient thanks to a perfectly regular, hard and non-deformable surface as a support surface for the feet of the slaves and for the hooves of the livestock. The smooth pyramid sides are made of white limestone casing blocks.

06- The temperature is more smooth at the level of the intermediate platform, formed by the unfinished truncated pyramid, than at ground level (when the sun light irradiate the sand around the zenith, the lowest layers of the atmosphere are heated in a more extreme way and the diurnal radiation cools the lowest layers of the atmosphere in a more extreme way as well). Therefore, thanks to a smoother temperature, it may give the possibility for the slaves and the cattle to stay permanently at the intermediate platform formed by the unfinished truncated pyramid. Furthermore, it minimizes further the walking path of the slaves.

07- There are only dust storms but there are no sandstorms (only a few meters above ground level) at the level of the intermediate platform, formed by the unfinished truncated pyramid. Moreover, above 10-25 meters, the tropical diseases begin to decrease a little at the level of the intermediate platform, formed by the unfinished truncated pyramid.

08- Minimizing further the coefficient of friction by fixing two large & thin copper rails on a smooth pyramid side made of white limestone casing blocks, and by using few huge copper sleds to move the pyramid blocks. Two slave children can take positions at the front of each huge copper sled in order to lubricate regularly the two large & thin copper rails while the pyramid block is climbing. For more stability, at the bottom end, the very long rope separate itself into two ropes that attach to the left and right side of each huge copper sled.

09- When a cattle dies at the intermediate platform, formed by the unfinished truncated pyramid, its corpse can be used to make grease which is later used to lubricate the huge copper sleds and the two large & thin copper rails.

10- In order to make a smoother pivoting transition of the climbing pyramid blocks, at the edge of the intermediate platform formed by the unfinished truncated pyramid, the longest edge of the climbing pyramid blocks should be parallel of that edge of the intermediate platform. To further make a smoother pivoting transition, a special thin round block should be placed below the rope at that edge of the intermediate platform formed by the unfinished truncated pyramid. That thin round block should have a copper coating and should be lubricated as well. That thin round block should be pulled back progressively while each climbing pyramid block is progressively pivoting at that edge of the intermediate platform formed by the unfinished truncated pyramid. For a better force distribution, other thin round blocks can be used as well during the pivoting transition of each climbing pyramid block at that edge of the intermediate platform.

11- Using the intermediate platform, formed by the unfinished truncated pyramid, as a concentration labor camp and as a "natural" enclosure for the livestock. Using the intermediate platform, formed by the unfinished truncated pyramid, as a concentration labor camp would make it very easy to monitor with guards positioned at regular intervals at the bottom of that pyramid.

12- Domesticated cattle are very useful to pull the pyramid blocks. Especially when the instantaneous pulling force is very large. In the ancient Egypt civilization, the cattle has been domesticated much before the construction of the great pyramid of Giza. Ancient Egyptian cattle were of four principal different types : long-horned, short-horned, polled and zebuine. The earliest evidence for domestic cattle in Egypt is from the Faiyum region, dating back to the fifth millennium BC.

Important Remark 01 : Instead of fixing the two large & thin copper rails on a smooth pyramid side made of white limestone casing blocks, a simpler solution would be fixing a regular grid of copper punches inserted between those white limestone casing blocks.

Important Remark 02 : The regular grid of copper punches inserted between the pyramid blocks of the raised road and the regular grid of copper punches inserted between the white limestone casing blocks of a smooth pyramid side, are both easily accessible to any thief and does not remain at their original places very long.

We can roughly estimate the construction time of the great pyramid of Giza in years and the corresponding amount of the human resources :

$$N_{Human-Resources} = \left(\frac{3}{4}\right)^2 \frac{a^2}{\rho_{Human-Resources}} \quad (1)$$

$$= \left(\frac{3}{4}\right)^2 \frac{230.35^2}{120} \quad (2)$$

$$= 250\ ppl \quad (3)$$

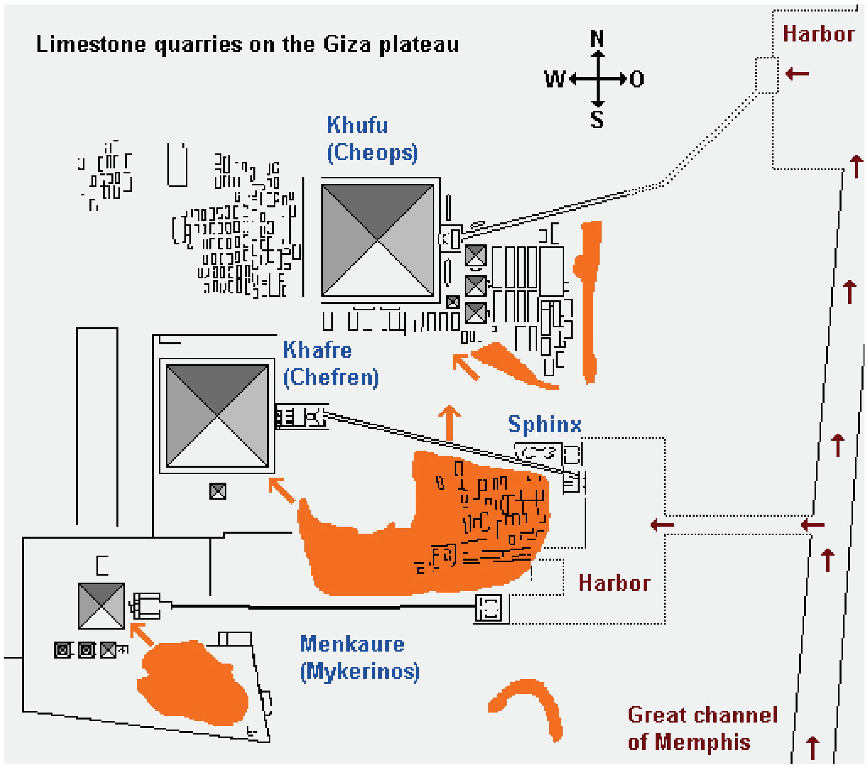

FIGURE 1. Orange = Limestone quarries on the Giza plateau. Dashed line = harbor facilities, their exact position is not known.

FIGURE 2. Picture of the Limestone quarries on the Giza plateau.

(4)
$$\Delta t_{Giza-Potential} = \frac{E_{Potential}}{N_{Human\ Resources} \times W_{Slave} \times Days \times Hours \times Seconds}$$

(5)
$$= \frac{a^2 \times h \times \rho_{Limestone} \times g \times (h/4 + \delta)}{3 \times N_{Human\ Resources} \times W_{Slave} \times Days \times Hours \times Seconds}$$

(6)
$$= \frac{230.35^2 \times 146.59 \times 2\,710 \times 9.81 \times (146.59/4 + 42)}{3 \times 250 \times 50 \times 250 \times 10 \times 3600}$$

(7)
$$= 48.8\ years$$

FIGURE 3. Picture of the Limestone quarries on the Giza plateau.

FIGURE 4. Picture of the Limestone quarries on the Giza plateau.

(8)
$$\Delta t_{Giza-Friction} = \frac{E_{Friction}}{N_{Human\ Resources} \times W_{Slave} \times Days \times Hours \times Seconds}$$

(9)
$$= \frac{a^2 \times h \times \rho_{Limestone} \times g \times \mu_K \times d}{3 \times N_{Human\ Resources} \times W_{Slave} \times Days \times Hours \times Seconds}$$

(10)
$$= \frac{230.35^2 \times 146.59 \times 2\ 710 \times 9.81 \times 0.1 \times 550}{3 \times 250 \times 50 \times 250 \times 10 \times 3600}$$

(11)
$$= 33.7\ years$$

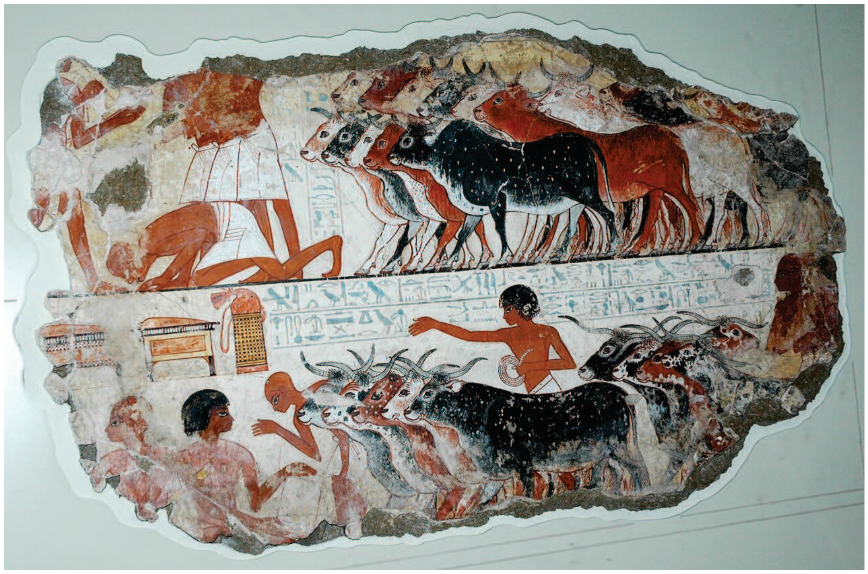

FIGURE 5. Domesticated Cattle are very useful to pull the pyramid blocks. Especially when the instantaneous pulling force is very large. In the ancient Egypt civilization, the cattle has been domesticated much before the construction of the great pyramid of Giza. Ancient Egyptian cattle were of four principal different types : long-horned, short-horned, polled and zebuine. The earliest evidence for domestic cattle in Egypt is from the Faiyum region, dating back to the fifth millennium BC.

$$N_{tot} \cong 14 \times N_{Human\ Resources} = 3\ 500 \tag{12}$$

Where δ is the denivelation between the bottom of the great pyramid of Giza and most of the limestone quarries. And where d is the distance between the bottom of the great pyramid of Giza and most of the limestone quarries.

The human resources for the construction of the great pyramid of Giza can be decomposed in the following way :

01- $N_{Human\ Resources}$ for pulling the pyramid blocks from the bottom of the pyramid to the intermediate platform formed by the unfinished truncated pyramid.

02- $N_{Human\ Resources}$ for pulling the pyramid blocks from the edge of the intermediate platform, formed by the unfinished truncated pyramid, to their final position.

03- $N_{Human\ Resources}$ for the construction of the smooth sides of the great pyramid of Giza made of the white limestone casing blocks.

04- $N_{Human\ Resources}$ for building the galleries and the chambers inside the great pyramid of Giza.

05- $N_{Human\ Resources}$ for pulling the pyramid blocks from the limestone quarries to the bottom of the great pyramid of Giza.

06- $0.25 \times N_{Human\ Resources}$ for pulling the pyramid blocks from the water canals, inside the mangrove swamps of the Nile Delta, to the bottom of the great pyramid of Giza.

07- $0.25 \times N_{Human\ Resources}$ for sailing the ships from the limestone quarries to the water canals inside the mangrove swamps of the Nile Delta.

08- $0.25 \times N_{Human\ Resources}$ to repair and to maintain the ships from the limestone quarries to the water canals inside the mangrove swamps of the Nile Delta.

09- $0.25 \times N_{Human\ Resources}$ for pulling the pyramid blocks from the limestone quarries to the ships.

10- $3 \times N_{Human\ Resources}$ for extracting the limestone block at the limestone quarries.

11- $5 \times N_{Human\ Resources}$ for monitoring and recruiting all the labor force working for the construction of the great pyramid of Giza.

Since the ancient Egypt civilization is a primary agricultural civilization with a lot of tropical diseases, a sustainable labor force working exclusively for the construction of the great pyramid of Giza, is very unlikely to exceed more than $0.1\% - 0.5\%$ of the total population (1 million people about).

The realistic total time for the construction of the great pyramid of Giza is $2\times$ times the theoretical one about : 82.5 years.

The great pyramid of Giza was built during the polytheistic period of the ancient Egypt civilization and not during the later monotheistic period of the ancient Egypt civilization, because the working conditions for its construction were too barbaric for a monotheistic civilization. It is also very likely that the labor force is made of people with African ethnicity since it requires a large musculature to pull large weights from the pyramid blocks.

None of the listed Egyptian mummies (royalty) came from a pyramid but instead they come from different necropolis. The pyramid of Merenre had an Egyptian mummy inside it but it is not considered as an Egyptian pyramid comparable to the other ones since its pyramidal shape is not enough specific. Therefore, the Egyptian pyramids themselves may have been used for other purposes as for example, an impregnable safe to guard the wealth of pharaohs and queens until their believed reincarnations. As it was proposed ingenuously by Philippe Lheureux, the great pyramid of Giza is a giant impregnable safe with a giant hydraulic lock. That theory has successful predicted the existence of a large secret room inside the great pyramid of Giza near the "King's Chamber" and it is well confirmed by several experiments involving cosmic muon rays. Finally, that theory gives also satisfactory explanations about the existence of the shafts of the great pyramid of Giza.

The concept of using the intermediate platform formed by the unfinished truncated pyramid, as a concentration labor camp and as a "natural" enclosure for the livestock, explains well the size change of the pyramid blocks between the top and the bottom of the great pyramid of Giza. The pyramid blocks at the top of the great pyramid of Giza are approximately $10\times$ times smaller than the pyramid blocks at the bottom of the great pyramid of Giza.

The great pyramid of Giza may be an extension/update of a previous smaller pyramid containing the "Queen's Chamber" as its initial chamber. That hypothesis can naturally explain why the "Queen's Chamber" is located exactly on the central axis of the pyramid unlike the "King's Chamber". Additionally, it may explain the slope of the Grand Gallery and it may also explain that the top of the stairs of the grand gallery lies exactly on the central axis of the pyramid unlike the "King's Chamber". Finally, it is more natural to consider the construction of the great pyramid of Giza in two stages since it is the largest one. Indeed, during the very long construction of the extension/update of the great pyramid of Giza, the "Queen's Chamber" may be used as a temporary chamber.

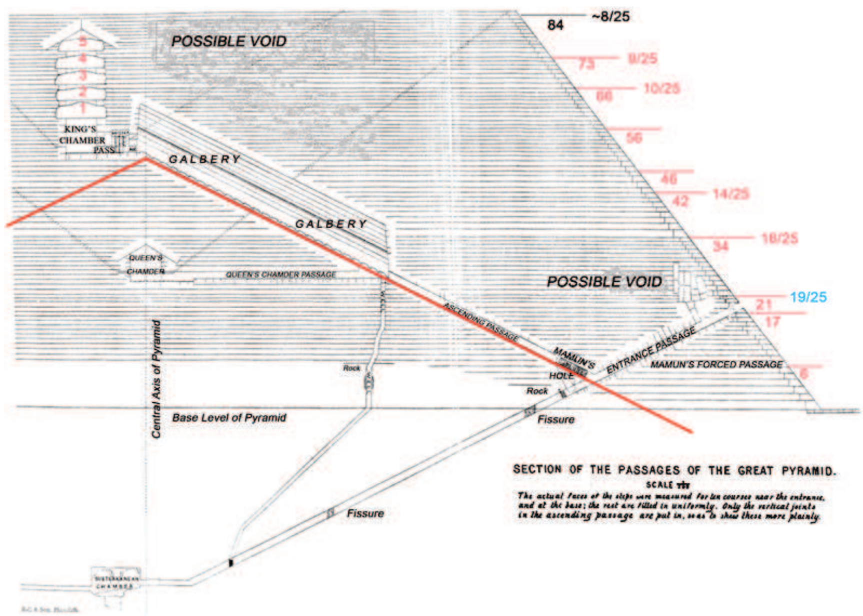

Figure 7. The great pyramid of Giza may be an extension/update of a previous smaller pyramid containing the "Queen's Chamber" as its initial chamber. That hypothesis can naturally explain why the "Queen's Chamber" is located exactly on the central axis of the pyramid unlike the "King's Chamber". Additionally, it may explain the slope of the Grand Gallery and it may also explain that the top of the stairs of the grand gallery lies exactly on the central axis of the pyramid unlike the "King's Chamber". Finally, it is more natural to consider the construction of the great pyramid of Giza in two stages since it is the largest one. Indeed, during the very long construction of the extension/update of the great pyramid of Giza, the "Queen's Chamber" may be used as a temporary chamber.

To conclude, the present article is an attempt to give a significant input, from theoretical physics, into the construction of the great pyramid of Giza at different steps of its construction.

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