地学雑誌(Chigaku Zasshi)
Journal of Geography
120(5) 864-868 2011

**The 100s: Significant Exposures of the World (No. 1)**

# Geomorphological Aspects at the Giza Plateau in Egypt during the Age of Pyramid Building

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**Abstract**

The constructions of Giza pyramids were architectural landscape projects. Old Kingdom monarchs made effective use of Eocene limestone bedrocks, called Moqattam and Maddi Formation.

**Key words**: Giza, Pyramids, landscape archaeology, environmental archaeology, 3D Laser Scanning

## I. Introduction

The Giza Plateau is located on the west bank of the river Nile (Fig. 1), approximately 12 km to the southwest of central Cairo, where the three large pyramids, Great Sphinx, temples, and *mastabas*[1] were built during the Old Kingdom (2575-2134 BCE[2]). The plateau during this period was an area with an abundance of lush vegetation which was remarkably different from today's landscape. King Khufu, his second reigning son Khafre, and Menkaure each built three pyramids (one for each) for their tombs. Constructing these megalithic structures were huge architectural landscape projects. As the Giza plateau was arguably one of the largest limestone quarries in the ancient world, the local geology and geomorphology affected the overall framework and design of the site. Studies by Aigner (1982) and Lehner and Wetterstrom (2007) revealed a geographical history of Giza Plateau. Around 50 million years ago

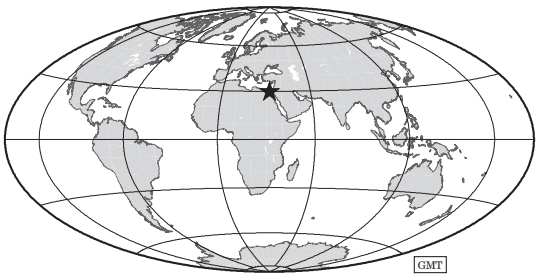


Fig. 1 Locality index of the Giza plateau, Egypt.

(the Eocene), a pre-existing shallow sea retreated to leave an embankment that became the northwest part of the Giza Plateau. The bedrock of this embankment is composed of shallow marine sedimentary rocks called the Moqattam Formation (Fig. 2). In the northeast embankment, the well-known large-tested foraminifer fossil, *Nummulites gizehensis*, occurs abundantly. The Moqattam Formation consists of interbedded hard and soft limestone, which dips steadily southeast at 3 to 6 degrees. The continuous exposure of this formation,

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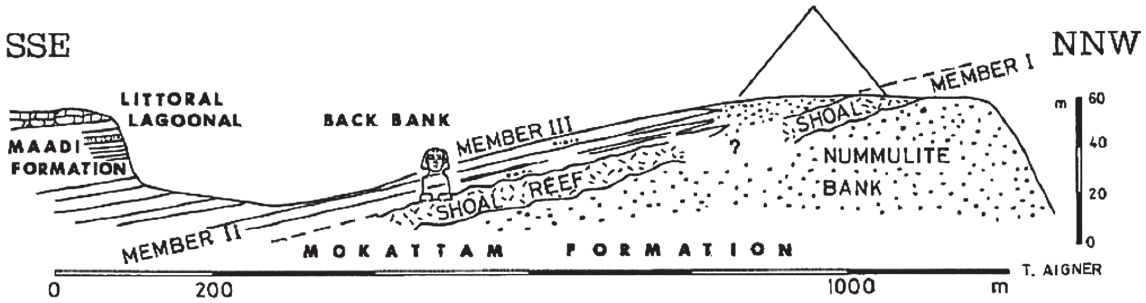


Fig. 2 Sectional overview of the Giza Plateau (courtesty of Thomas Äigner).

for about 2.2 km in the east-west direction and for 1.1 km in the north-south direction, was ideal for collecting large stone blocks for building the pyramids, tombs, and temples. The masons probably chipped off the soft layers first and took out large solid blocks from the hard limestone. Because the Sphinx was built *in-situ* using the original bedrock, the primary bedding planes of the limestone are still visible in the body and head of the Sphinx. In contrast, the Maddi Formation exposed on the south of the pyramid sites has many fissures and gullies in the limestone. This inappropriate limestone for quarrying large solid blocks is called *tafla* (natural desert clay) and was used as a supporting material for the pyramids.

## II. Building the Pyramid

Khufu's pyramid originally rose to a height of about 147 m, and contained 2,590,000 cu. m of stone (Lehner, 1985). Priorities for the pyramid construction were presumably the choice of quarry and verification of local stone. For practical reasons the location of a quarry would have preferred proximity to the construction site for supplying the bulk of stones for the pyramid core. At Giza, Khufu's quarry, a huge horseshoe-shaped quarry, was discovered 300 m south of the Great Pyramid. The approximate amount of stone removed is estimated to be c. 2,760,000 cu. m, which neatly corresponds to the mass of Khufu's pyramid (*ibid.*).

The image below is a reconstruction of the Giza Plateau at the end of Khufu's reign (Fig. 3). The quarry is located to the south of the pyramid. To quarry the limestone blocks, the Central *Wadi*, which once served as a route for hauling non-local materials required for building the three main pyramids at Giza, was widened.

## III. Sculpting the Sphinx

The second pyramid builder Khafre ordered the fashioning of 100 to 200 statues of hard stone. Among those, the Great Sphinx was the largest and the first colossal sculpture in ancient Egypt, measuring 73.5 meters long, 6 meters wide, and 20.22 meters high. This monolithic statue was hewn directly from natural rock at the base of the southern slope of the Moqattam Formation (Lehner, 1997).

The Sphinx was formed from three principle geological layers. They were labeled Members III, II, and I, respectively (from the top). Member I is composed of hard limestone of an ancient reef, from which the lowest part of the statue was carved. Member II corresponds to the bulk of the body of the Sphinx. Within this member, seven layers of alternating softer and harder strata can be identified. Member III is composed of another hard layer from which the head (of Sphinx) was sculpted (Lehner *et al.*, 1980).

The Sphinx and the sphinx temple were unique

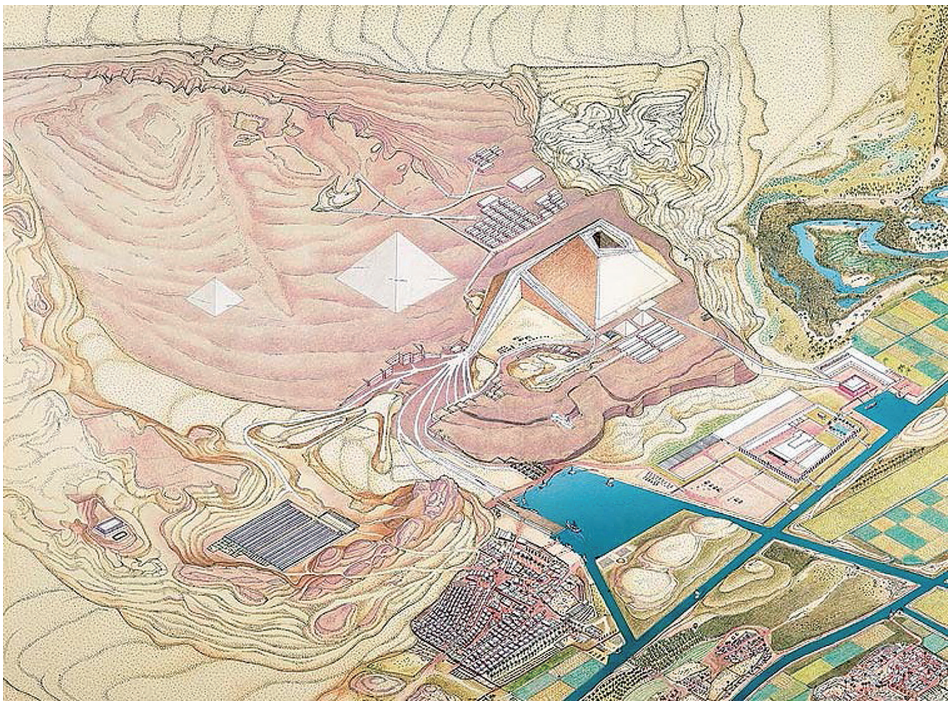

Fig. 3　A Reconstruction of the Giza Plateau（courtesy of Mark Lehner）.

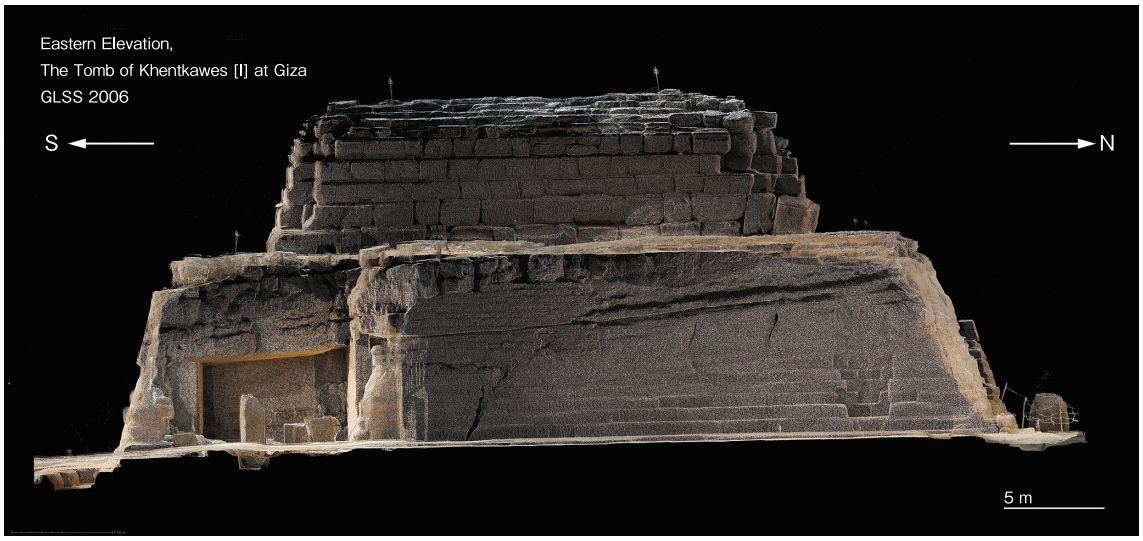


Fig. 4　Orthophotograph of the eastern elevation of the tomb, © Giza Laser Scanning Survey 2006.

elements of Khafre's Pyramid Complex, which consists of pyramid, funerary temple, causeway, and mortuary temple. A study of the geological layers of the sphinx and their relationship with the stone surrounding Khafre's temples revealed the sequence of quarrying and building this Pyramid Complex. There have been suggestions that the Sphinx was sculpted during the reign of Khufu, but archaeological and geological evidence clearly suggest that it was built at the very end of Khafre's building period (Lehner, 1997).

## IV. Last Royal Monument at Giza

The last royal tomb at Giza was built by Queen Khentkawes, a daughter of Menkaure, in a topographically limited space after the massive pyramid construction activities. The tomb appears as a giant *mastaba* or a step pyramid, composed of two parts: a base, which is 45.5 m × 46.50 m and 10.0 m high, formed by cutting into the natural limestone rock, and a superstructure rising in seven courses of limestone blocks to a height of 7.5 m (Kamei *et al.*, 2009; see Fig. 4).

Lehner (2008) indicated that from the Ikonos satellite view of the Giza plateau, with the Khentkawes monument at its center, a great circle quarried of approximately 400 m can be identified. Three quarters (NW, SW, and SE) of the circle was exploited during construction of the pyramids. Ancient Egyptians started to quarry limestone in the northwest quarter, which is the closest to the first pyramid. They perhaps, intentionally left this small part of bedrock as a kind of benchmark for volume calculations of stone or to monitor work. Eventually, when the Giza necropolis was abandoned at the end of the 4th dynasty of the Old Kingdom, the small patch of bedrock was used for the last royal tomb at Giza of Queen Khentkawes. Like her name, Khentkawes, "In-front-of-Her-Kas (her ancestors)", her tomb is located in front of the pyramids of the late kings. This monument was also positioned at the edge of Central *Wadi*, symbolically and practically closing the Giza necropolis (Lehner, 1997).

### note

1) Arabic word for bench; a type of ancient Egyptian tomb having a rectangular structure like bench.
2) The date is based on the chronology mentioned in Lehner (1997).

### References


Aigner, T. (1982): Zur Geologie und Geoarchälogie des Pyramidenplateaus von Giza, Ägypten. *Natur und Museum*, **112**, 377–388.

Kamei, H., Kawae, Y., Tsukamoto, T., Kanaya, I. and Okamoto, A. (2009): Giza laser scanning survey 2006: A reinvestigation of Khentkawes's Monument at Giza. *Journal of West Asian Archaeology*, **10**, 51–63.

Lehner, M. (1985): The Development of Giza Necropolis: The Khufu Project. *Mitteilungen des Deutschen Archäologischen Instituts Abteilung Kairo*, **41**, 109–146.

Lehner, M. (1997): *The Complete Pyramids*. Thames and Hudson, New York.

Lehner, M. (2008): Giza: Overviews and ground truths. *AERAGRAM*, **9**, 14–15.

Lehner, M. and Wetterstrom, W. (2007): *Giza Reports: The Giza Plateau Mapping Project*. Ancient Egypt Research Associates, Boston, MA.

Lehner, M., in Collaboration with Allen, J.P. and Gaurifa, K.L. (1980): The ARCE Sphinx Project—A preliminary report. *American Research Center in Egypt Newsletter*, **112**, 3–33.

# エジプトのギザ台地におけるピラミッド時代の地形学

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三大ピラミッドが建つギザ台地はおもに新生代始新世時代に遡るモカッタム累層と呼ばれる浅海成石灰岩の岩盤からなっている。古代の巨石建造プロジェクトにおける最優先事項の一つは採石場の選択であるが，この累層の石灰岩は硬い層と柔らかい層の交互層からなるため採石に適していた。古代人は柔らかい層を除去し，硬い層からピラミッドや神殿建設のための巨大な岩塊を採石した。

2,590,000 立方メートルの石材からなるクフ王の大ピラミッドの採石場は，南約 300 メートルに近在しており，そこから約 276,000 立方メートルの石灰岩が切り出されたと概算されている。第 2 ピラミッドの造営者カフラー王もギザの地形を考慮しながら自らのピラミッド複合体の建造を推進し，プロジェクト最後にはモカッタム累層の岩盤を生かし，スフィンクスを巨大な彫像としてつくりあげた。王家最後の巨石建造物は，ケントカウエスと呼ばれる女王が建てさせた彼女の 2 段式の墓で，独特な形をもつ。墓はもともとクフ王の石切場の中央に，おそらく石材量を量るために，残されていた岩塊だった。三大ピラミッド建造後の限られた空間のなか，彼女は使用可能な最後の土地を巧みに利用し自らの墓を建てさせた。これによってギザ台地の巨石建造プロジェクトは終焉を迎えた。

**キーワード**：ギザ，ピラミッド，景観考古学，環境考古学，3D レーザー・スキャニング

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