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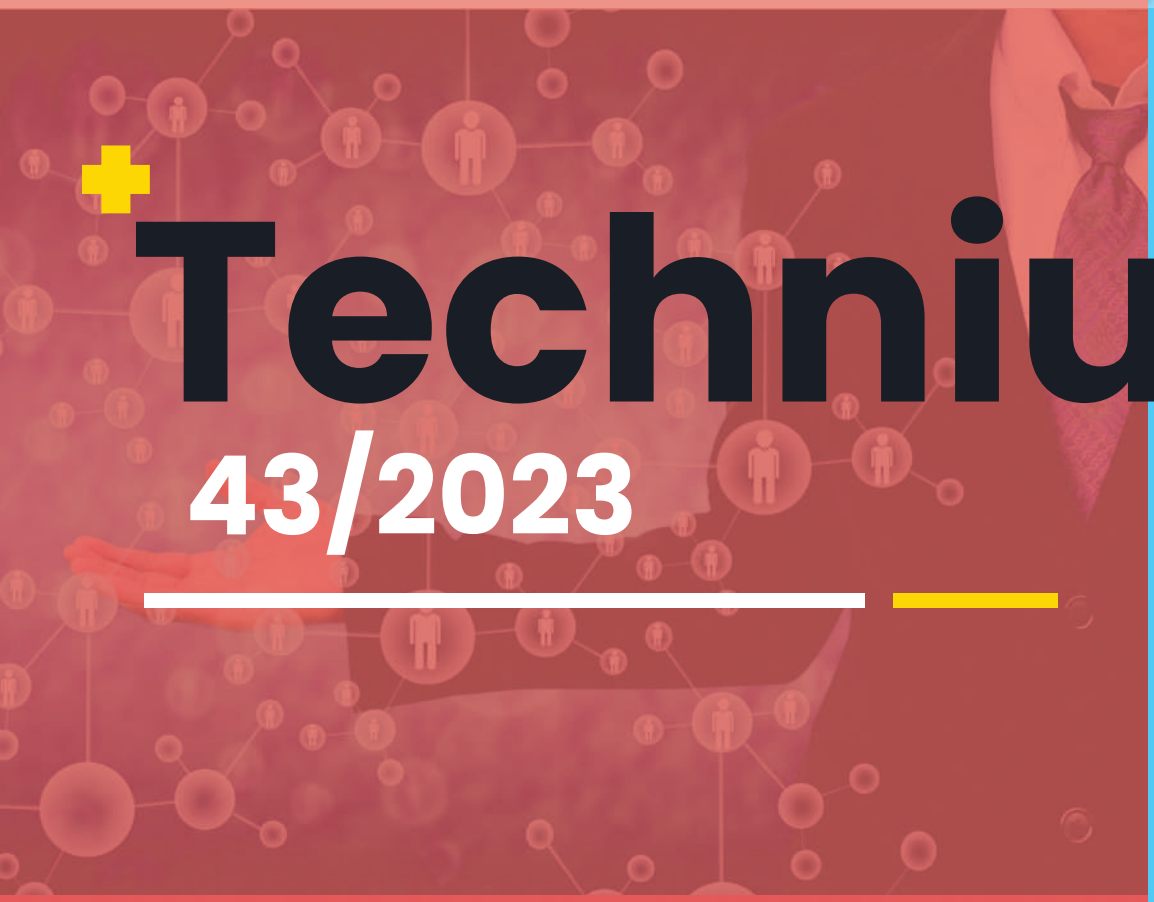

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# Transport chains in the time of the Egyptian Pharaohs: a still unknown organizational efficiency

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**Abstract**. The Egypt of the Pharaohs has been the subject of a huge deal of research by historians, archaeologists, and engineering specialists over the past decades. The construction of immense pyramids is largely the focus of attention insofar as it bears witness to the human genius capable of erecting monuments that have survived the millennia. The question of the logistics management involved in these majestic constructions is still little known, or at least rarely addressed. It is however undeniable that without a perfect organization of transport chains, the construction of the pyramids could not have been achieved. This article uses the example of the Great Pyramid of Giza to illustrate this point, the importance of which must be recognized by researchers specializing in management science.

**Keywords**. Antiquity, Giza Great Pyramid, logistics, organization, transport chains.

## 1. Introduction

For several decades now, historians have been looking more and more systematically at transport and logistics issues, not least to identify their military roots. This is the case, for example, of Roth (1999), whose contribution on the powerful logistics of Roman armies two centuries BC, or on the contrary the contribution of logistical limitations of the Hannibal army during the battle of Canae (216 BC) by Shean (1996), are authoritative in the academic world. While this approach is highly relevant, it seems interesting to go back in Antiquity to identify even more distant logistical dimensions, partly ignored by both managers and students. Are we aware of the centrality of transport operations in the construction of the pyramids in the Egypt of the Pharaohs, even though we know a lot about their "cosmic orientation" (Badawy, 1977), among other things? Many observers are enthusiastic about the majesty of these monuments, which are the product of human genius, but it is rare that exceptional management of transport chains is associated with them; the doctoral dissertation by Bloxam (2004) is an outstanding exception.

This is what the article is about, based on the case of the Great Pyramid of Giza. It is not a simple illustrative example but, on the contrary, the emblematic manifestation of a unique project in the history of humanity. It is not only the height of the Great Pyramid of Giza that is impressive, but also the precision with which it was designed and executed as the greatest difference in length between the four sides of the pyramid is only 4.4 cm and the base

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is levelled to within 2.1 cm, an architectural achievement that would be difficult to replicate today, even with ultra-modern equipment (Bartlett, 2014). While many works have addressed the engineering dimension of the Great Pyramid of Giza (Wier, 1996), this is not the case for the organization of the transport chains, over several hundred kilometers. Without efficient transport chains, the project would certainly not have been successful. The transport chain is understood here to mean the handling of product shipments for which several complementary or competing modes of transport may be used.

To argue the central importance of transport chain management in the time of the Egyptian Pharaohs, the article is organized in two parts. In the first section, some information is provided on the Great Pyramid of Giza in terms of its exceptional dimensions and the resources it required to complete its construction. Even though there are still areas of uncertainty, recent work by historians, especially the French archaeologist Pierre Tallet, provides reliable information on the stages of the construction process of the Great Pyramid of Giza. In the second section, the focus is on the organization of the transport chains that supported the project. Thanks to the research of Pierre Tallet, associated with the American archaeologist Mark Lehner, it is now possible to describe the very sophisticated supply systems put in place. They demonstrate a "supply chain maturity" that has almost never been analyzed in management research and that certainly deserves to be investigated further.

## 2. The case of the Great Pyramid of Giza

The Pyramid of Khufu (or Cheops) in Egypt, better known as the Great Pyramid of Giza (see Illustration 1), is considered by scholars to be the most ambitious and successful construction project of all antiquity (Bender and Morgan, 2002; Procter and Kozak-Holland, 2019). According to Crozat and Verdel (2007), it is even possible to speak of a "constructive system" whose technological level is unique for its time. As such, the pyramid does not cease to hold the attention of researchers in history and archaeology, but more recently in management of the transport chains considering the exceptional system of supply that the realization required on nearly three decades. As we know, the Great Pyramid of Giza is the tomb of the Pharaoh of the fourth dynasty: Cheops. It took about 27 years to build, 2,700 BC, and was the tallest man-made structure in the world for 3,800 years, until the construction of the Cathedral of the Virgin Mary in Lincoln, UK, was completed in 1311.

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**Illustration 1.** The Great Pyramid of Giza today

*Source*: https://www.radiofrance.fr/ (Accessed July 6, 2022).

The dimensions of the Great Pyramid of Giza are truly staggering on a human scale. It is 146.7 m high with a base of 230.6 m long –the equivalent of about seven football fields– and is built from about 2.3 million large blocks of stone, weighing a total of six million tons. The materials used include some 5.5 million tons of limestone from the Giza Plateau, and about 8,000 tons of granite blocks from Aswan, more than 800 km away (see Illustration 2 following page). The largest of these blocks weigh between 25 and 80 tons each and were transported to the construction site by boat on the Nile (Davidovits, 2008). It is estimated that the entire project required an average daily labor force of about 13,000 people, with peaks of up to 40,000 people at different stages of the project (for a total population of about one million in Egypt), in the service of a megaproject with a strong religious dimension (Berisha and Pervorfi, 2022).

Regarding the design itself of the Great Pyramid of Giza, the *Scan Pyramids* project launched in October 2015 has uncovered some elements related to its structure. For two years, Japanese, French and Canadian scientists studied the monument to conclude that hidden cavities exist inside. In an article published in 2017, they announced that they had discovered a still unknown corridor hidden behind the main entrance, as well as a "big void", the size of a 200-seat airplane, in the heart of the pyramid (Morishima *et al.*, 2017). The research team also has no information on the role of this "big void" of about 30 m, which is 105 m above the ground. It could be a succession of chambers adjoining each other, a huge horizontal corridor, a second large gallery, or even a "logistical" space for the storage of stone blocks, all hypotheses that maintain the mystery, and reinforce the mystical dimension of the Great Pyramid of Giza.

Until now, the way in which the Egyptians at the time of the Pharaohs built the Great Pyramid of Giza could not be fully informed, so much it is true that the ambition and the

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ingenuity of the project question the technology mobilized to move blocks of stones of 80 tons on several hundred kilometers (Edwards, 2003). Faced with the technical and logistical feats that this implies, far-fetched explanations are obviously circulating on social networks, the most famous of which is that of the participation of aliens in the construction itself. The legend has been circulating since the 1960s, with the publication of von Däniken's book (1968/2018), whose film adaptation in 1970... was nominated in the United States for the Oscar for best documentary! At the end of July 2020, in a series of tweets on @elonmusk (37 million followers), Elon Musk echoed these wild statements, even adding that Pharaoh Ramses II was himself an alien. Fortunately, science prevails since then on the pseudo-science thanks to the brilliant works of the French archaeologist Pierre Tallet.

What do we know with a relative certainty? Standing on the Giza Plateau, a few kilometers south of Cairo, the Great Pyramid of Giza is the only remnant of the reign of the Pharaoh Cheops, whose mummy has never been found, and it is considered one of the Seven Wonders of the ancient world. The Great Pyramid of Giza is built of limestone, granite, basalt, gypsum (mortar) and mud bricks. If the limestone blocks were extracted at Giza, and perhaps at other nearby sites, the granite probably came from Aswan, upstream of the Nile, the alabaster from Luxor and the basalt from the Fayum depression. It was understood that for transport management over such long distances, the blocks of stone were loaded onto barges and transported on the river. It was then up to the workers to dig canals to bring the barges closer to the reception site. To tell the truth, little is known about a subject that is nevertheless essential if one wishes to know more about the progress of the project. Papyri recently discovered by Pierre Tallet, in addition to those of 2011, provide crucial details on the functioning of the transport chains.

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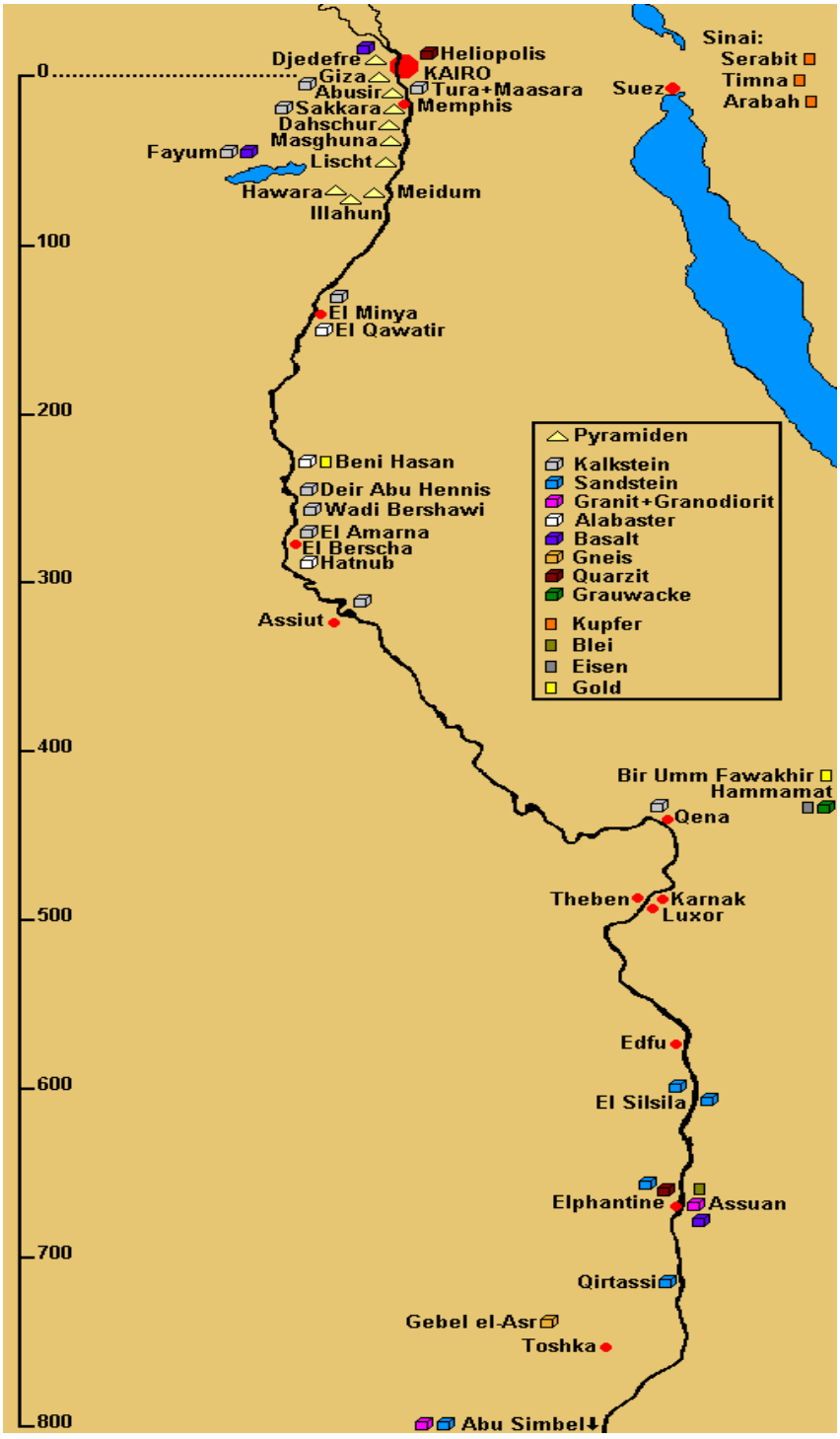
**Illustration 2.** Quarries of extraction of stones for the construction of the pyramids




*Source*: https://www.cheops-pyramide.ch/khufu-pyramid/stone-quarries.html (Accessed September 11, 2022).

## 3. Organization of transport chains

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Based on close examination of papyri, recovered from the remains of a boat storage facility, Tallet (2021) describes a team of handlers loading their boat with limestone at Tura and then transporting it down the Nile to the site of the Great Pyramid of Giza. Another discovery confirms that the blocks of stone necessary for the construction of the pyramid were not dragged on land but delivered by boats to reach their exact location, only a few meters from their final place of deposit thanks to a complex system of channels. It is to the American archaeologist Mark Lehner that we owe this significant advance. He has demonstrated the existence of a waterway under the great plateau of Giza, playing the role of the main delivery area (Lehner, 2020). This confirms that while the ubiquitous donkey was widely used to transport goods in ancient Egypt, the main transport artery remained the Nile.

Several quarries were set up depending on the construction site and the period. Some quarries were exploited during specific works, others were exploited permanently, but in both cases, these quarries supplied materials for the construction of the pyramids (Harrell and Storemyr, 2009), but also for the cities that were built around them, as Egyptian civilization advanced. The question of transport from the quarries obviously arose very quickly, but with a pioneering advantage. As Smith (2004) underlines, as skilled boat builders and seasoned sailors, the Egyptians developed early craft ranging from small reed boats to ocean-going vessels. They sailed along the Mediterranean coast to the north of what is now Palestine, Lebanon, and Syria, and crossed the Red Sea to Saudi Arabia. For the transport chain of stone, they used sailing ships and barges, some of which had a capacity of at least 100 metric tons, and even 1,000 metric tons in some special cases. For even larger loads, Smith (2004) adds, it is likely that rafts made of logs were assembled. Thus, it was through total control of the long-distance transport chains that supplies could be organized for 27 years.

But as the extensive literature about transport chains points out, the management of the last mile remains perhaps the most complex to organize (Olsson *et al.*, 2019), and the supplies associated with the construction of the Great Pyramid of Giza were no exception to this rule. In addition to the blocks of stone transported down the Nile, archaeologists' work confirms that many other stones were quarried near the site where the pyramid was erected. In the absence of modern means of transport and with an average weight of 2.5 kg per stone, the workers managed to transport the stones from the quarries to the construction site, with a distance between the construction site and the quarries of about 300 m, and a height difference of 15 to 25 m. If the inclination was greater than five degrees, the workers probably used a rope roller to deliver the material.

The wheel, which had not been discovered by the Egyptians, would not have been useful on the sand and gravel of the desert. The workers therefore probably dragged the stone blocks with sleds, in the shape of a quarter circle, which fitted onto a rectangular block. They would attach the sleds to the block and a team of about eight men would roll them across the ground, much like rolling a beer barrel. Ropes were attached to the sled, brought up to the rope roller, hung from the roller crossbeam and then sent back. For this step, 11 workers were needed on a five-degree slope. On one side of the slope, they walked up and on the other side they walked down and pulled the rope. With this technique, they lifted the stone using their own body weight. Once the stones arrived at the site and the pyramid's plateau was completed, construction could begin. Another hypothesis is suggested by a European team of physicists based on laboratory tests (Fall *et al.*, 2014). The researchers thus demonstrated that with a certain amount of water, the friction between the sand and the moving object was so greatly reduced that the force required to move the object was reduced by 50%. With this technique, the Egyptians would thus have used only half the men needed to pull the stones.

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However, no one really knows how the workers were able to transport the 2.5-ton blocks of stone from the quarries to the construction site. Egyptologists estimate that workers placed approximately 300 stones per day during the construction of the Great Pyramid of Giza (Smith, 2004). While several theories co-exist, including the presence of lever or kite systems, to explain how the huge blocks of stone were placed, the most common idea is that ramps existed, although their exact configuration is still debated (De Haan, 2014; Yasseen, 2018; Brichieri-Colombi, 2020), long and straight, perpendicular to the sides, or wrapped around the core. The most likely option is that the stones were raised onto the superstructure floor by floor following a gently sloping ramp, knowing that archaeology has proven that this type of ramp was indeed used, on the pyramid of Sesostris I at the necropolis of Litch. Regardless, the handling operations were conducted in a particularly efficient manner, indicating a proven logistical performance.

At the river level, in addition to the port system set up and connected to the great Memphis canal, artificial basins between the Great Pyramid of Giza and the Nile were created to be transformed into artificial lakes, generating in fact a sort of “hydraulic elevators” during the periods of high water. Of course, the builders could not place these hydraulic elevators everywhere. At some point during their 150 km long journey through the desert, they had to cross the land to reach the next body of water. Based on the most current examinations of wooden pieces from ancient boats, Egyptologists believe that the Egyptians assembled them with a rope. This allowed them to easily dismantle the boats once they reached land, and conversely, to reassemble them once they reached water. The article by Sheisha *et al.* (2022) seems to confirm the existence of an artificial branch of the Nile –now disappeared– with water levels high enough to reach Giza at 7 km from the river. The heavy blocks of stone used to shape the pyramids could therefore have been transported without difficulty from the various quarries on the Nile to the construction site of the Great Pyramid of Giza.

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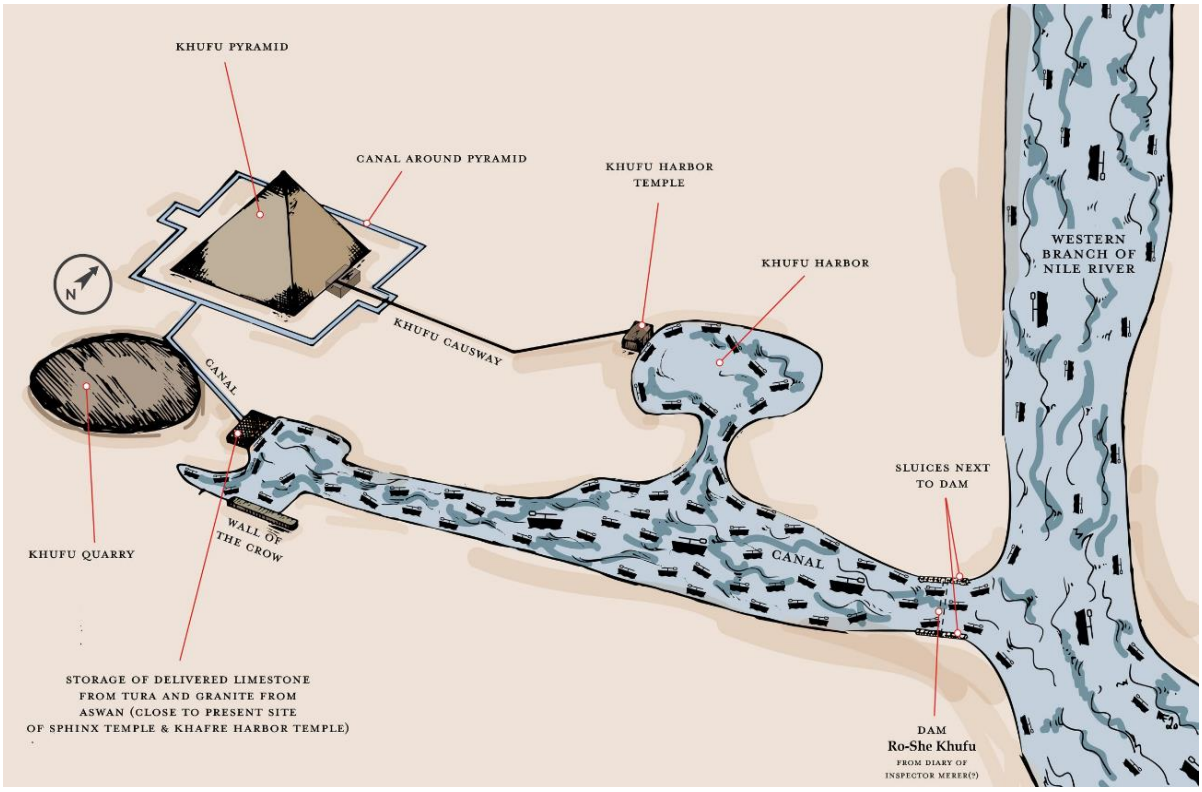
**Illustration 3.** Probable look of waterways at Giza during Khufu (Cheops) time




*Source*: https://www.secretofthepyramids.com/projects/project-three-water-transportation-at-giza (Accessed April 16, 2023).

If the transport chains associated with the construction of the Great Pyramid of Giza are a key element of success, the main reason lies in the fact that the Egypt of the Pharaohs possessed an important technological advance. Thus, the transport of objects of varying weight and bulk relied on a wide range of boats: from the smallest and most primitive (papyri boats, skiffs with a load-bearing floor) to the most imposing and sophisticated (large wooden vessels). For the heaviest loads, such as stones extracted from quarries, the transport chains used barges driven by traction or towed, propelled by sail or by oar. Concerning specifically the rowers, they were most often free men, not slaves, under the orders of a rowing commander. It is thus possible to speak of a real "wage-employment" in the service of transport chains, associating military and civilian personnel. From this point of view, logistics management is at the heart of what we will call the *economy of the construction of the pyramids*, well before military logistics was formalized by the Romans.

## 4. Conclusion

It is very unlikely that the construction of the Great Pyramid of Giza could have been completed without an exceptional organization of the transport chains (Fitchen, 1978; Müller-Römer, 2008). Of course, this is a very old story, and one may ask whether it is of interest to today's decision-makers. Unambiguously, following the example of Bamyaci (2021), many researchers emphasize how essential it is to delve into this history to better understand contemporary issues relating to the management of companies and major projects. From this

point of view, other examples could be used to illustrate the point, such as the construction of cathedrals in Europe or certain temples in Asia (the Angkor site in Cambodia, for example). This is undoubtedly an exploration that is rather neglected in management, which is regrettable insofar as learning from the past allows us to better think about the present and, above all, to imagine a better future for humanity.

It is particularly important to emphasize that the long duration of a project generates risks threatening its realization. In the case of the Great Pyramid of Giza, a bad harvest having been anticipated during the more than twenty years of the project, with a risk of food shortage endangering the workers of the construction site, a storage of cereals was organized from one year to the next, in an immense warehouse located in the heart of the village accommodating these same workers (Murray, 2005). Other extreme events are possible in the contemporary world, as shown by the two successive crises experienced on a global scale since the beginning of 2020: the Covid-19 pandemic, on the one hand, and the war between Ukraine and Russia, on the other. From this point of view, the lessons that can be drawn from the construction of the Great Pyramid of Giza are very instructive to analyze and remember despite the almost five millennia that separate us from the realization of the project.

While the management of transport chains is often confined to pure operational aspects (Fulconis and Paché, 2022), such as the definition of optimal delivery capacities or the choice of alternative modes of transport, it is essential to identify logistical needs at the very moment the project is conceived, and not to consider that it will be possible to find solutions as the project progresses by resorting to specialized partners. This is a reality known in the time of the Egyptian Pharaohs, with transport chains carefully thought out according to the location of the quarries (upstream) and the location of the reception sites (downstream). Thus, as the level of the Nile varies greatly between the flood season and the low-water season, a waterway was dug beforehand to allow the boats to unload the stones continuously near the construction sites. This early “strategic vision” confirms that historical facts and practices are a major resource for today’s decision-makers, and as such, it should certainly be taught in all business schools.

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**References**

[1] Badawy, A. (1977). The periodic system of building a pyramid. *Journal of Egyptian Archaeology*, **63**(1), 52–58.

[2] Bamyaci, M.-E. (2021). Definition, importance and historical development of logistics from the beginning to the present. In Unar, S., & Karagoz, S. (Eds.), *Social and humanities science: research, theory* (pp. 243–255). Lyon: Livre de Lyon.

[3] Bartlett, C. (2014). The design of the Great Pyramid of Khufu. *Nexus Network Journal*, **16**(2), 299–311.

[4] Bender, J., & Morgan, W. (2002). The search for the process of the modern project management in Antiquity. *Proceedings of the 2002 Academy of Strategic Management Conference*. Las Vegas (NV), 1–6.

[5] Berisha, L., & Pervorfi, L. (2022). Literary tradition and the Egyptian *Book of the Dead*. *Technium Social Sciences Journal*, **32**, 691–697.

[6] Bloxam, E. (2004). *The organisation, transportation and logistics of hard stone quarrying in the Egyptian Old Kingdom: a comparative study*. Unpublished doctoral dissertation. London: University of London.
[7] Brichieri-Colombi, S. (2020). A spurred spiral ramp for the Great Pyramid of Giza. *PalArch's Journal of Archaeology of Egypt/Egyptology*, **17**(3), 1–20.
[8] Crozat, P., & Verdel, T. (2007). Le génie des pyramides [The genius of pyramids]. *Revue Européenne de Génie Civil*, **11**(9–10), 1135–1154.
[9] Davidovits, J. (2008). *They built the pyramids*. Saint-Quentin: Geopolymer Institute.
[10] De Haan, H.-J. (2014). More insight from physics into the construction of the Egyptian pyramids. *Archaeometry*, **56**(1), 145–174.
[11] Edwards, J. (2003). Building the Great Pyramid: probable construction methods employed at Giza. *Technology & Culture*, **44**(2), 340–354.
[12] Fall, A., Weber, B., Pakpour, M., Lenoir, N., Shahidzadeh, N., Fiscina, J., Wagner, C., & Bonn, D. (2014). Sliding friction on wet and dry sand. *Physical Review Letters*, **112**(17), Article 175502.
[13] Fitchen, J. (1978). Building Cheops' pyramid. *Journal of the Society of Architectural Historians*, **37**(1), 3–12.
[14] Fulconis, F., & Paché, G. (2022). La logistique: un champ disciplinaire singulier des sciences de gestion et du management [Logistics: a unique field of management science]. In Deville, A., Dupuis, J., Lebraty, J.-F., Nègre, E., Riché, C., & Sattin, J.-F. (Eds.), *La disputatio au cœur du management: débats et controverses* (pp. 173–186). Aix-en-Provence: Presses Universitaires de Provence.
[15] Harrell, J., & Storemyr, P. (2009). Ancient Egyptian quarries–An illustrated overview. *Geological Survey of Norway Special Publication*, **12**, 7–50.
[16] Lehner, M. (2020). Lake Khufu: on the waterfront at Giza–Modelling water transport infrastructure in Dynasty IV. In Barta, M., & Janak, J. (Eds.), *Profane landscapes, sacred spaces* (pp. 191–292). Sheffield: Equinox.
[17] Morishima, K., Kuno, M., Nishio, A., *et al.* (2017). Discovery of a big void in Khufu's pyramid by observation of cosmic-ray muons. *Nature*, **552**(7685), 386–390.
[18] Müller-Römer, F. (2008). A new consideration of the construction methods of the ancient Egyptian pyramids. *Journal of the American Research Center in Egypt*, **44**, 113–140.
[19] Murray, M.-A. (2005). Feeding the town: new evidence from the complex of the Giza pyramid builders. *General Anthropology*, **12**(1–2), 1–9.
[20] Olsson, J., Hellström, D., & Pålsson, H. (2019). Framework of last mile logistics research: a systematic review of the literature. *Sustainability*, **11**(24), Article 7131.
[21] Procter, C., & Kozak-Holland, M. (2019). The Giza pyramid: learning from this megaproject. *Journal of Management History*, **25**(3), 364–383.
[22] Roth, J. (1999). *The logistics of the Roman army at war (264 B.C.–A.D. 235)*. Leiden: Brill.
[23] Shean, J. (1996). Hannibal's mules: the logistical limitations of Hannibal's army and the Battle of Cannae, 216 BC. *Historia: Zeitschrift für Alte Geschichte*, **45**(2), 159–187.
[24] Sheisha, H., Kaniewski, D., Marriner, N., Djamali, M., Younes, G., Chen, Z., El-Qady, G., Saleem, A., Véron, A., & Morhange, C. (2022). Nile waterscapes facilitated the construction of the Giza pyramids during the 3rd millennium BCE. *Proceedings of the National Academy of Sciences*, **119**(37), Article e2202530119.

[25] Smith, C. (2004). *How the Great Pyramid was built*. Washington DC: Smithsonian Books.
[26] Tallet, P. (2017). *Les papyrus de la mer Rouge I: le "journal de Merer"* [The papyri of the Red Sea I: the "Diary of Merer"]. Cairo: Institut Français d'Archéologie Orientale.
[27] Tallet, P. (2021). *Les papyrus de la mer Rouge II* [The papyri of the Red Sea II]. Cairo: Institut Français d'Archéologie Orientale.
[28] von Däniken, E. (1968/2018). *Chariots of the Gods: unsolved mysteries of the past*. New York: Berkley.
[29] Wier, S.-K. (1996). Insight from geometry and physics into the construction of Egyptian Old Kingdom pyramids. *Cambridge Archaeological Journal*, **6**(1), 150–163.
[30] Yasseen, A. (2018). Architecture of the Great Pyramid of Giza concept and construction. *International Journal on Proceedings of Science & Technology*, **1**(2), 97–108.