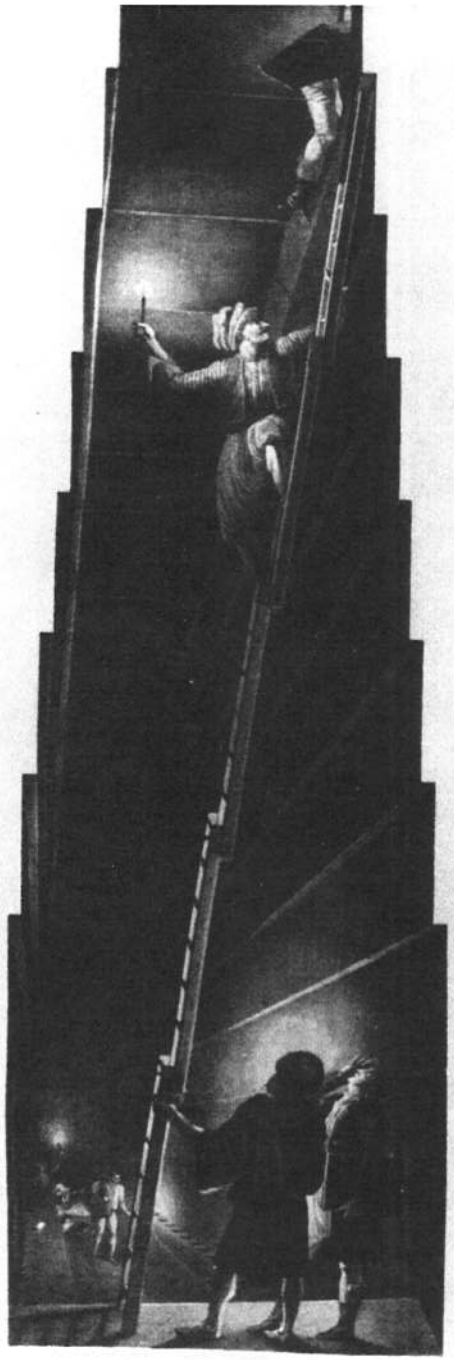

Miroslav Verner

THE PYRAMIDS

The Mystery, Culture, and Science of Egypt's Great Monuments

Translated from the German by Steven Rendall

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The pharaoh's ultimate goal was to rise as high as the sun that "shone over the horizon." This idea, understood as the "emergence [of the deceased's spirit] into the daylight," is central to the various "books of the dead," later collections of religious burial texts.

In the unsettled conditions of the First Intermediate Period, and especially during the Middle Kingdom, broader levels of society arrogated royal privileges to themselves.* In this way many formulas and some other elements from the pyramid texts made their way into a new body of religious texts called, after the place where they are usually found, coffin texts. In the New Kingdom and in the Late Period, these were incorporated—very freely and only partially—into the books of the dead. They were usually written on papyrus scrolls and laid alongside the coffin in order to ensure that they would accompany the deceased on his way into eternity.

The oldest collection of ancient Egyptian religious texts was discovered and first evaluated by Gaston Maspero, and France continues to play a leading role in the area of research on the pyramid texts. In the early 1950s, French archaeologists in Saqqara began a far-reaching research project on the pyramids. Along with Jean-Philippe Lauer, who was in charge of the architectural aspect, the young Egyptologist and gifted philologist Jean Sainte Fare Garnot (1908–1963) took part in this project. Unfortunately, the latter's premature death and the diplomatic disputes connected with the 1956 Suez conflict complicated the French scientists' archaeological activities. However, the situation soon improved. Another important French Egyptologist, Jean Leclant, joined Lauer and ultimately assumed leadership of the project. Today a team of French Egyptologists—epigraphists, archaeologists, and architects—is using the latest computer technology to reconstruct, out of hundreds of fragments, the ruined walls bearing pyramid texts in the underground part of Pepi I's pyramid in South Saqqara. The result will be a high point of Egyptological research in our time.

* Egyptologists do not agree regarding the precise chronological limits of the Middle Kingdom. However, the prevailing opinion is that it begins with Mentuhotep II's reign and ends with the outgoing Twelfth Dynasty. The Thirteenth Dynasty is assigned to the Second Intermediate Period.

The Pyramid Complex—The Dead Pharaoh's Residence

To suppose that the pyramid's only function in ancient Egypt was as a royal tomb would be an oversimplification. The pyramid complex consisted of a group of buildings, of which the pyramid was only one element, even if it was the most important one. The pyramid complex was the site of the dead pharaoh's mystical transfiguration, rebirth, and ascent to heaven, as well as his residence in the beyond, from which he ruled over all the people of his time. The arrangement of the complex mirrored the ancient Egyptians' worldview: the beginning of the world was associated with the primeval mound the pyramid symbolized.

The essential appearance of the pyramids did not change over time, if we set aside differences in size and the shift from the step pyramids of the Third Dynasty to the classical form of the pyramid that emerged at the beginning of the Fourth Dynasty. However, in response to developing religious ideas and cultural practice, the structures *surrounding* the pyramid underwent striking changes in both their architectonic outline and their orientation and arrangement.

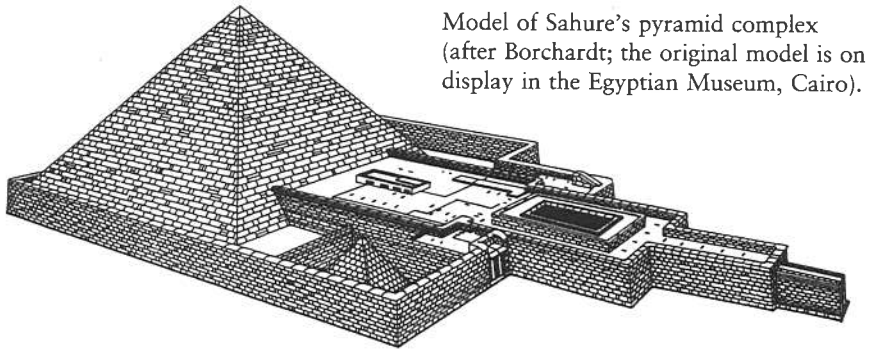
The oldest pyramid, that of King Djoser of the Third Dynasty, was surrounded by structures whose meaning is still debated. Egyptologists nevertheless generally agree that they were supposed to represent the ruler's death residence, which might have been inspired to some extent by parts of his earthly residence. In this complex, the mortuary temple was placed—as it was in all the other known step pyramids of the Third Dynasty—in front of the north side of the pyramid. Here was located the entrance to the underground rooms, which also served as the exit from the inner part of the pyramid and the burial chamber, through which the dead pharaoh went north to become one of the eternal stars around the North Star that never set.

At the beginning of the Fourth Dynasty, the sun religion gained prominence. The pharaoh was then believed to be born in the light of dawn, like the sun, to rise in splendor toward the zenith and die in the west, in order to be born anew in the eternal cycle of life, death, and resurrection. Under the influence of this significant religious transformation, the layout of the pyramid complex also underwent cer-

tain changes. The earlier north-south orientation was abandoned in favor of an east-west orientation. A valley temple was added to the complex, and from it a causeway climbing west toward the mortuary temple, which stood at the foot of the pyramid. The entrance to the underground rooms, that is, to the inside of the pyramid, continued to be located on the north side.

This new conception quickly became dominant, but its optimal architectonic realization in the pyramid complex crystallized only in the course of the Fourth Dynasty. Sahure's pyramid complex, built at the beginning of the Fifth Dynasty, was a milestone in the development of royal tombs, a masterwork not only in its fully achieved architectonic balance as a whole and in its individual parts, but also in its decoration and in the construction materials used. With a few modifications, Sahure's complex became the model for the royal tombs that followed during the Fifth and Sixth Dynasties, and to a large extent for later periods as well.

During the Middle Kingdom, pyramid complexes continued to be constructed, but they were already conceived differently in many ways. The entrance into the underground part of the pyramid was no longer necessarily placed on the north side, but might be in other, not precisely prescribed, locations. Above all, it was now important to conceal the entrance so that it would be invisible to thieves. In addition, the substructure of the pyramid—that is, the descending corridor, the barriers, and the burial chamber, which in some cases was accompanied by an antechamber—no longer had a fixed, unified layout. The



Model of Sahure's pyramid complex (after Borchardt; the original model is on display in the Egyptian Museum, Cairo).

influence of the Osiris cult favored the increasingly dominant conception of pharaoh's last resting place as the tomb of Osiris, surrounded by a labyrinth of passages, some of which led to dead ends or to hidden chambers. The king's grave was now accompanied by those of queens and princesses, and important changes were made in the decoration and the construction materials used for the other components of the complex.

In the New Kingdom, the royal tomb no longer took the form of a pyramid complex. The pyramid memorial nonetheless lived on in the architecture of private tombs and outside the borders of Egypt, in the royal tombs of the kingdoms of Napata and Meroe.

Let us return, however, to Egypt in the time of the Old Kingdom and to Sahure's complex in Abusir, and by examining its individual components try to understand something of its meaning and function. This will also shed light on the complex as a whole.

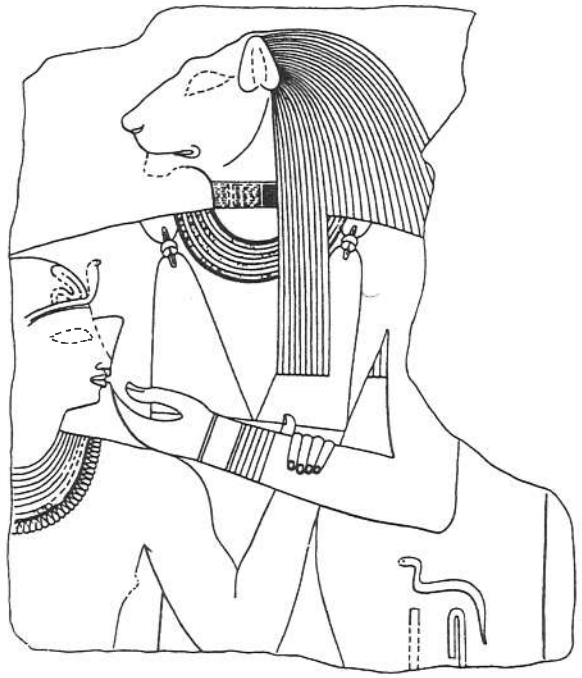
The entrance to Sahure's pyramid complex began where the Nile Valley and the desert met, metaphorically on the boundary between life and death. The lower or valley temple was both a monumental gateway and a landing ramp for the artificially constructed canal that connected the royal burial site with the Nile. It consisted of limestone blocks and, because of its high, only slightly inclined walls and flat roof terrace, it looked like a monolith.

From the main landing ramp on the east side of the temple—there was another landing ramp on the south side—a ramp led to a portico with black basalt pavement and pink granite columns in the form of stylized date palms. In the reigning conceptions of the beyond, the palm tree was a symbolic plant, connected with the Palm Grove in Buto, the ancient Egyptians' sacred cemetery. The ceiling of the portico was composed of enormous blocks of limestone decorated with yellow stars on a blue background, which looked very much like the night sky. He who entered there was entering the underworld, the world of the beyond.

Inside the temple was only a small room with two columns. Its walls were decorated with colorful scenes and inscriptions in bas-relief that had a ceremonial religious and mythical character. They included a representation of Sahure in the form of a lion tearing a captured enemy

to pieces with his claws, as well as a scene showing the tutelary goddess of Upper Egypt, Nekhbet, suckling the ruler and thus ensuring his eternal life among the gods. The reliefs in this temple and in the other parts of Sahure's pyramid field cover an amazing amount of ground—nearly ten thousand square meters. Many early Egyptologists believed that the embalming and mummifying rituals took place in the valley temples, yet in the valley temples discovered thus far no reliefs or other evidence support this view. While from the architectonic standpoint the valley temple was also the monumental gateway to the royal residence in the realm of death, its overall religious and cultic meaning remains in many respects obscure.

From the valley temple, the way into the interior of the tomb complex led through a long, covered, stone corridor that gradually ascended toward the west and was built on a ramp that compensated for the uneven terrain and the difference in elevation between the valley temple and the mortuary temple, which lay on the desert plateau.



Relief with the warlike lion-goddess Sekhmet, who is suckling the pharaoh Niuserre and thus ensuring the latter's power and eternal life; the king's pyramid temple in Abusir (after Borchardt).

Egyptologists call this corridor the causeway. It was also constructed of limestone blocks, and the indirect light that fell through the narrow openings in its flat ceiling slabs dimly illuminated the polychrome bas-reliefs. In the lower part of the causeway, mythical themes of an apotropaic character—the dismemberment of the leaders of enemy tribes, the incarnation of the powers of Evil and Chaos by the ruler in the form of a sphinx—were predominant. The reliefs in the causeway have been largely destroyed, as in other parts of the complex, but more secular subjects seem to have been depicted in its upper half: the completion of the work on the pyramid and an associated celebration including dance and sport performances, scenes of bringing offerings, and so on.

The mortuary temple (sometimes also called the pyramid temple or upper temple) was a spacious structure more or less rectangular in shape, its longer sides aligned with the east-west axis along which the pyramid complex as a whole was oriented. In spite of the structure's size, we can tell that it consisted of five basic elements: an entry hall, an open courtyard for sacrifices, a room with five niches for statues, an offering hall, and storerooms. A concern for symmetry is evident both in the arrangement of the parts and in the whole. Here as well, the dominant construction material was limestone blocks, but considerable quantities of other more valuable materials were also used: red and black granite, alabaster, and basalt.

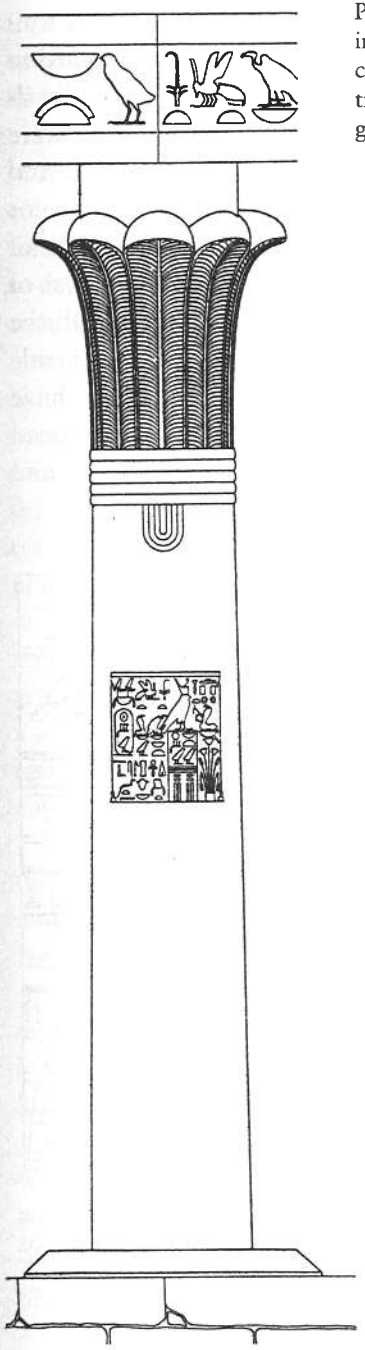
The transition between the causeway and the temple was represented by the entry hall, a long and dimly lit room. Apparently, it was modeled on the contemporary royal palace and on court etiquette. Egyptologists used to associate it with the Sed festival, the symbolic celebrations held on the occasion of the thirty-year jubilee of the king's ascent to the throne. Today, basing their opinions on the original Egyptian description of the entry hall as "the house of the great," Egyptologists generally maintain that high dignitaries kept a vigil there during Sahure's entombment, in order to be able to greet the dead ruler. The entry hall led to a granite doorway that opened out onto a spacious courtyard.

Around this courtyard ran an ambulatory supported by pink granite columns in the form of palm trees. On the courtyard side of each column was carved a hieroglyphic inscription with the ruler's name,

his titles, and symbols of the tutelary goddesses—on the north side of the courtyard Wadjet, and on the south side, Nekhbet. The pavement of black basalt slabs contrasted with the white limestone walls, richly ornamented with polychrome bas-reliefs. The ambulatory's ceiling was also colored blue with yellow stars to represent the night sky or the sky of the underworld. The subjects of the reliefs in the courtyard included the royal family, hunting, sea voyages, and enemies being ripped apart. It is even possible that additional statues stood there, representing kneeling, bound Asians, Nubians, and Libyans, in order to stress the idea of the pharaoh's mythical triumph. In the northwest corner of the courtyard stood the alabaster monolith of the altar, whose sides were decorated with scenes of sacrifice. Today it is still unclear why the altar was in this particular corner of the courtyard; we know only that the famous "royal offerings of the broad courtyard" were regularly sacrificed there.

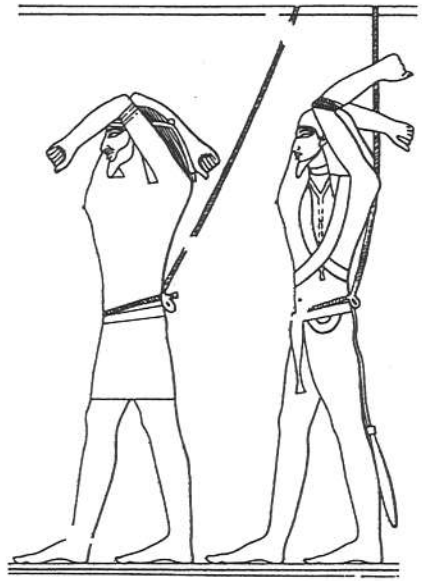
A longer corridor that ran straight across the main axis of the temple and was richly decorated with reliefs divided the eastern, outer part from the western, inner area, to which only a few priests had access. This inner area represented the main crossing point for the passageways both inside the mortuary temple and in its immediate environment.

A smaller but very important room with five niches was located west of this transverse corridor. It was reached by a short, steep alabaster stairway. The statues in the niches have not been preserved in Sahure's pyramid complex or in any other, and thus it is not surprising that only hypotheses exist regarding the appearance and meaning of the whole room. It was long supposed that these five statues symbolized five names, that is, five figures or functions of the Egyptian pharaoh. However, this assumption was shaken by the discovery of papyri in the archives of the nearby pyramid temple of Sahure's successor Neferirkare in the late nineteenth century. Writing on one of the papyrus fragments suggests that one of the statues represented the king as ruler of Upper Egypt, a second as ruler of Lower Egypt, and a third as ruler over the realm of the dead, as Osiris. The identification of the two remaining statues does not appear on the papyrus.

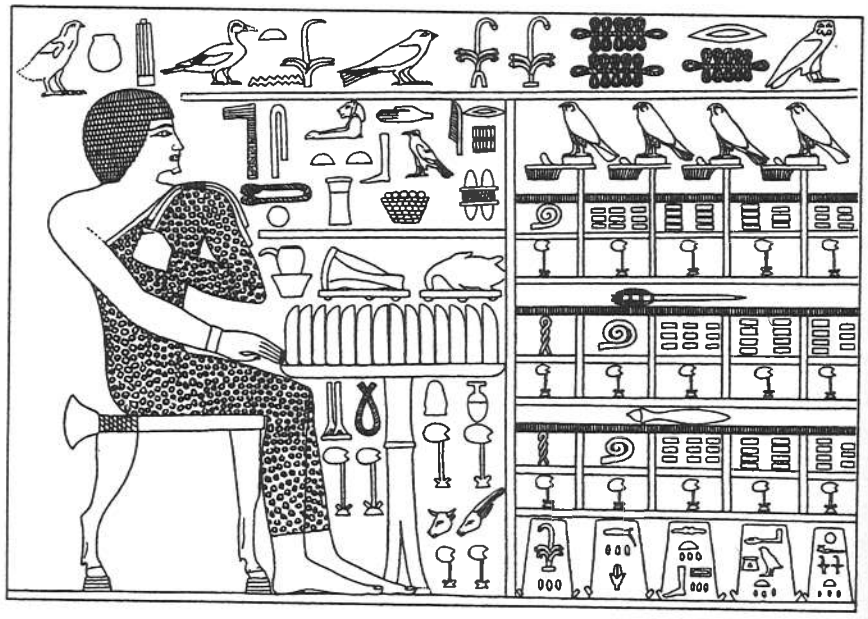


Palm-shaped column; Sahure's pyramid temple in Abusir (after Borchardt). On the shaft of the column is an inscription with the name and titles of the pharaoh Sahure and of the tutelary goddess of Lower Egypt, the cobra Wadjet.

Relief with Asiatic and Libyan prisoners, enemies of Egypt. Sahure's pyramid temple in Abusir (after Borchardt).



In the farthest, westernmost part of the temple, near the east wall of the pyramid, was located the most significant place with regard to the worship of the dead—the offering hall. Its vaulted ceiling was illuminated by a flickering light only when ceremonies of sacrifice were being performed. It was entered through a black granite door, and the materials that were used to construct it produced striking color effects: the floor was of alabaster and the dado on the lower part of the wall was of black granite, while the upper part of the wall was of white limestone decorated with colorful scenes in bas-relief. On the west wall of the room, the one closest to the king's mummy inside the pyramid, was a "false door" made of granite, which may have been covered with copper or gold. Through it the spirit of the dead ruler was supposed to enter the room to eat his meal for the dead and



Prince Iunu's (Fourth Dynasty) funerary repast. Clad in a leopard skin, he sits at the offering table. His name and titles are recorded in the horizontal row of hieroglyphs on the upper border. Another component of the scene is a representation and a list of sacrificial offerings, which includes incense, fragrant balm, a basket of figs, and storehouses with various kinds of grain. (after Junker)

then return to his tomb. In this room stood a statue of the ruler carved in black granite, which embodied the spirit during the ceremonies of sacrifice.

On either side of this room, in the northwest and southwest parts of the mortuary temple, were two larger systems of storerooms of considerable capacity, built on two levels. Neither reliefs nor inscriptions appeared on the walls of the storerooms, so today it is difficult to determine with precision the function of the individual rooms. The smaller, northwestern storeroom apparently served as the temple's treasure chamber, in which, for example, cult vessels made of precious materials were kept.

In contrast, the larger, southwestern storeroom served to accommodate temporarily the sacrificial offerings, vessels with food and drink, sacks of grain, chests of linen, and the like. A smaller side entrance from the southwest, framed by two black granite columns, provided convenient access.

The mortuary temple included other spaces, such as the temple archive, in which papyrus scrolls and documents relating to religious activities were kept, and a room for the temple guard. There was also a small stairway that led to the roof terrace known as the "the temple's head," from which the priests observed the heavens day and night and made various astronomical measurements.

Near the mortuary temple's south wall, at the southeast corner of the pyramid, stood a miniature copy of its great neighbor. In the underground part of this tiny pyramid lay another burial chamber, but no one was buried in it. The meaning of this somewhat bizarre structure within the pyramid complex has long been debated by experts. It seems to have been purely symbolic and was perhaps meant to provide lodging for the ruler's spirit. Egyptologists call it the satellite or cult pyramid.

Sahure's true tomb was the great pyramid, which concluded the whole complex in the west. A corridor that began at the foot of the north wall led into the underground burial chamber. After the burial rites were completed and the king's mummy had been laid in a basalt sarcophagus, the entrance was sealed with huge stone blocks. The place in the north wall where the corridor came out was covered with

a limestone slab in such a way that it could not be differentiated from the rest of the outside of the pyramid. Henceforth, nothing was to disturb the pharaoh's eternal rest. The enormous stone wall that surrounded the pyramid and the mortuary temple increased the seclusion and inaccessibility of the place where the god on earth rose into heaven.

The pyramid complex included auxiliary administrative and commercial buildings that had no direct ceremonial function but were nonetheless necessary to the worship of the dead. These were concentrated in immediate proximity to the valley temple, in the area where there was still vegetation and water. They provided lodging for the priests, as well as space for laundries, bakeries, slaughterhouses, offices, and markets. Sometimes they constituted whole "pyramid towns," large settlements with streets and many splendid buildings. It is assumed that the royal palace was also part of this complex.

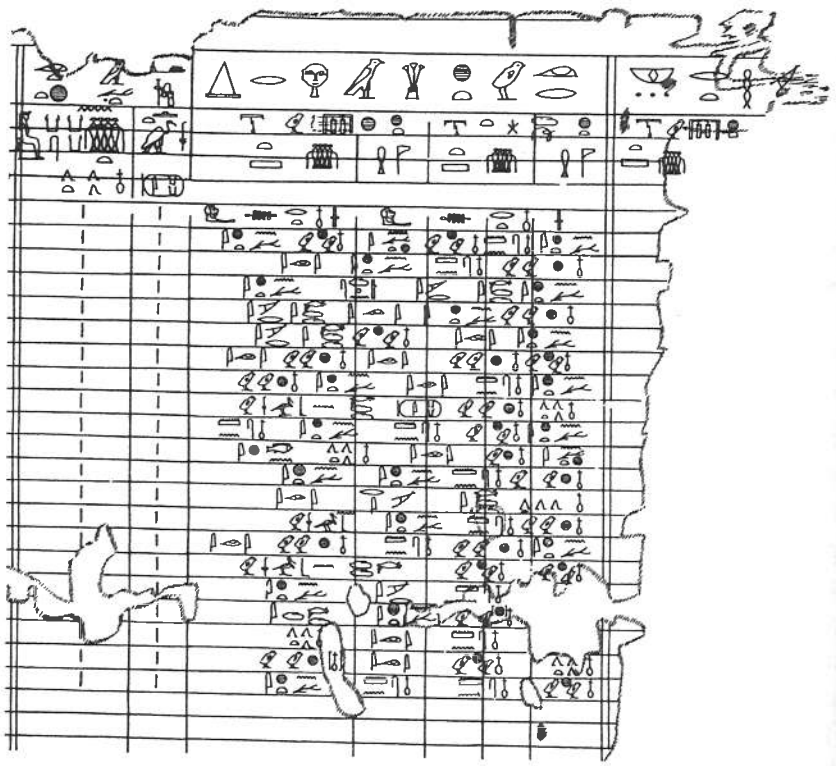
Excavations have shown that the pyramid complex was in no sense a dead city in the scorching hot desert, but they have not yet produced much concrete information regarding its administrative background, the means by which it was financed, or the worship of the dead king. Surprisingly, not archaeologists but grave robbers have contributed most to the unraveling of this enigma.

The Testimony of the Temple Archives

At the end of the nineteenth century, grave robbers discovered scraps of papyrus in the ruins of Neferirkare's mortuary temple in Abusir, in close proximity to the royal pyramid. Shortly afterward, these fragments, after passing through several intermediaries, fell into the hands of Egyptologists, causing great excitement among scholars. Examination showed that these papyri came from the archive of Neferirkare's pyramid temple and were by far the oldest written documents of their kind. Most of them were bought by museums in Cairo, London, Berlin, and Paris—and the matter rested there for the moment. The ancient cursive (i.e., hieratic) writing proved difficult to decipher and, far from providing sensational new information, seemed at first to consist only of administrative records with no historical interest. The papyri once again fell into oblivion for a long time.

More than half a century later, another event attracted the attention of Egyptologists, this time in Paris. A librarian at the Sorbonne happened to open a folio of Maspero's papers, which had been brought back from Cairo after his death, and found in them a papyrus fragment. Subsequent analysis by the leading French papyrus expert, Georges Posener (1906–1988), showed that the fragment came from Neferirkare's temple archive. Posener's wife, the Egyptologist Paule Posener-Kriéger, took care of the fragment and gradually examined all the associated documents, which were scattered in museums all over the world. In 1976, after twenty years of arduous labor, she published an edition of the papyri from Neferirkare's temple archive and thereby offered Egyptologists an unexpected, completely novel, and sometimes astonishingly detailed view of the necropolis in Abusir and of "life" in the realm of the dead. The Czech archaeological expedition has recently made two further papyrus archives available. The smaller was found in the pyramid temple of the queen mother Khentkaues II, and the larger, which is comparable in scope to Neferirkare's, in Neferefre's pyramid complex.

The bureaucratic expertise and pedantic care with which the scribes prepared and archived their official and financial documents are today of incalculable assistance to Egyptologists. The documents' value is increased by the fact that the information recorded is factual, authentic, immediately and absolutely objective. It concerns the temple's accounts, duty rosters for priests, supervision of the temple's inventory, repair and improvement of damaged parts of the temple, preparations for ceremonies, correspondence with various offices, and much more. There is also no lack of royal decrees. What defect can we find in an archive in which a scribe notes that a chest in the storehouse contains a single pellet of natron, which was commonly used in the daily ceremonies? Probably only that no more than a small portion of the entire body of documents has been preserved.



Hieroglyphic transcription of a segment of a text on a papyrus fragment from Neferirkare's mortuary temple. The text mentions the performance of ceremonies in the open courtyard around Neferirkare's pyramid and in the mortuary temple of the queen mother Khentkaues II (after Posener-Kriéger).

These papyri show that the activity in the mortuary temple was focused on the religious service. Rituals regularly enlivened the dark hall, and the spirit of the dead ruler came to his death table to feast. Every morning and evening a procession of priests passed, in flickering lamplight, into the five-niche room. They opened one small niche door after another and ritually cleaned the ruler's statue and rubbed it with fragrant oil before setting the magnificent table of sacrifices before the spirit who entered the statue. The lector priest rolled out the papyrus scroll and recited the formulas written on it. When the ritual was completed, the priests sprinkled the room with water and

wiped away the traces of their presence as they went out, so that they could not be exploited by evil spirits. Then they went into the offering hall, in which they performed a similar ritual.

Every morning and every evening, the priests also went around the pyramid, sprinkling it with water and ritually cleaning it. When they had finished this and other prescribed ceremonies, they put the cult equipment in a chest and sealed it. The consumable part of the offerings was divided between the priests and the secular temple servants. The latter were numerous; dozens or even hundreds of people performed a range of auxiliary activities, from transporting offerings to guarding the complex, the number of servants depending on how well the temple was funded and its material needs met.

The meal provided for the spirit of the dead pharaoh was not the only ritual performed every day. Many other rituals relating to the festivals of the gods and important events in the life of the whole country also took place. The most common of these was the monthly lunar festival, which included the worship of the ruler's statue.

The famous Sokar festival occurred only once a year, on the twenty-sixth day of the fourth month of flood season.* On this occasion the god Sokar (the ruler of tombs and the dead, from whose name that of Saqqara was probably derived) visited the dead king. The large, very colorful procession, which could not enter the interior of the pyramid complex, stopped at the mooring point, and the ritual was carried out in the valley temple.

The festival of Re fell on the twenty-first day of the fourth month of the harvest season. All the priests stayed up during the preceding night and offered, under the direction of the lector priest, a sacrifice to the sun god, which ended before dawn with a ceremonial procession to the nearby temple of the sun.

The festival of the annual, life-giving Nile flood was evidently the feast day of the fertility goddess Hathor. Her return from the realm

* There were three seasons in the ancient Egyptian calendar: inundation season, sowing (literally "coming out") season, and harvest (literally "heat") season. Each consisted of four months of thirty days apiece. The remaining days were dedicated to the gods.

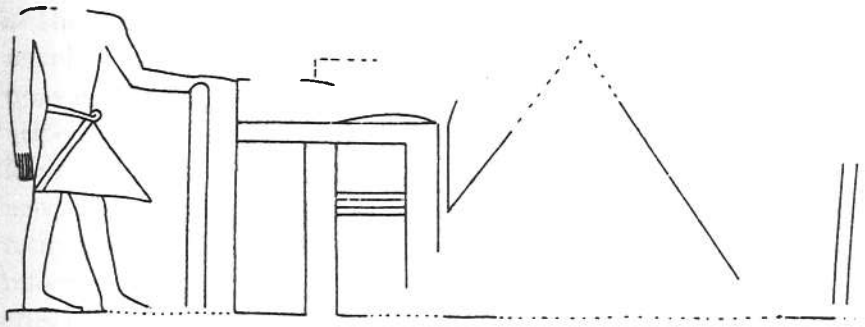
of the gods to the Nile Valley was associated with the return of the moon and the beginning of the floods.

The sed festival, as mentioned previously, was simply a memory of the thirty-year jubilee of the pharaoh's ascent to the throne, and it later took place at shorter intervals.

One of the most important festivals was that of the divine symbols—the griffin, the cobra goddess Wadjet, the scorpion goddess Selket, and others. This involved a large ceremonial gathering, in which not only all the priests and servants of the pyramid complex, but also the local population took part. Because of the great number of participants, the ceremonies, in which fetishes were worshiped, had to take place outside the pyramid complex.

The magnitude of some of these festivals is shown by one of the papyrus fragments from the temple archive of Neferirkare's successor, Neferefre, that was recently discovered by the Czech archaeological expedition in Abusir. It is an account indicating that on the occasion of a ten-day festival (about which we have no details), thirteen oxen were sacrificed to the pharaoh every day. Afterward, the priests divided all these sacrifices among themselves and the other participants. It is estimated that one ox was divided among as many as two thousand people. However, there are many indications that the meat was not used all at once; part of it was dried and stored.

It is clear that a large number of people and a considerable amount of financial support were required to keep the pyramid complex functioning with its daily sacrificial ceremonies and its religious festivals. For this reason the pharaoh, almost from the moment he ascended the throne, set about constructing his pyramid and chose land, villages, and workshops whose production was to ensure his eternal life. These so-called mortuary temple estates constituted only one of the pyramid complex's sources of income; other sources included the sun temple, which had its own resources and income, the royal residence, the palace, and temples of some gods. The size of the royal tomb complex, the large number of private tombs, and the scope of the worship of the dead would gradually but steadily exhaust the material resources and workforce. Indeed, the longing to be guaranteed eternal life in the beyond contributed in no small measure to the ex-



Fragmentary, somewhat enigmatic, but unique representation of a "priest opening the door to the temple at the foot of the pyramid" (?). Detail from the decoration of the tomb of Inti, called Shedu, in Deshasha (after Petrie).

haustion of the economic resources of the state and to doubts about the meaning of life in this world.

The basic echelon of the priests employed at the pyramid complex was "god's servants" and those who bore the ambiguous title of *khentiu-she*. The latter were responsible for various kinds of agricultural and technical work, the transportation of goods into the temple, and guard duty; they also took part in the ceremonies. Together with god's servants, they regularly spelled each other in their duties. A relatively small proportion of the temple personnel consisted of the priests who were known as "the pure." The lector priests constituted a very small and in many respects exclusive group that was not expected to perform any economic or guardian function but was responsible solely for the conduct of the ritual; they organized the ceremonies in accord with the principles of the temple cult.

In addition to the priests involved in the worship of the dead ruler, many other people worked at secular tasks connected with the daily life of the temple complex, and today it is still difficult to determine their precise function in relation to the king's tomb, despite the valuable information discovered in temple archives. This second group included high state officials—the vizier, judges, scribes, directors of royal affairs in the various areas of Upper and Lower Egypt, military commanders, storeroom supervisors, heads of the weaving shops, and so on. However, there were also butchers, hairdressers, manicurists,

Women personifying the funerary estates that provided the sacrifices for the worship of the dead. Ti's mastaba, Saqqara (Fifth Dynasty; after Wild).

physicians, and singers. Even the "flute-player of the White Crown," who played a role in the veneration of this symbol of dominion over Upper Egypt, must have been there.

The pyramid complex was thus in no way a secluded and abandoned world of eternal silence, a realm of death. It lived, and with it the whole cemetery around it lived its daily life and its festivals. No sharp dividing line was drawn between the world of the living and the world of the dead; the boundary was barely discernible. Life was preparation for eternity and death only an episode on the way toward it.

The discovery of the papyrus archives in Neferirkare's mortuary temple in Abusir made it possible to situate archaeological excavations in the pyramid necropolises in a much broader context. They helped answer many questions but also raised, as usual, new problems. For the first time, research on the pyramids entered a completely new, sensational dimension: archaeological discoveries could be directly checked against written descriptions, insofar as the latter were informative and well preserved. Conversely, archaeological discoveries helped to determine the meaning and wider context of unclear passages in the descriptions.

The papyri also refer to temples and palaces that once existed in the necropolis near Abusir but have not yet been discovered. Up to now, not a single royal palace from the Old Kingdom has been discovered and archaeologically explored. The papyrus archives can therefore necessitate more intensive excavations, particularly since discoveries of similar documents from that period are unlikely.

Chapter Three

THE CONSTRUCTION OF THE PYRAMIDS

The White Stone

An accessible abundance of many kinds of building stone so strongly marked ancient Egyptian civilization that the latter was sometimes called the state of stone. Limestone was especially plentiful because during the Cretaceous period Egypt was covered with seawater.

The ancient Egyptians called limestone white stone and made full use of its advantages, especially in construction and statuary. For a long time limestone was the fundamental construction material, and its characteristics had a profound effect on the works of the age of the pyramids. Only in the middle of the second millennium B.C.E., at the beginning of the New Kingdom, did architects begin to make increasing use of sandstone, especially in the southern part of the country.

The Egyptians first became acquainted with quarrying and shaping limestone during the construction of the oldest tombs in Saqqara. Here, not far from the White Walls, the capital city of united Egypt, the oldest monumental stone architecture in the world was born.

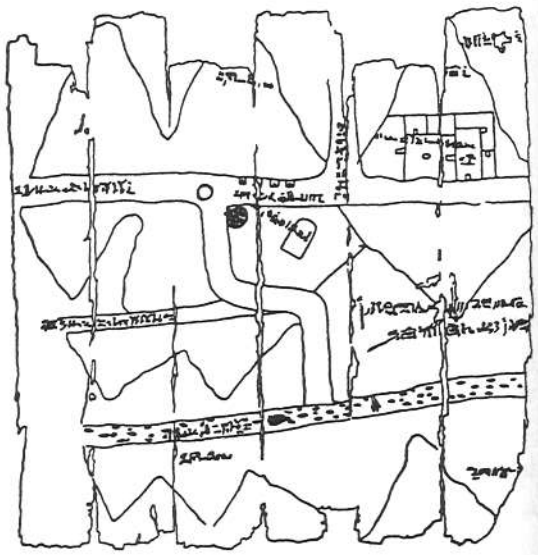
Several favorable circumstances led to the use of limestone for construction in Saqqara. The stone there is not of very high quality, but it is sedimented in regular, strong layers as much as half a meter thick, some of which differ in color and are separated from each other by thin layers of clay. This made quarrying easy, and it could even be carried on near the construction site. All workers had to do was measure the length and breadth of the building blocks and mark them out on the stone; their thickness was determined by that of the layer. Between the marks corresponding to the length of the future blocks,

small passageways were left that were just wide enough for a worker to dig out a deep ditch. In this way it was possible to rapidly break out blocks of a standard size.

The workers used copper pickaxes and chisels, as well as hammers made of granite, dolerite, and other kinds of hard stone. The work of any given laborer was controlled by means of a stick wielded from the top of the shaft. The remains of such quarries have been found not only in Saqqara but also in Giza, Dahshur, and elsewhere. The limestone from those quarries was of lesser quality, however—coarse grained and with yellow to greenish gray shadowing; therefore, it was used for the inner parts of the wall and for the inner core of the pyramid. For the outer casing, fine-grained white limestone was used, but it was not available on the west bank of the Nile in the area of the capital city.

The nearest source of such finer stone to the capital was in the Muqattam hills west of the Nile, not far from modern Tura and Maasara. The stone lay far from the surface there and had to be mined by digging tunnels, which created enormous caverns that were sometimes ten meters high and descended as much as fifty meters below the surface. Some of the rock debris has remained, but not many written documents—instructions, marks on the stone, and the like—could be preserved, since shortly after being incised on the rock walls, they were usually knocked off along with the stone blocks. The ancient Egyptians broke the large chunks of stone into smaller blocks and then listed them in their registers with bureaucratic precision, in the interest both of monitoring performance and of determining whether the blocks met the demands of the construction project that was planned or already being carried out.

The blocks were dragged down to the mooring on the banks of the Nile by men and animals working together, as demonstrated by one of the images preserved on a rock wall near Tura. It shows a large block of limestone lying on a wooden sledge, hitched to three brace of oxen. The path to the bank had to be well prepared, leveled out and sprinkled with water mixed with mud from the Nile, in order to reduce the friction. The work in the quarries did not continue uninterrupted with a set group of laborers but was instead carried out



The map of the quarry in Wadi Hammamat is preserved on a papyrus from the Twentieth Dynasty (Egyptian Museum in Turin, nos. 1879, 1899, 1969).

periodically, depending on the size of the edifice under construction. The state organized workforces, placed them under paramilitary command, and sent them into the quarries. As the sole proprietor of the country's natural resources and labor, the ruler had ultimate control over the entire process.

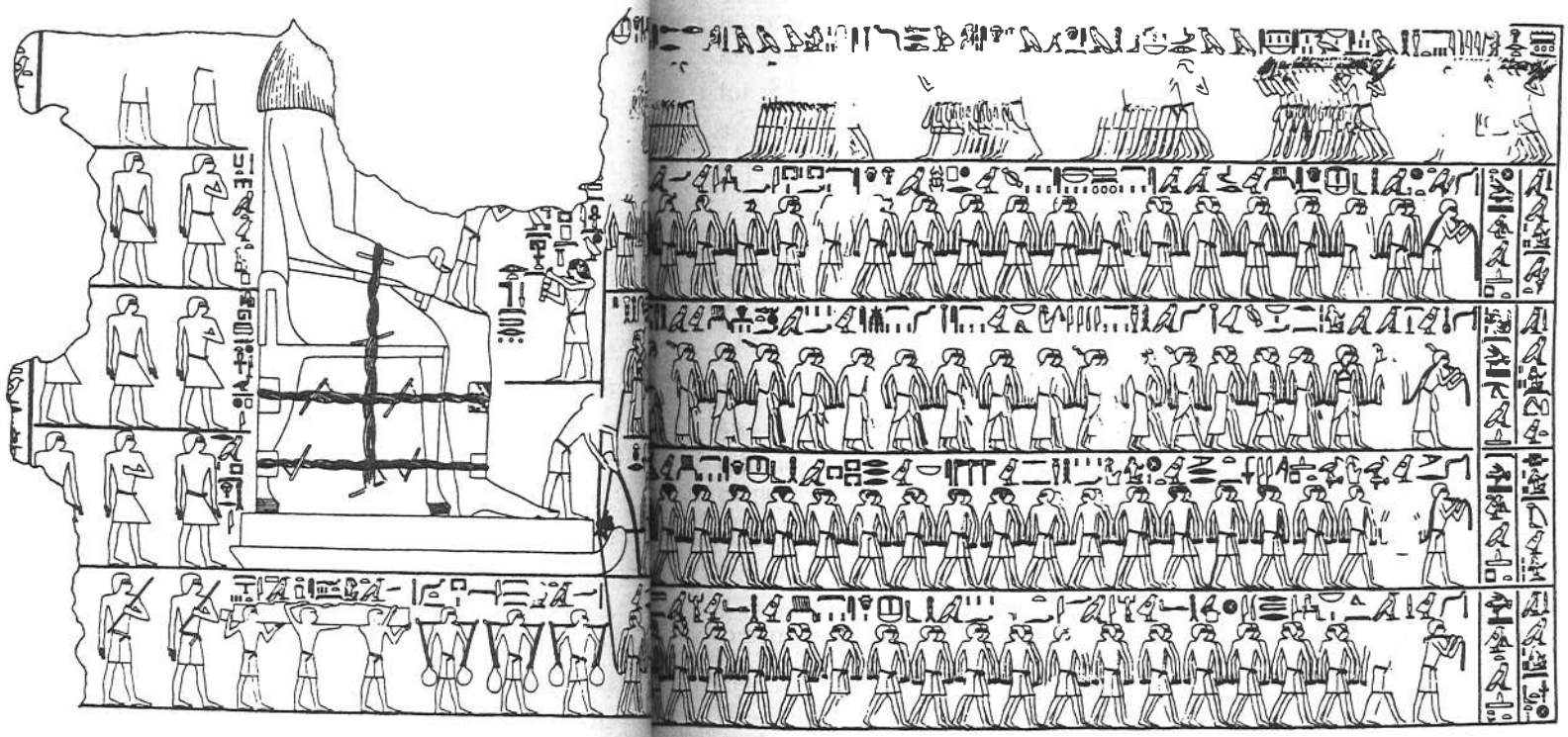
Expeditions to the Quarries

For construction, especially royal construction, other kinds of stone were needed as well. These generally lay far from the capital city, around which the greatest construction activity was concentrated. Pink granite was quarried far in the south, at the first cataract of the Nile, near modern Aswan; alabaster around Hatnub in Central Egypt; diorite in the eastern desert or in Nubia, near modern Abu Simbel; and slate and many other kinds of stone in Wadi Hammamat, in the "valley of baths," and in other places in the eastern desert. While unskilled labor, which was sufficient for the quarrying and transportation of large volumes of stone, constituted most of the workforces sent to quarries near the capital city, more qualified workers were sent to the

distant places where precious materials were found, accompanied by a considerable number of soldiers who protected them in regions populated by dangerous Bedouins.

Many extant sources, including inscriptions on rock walls along the way or in the quarries themselves, yield information about these expeditions. Some of them suggest that the expeditions were carried out under the ruler's command. Often we encounter references to dates, the expedition's goal, the number of participants, and expressions of gratitude to the tutelary divinities. The organizational structure and leadership of the expeditions are significantly reflected in the titles of their leaders and other participants. Expedition leaders were commonly called "troop commanders," "fleet commanders," "chiefs of the royal works," and "bearers of the god's seal" (the ruler's seal). Scribes and priests aided the expedition's leadership. There were specialists such as prospectors and stonemasons. The inscriptions at the alabaster quarries in Hatnub indicate that an overall number of workers ranged from three hundred to sixteen hundred, and alabaster was one of the more valuable stones used to a limited extent, so there would have been fewer workers in the alabaster quarries than in the limestone quarries.

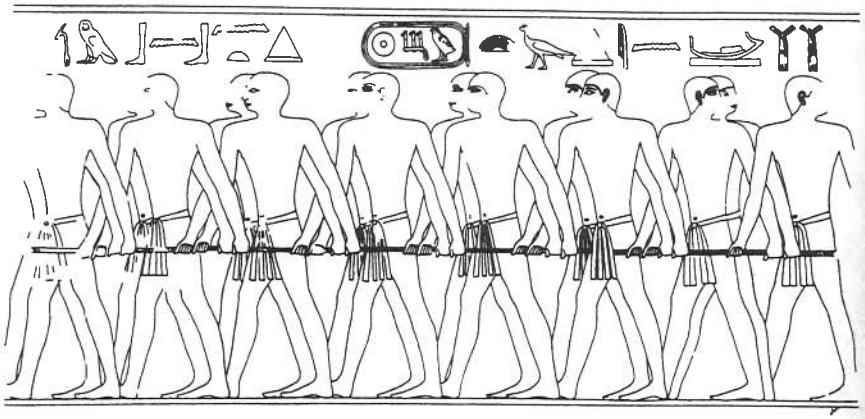
Transporting the quarried building stones presented an exceptionally difficult task from a technical and organizational standpoint. The size and weight of the blocks varied considerably. Some of the blocks from nearby quarries used in the construction of Menkaure's pyramid in Giza reached the gigantic proportions of 8.5 by 5.3 by 3 meters, and a weight of some 220 tons. When the stone was not available close to the building site, it sometimes had to be brought down the Nile as far as several hundred kilometers. This was the fastest and least difficult mode of transportation, and written and pictorial evidence proves that it was quite often used, taking advantage of a network of artificial canals, and especially the annual floods, which caused the Nile's level to rise several meters so that its water flowed far out over the land, right up to the foot of the desert plateau chosen as a construction site. In that way, overland transport could be reduced to a minimum, and in the higher locations it offered a natural means of moving heavy stone blocks onto the construction site.



Transportation of a huge statue. Scene from the tomb decoration of the nomarch Djehutihotep in Bersha.

Not all researchers agree that the main transportation work was done during the period of flooding on the Nile. They point out, for example, that the heavily laden boats would not have been able to navigate the overflowing Nile without peril, and the flooded banks would have made unloading more difficult. The French scholar Georges Goyon assumes that the transportation of materials for the construction of the pyramids went on over the whole year, and that for this purpose the ancient Egyptians used an artificial waterway, which they called the Great Canal. This canal, which may have been laid out during the First Dynasty and is now called in Arabic Bahr el-Jussef (Joseph's River), branches off from the Nile in Upper Egypt and runs parallel to it for some two hundred and twenty kilometers; then it turns west into the Fayyum oasis. From there it runs northward, under the name of Bahr el-Libeini (the Libyan Canal), past the foot of the rock plateaus with the pyramids, and finally flows, near Alexandria, into Lake Maryut and the Mediterranean. Goyon found archaeological remnants of a port on the canal that was established for the construction of Khafre's and Menkaure's pyramid complexes in Giza, as well as those of Unas and Pepi II in Saqqara.

However, water did not provide transportation for the greater part of the materials necessary for the construction of the pyramids. As previously mentioned, most of the stone came from quarries near the construction sites. Indeed, the proximity of a sufficient supply of easily accessible limestone was one of the chief criteria determining the choice of the site for a pyramid. On the basis of archaeological evidence, we can reconstruct the local production of limestone and its transport to the building site. For example, south and southwest of the Red Pyramid in Dahshur, limestone quarries were discovered from

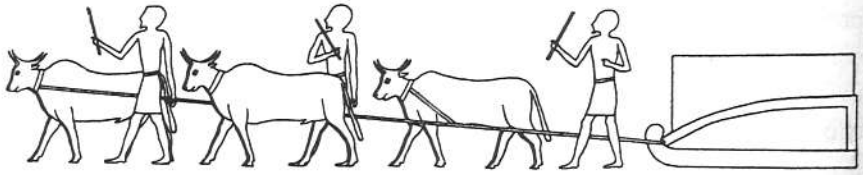


The transportation of a pyramidion to Sahure's pyramid construction site in Abusir. The representation of the pyramidion itself was on a subsequent block, which has not yet been found. This can be inferred from the inscription, which even implies that the pyramidion was covered with gold. Detail of the decoration of the causeway leading to the king's pyramid.

which three access roads (ca. one kilometer long and fifteen meters wide) led to the pyramid. On the ruins of the core of this structure are three mason's inscriptions that make it possible to estimate the scope of the works. According to them, workers transported three hundred to six hundred blocks daily.

Sun and Stars, Poles and Ropes

Building a pyramid involved more than supplying and transporting the necessary materials; it was a multifaceted enterprise involving a



Late Period rock drawing from the Tura limestone quarries depicting the transport of a limestone block on a wooden sledge drawn by three brace of oxen.

number of specialists led by the "royal master builder." The vizier, in his capacity as "head of all royal works," was ultimately responsible for the success of this enterprise and had at his disposal all the necessary means, including a list of all the residents capable of working, which was kept in the "bookhouse" or archive of the royal residence.

The first step in the process was taken in the "project office," where specialists drew up plans on papyrus; while building was under way, they drew sketches of construction details on papyri or flat slabs of limestone. It can even be assumed that planners made models of whole projects. Evidence of this appears in some archaeological discoveries, such as the limestone model of the substructure of an unknown pyramid (probably from the Thirteenth Dynasty) that was found in Amenemhet III's valley temple in Dahshur.

The extent of ancient Egyptian mathematical knowledge is evident in many extant written documents. The Rhind papyrus and the Moscow papyrus, for example, contain various mathematical procedures and problems that show that although ancient Egyptians were not able to formulate mathematical laws with precision, they possessed sound practical knowledge and knew how to make the fullest use of it. They worked with a decimal system and were able to use fractions. They could calculate the area of a triangle, a rectangle, a circle, and even the surface area of a hemisphere; they could determine angles and the volumes of geometrical shapes, including pyramids, cylinders, and cones. They also knew the relationship between the sides of a right triangle—Pythagoras's theorem—constructing the right angle using a triangle whose sides were in a ratio of 3 : 4 : 5.

Schematic plan of the stone tomb of Ramesses IV, sketched on papyrus (Twentieth Dynasty; Egyptian Museum in Turin, no. 1885).

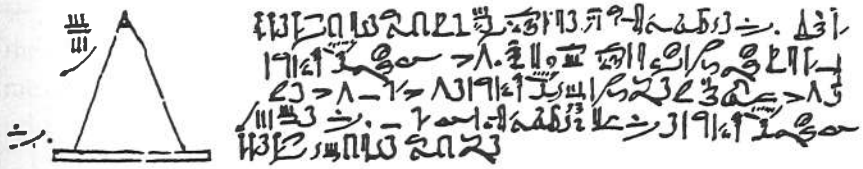
The ancient Egyptians' constructions are the best evidence of their mathematical capacities. Let us take, for instance, the Great Pyramid in Giza. If we imagine a circle whose radius is the height of the pyramid, then the circumference is identical with the base of the pyramid. This could be achieved only if the wall had the correct angle, and everything had to be calculated in advance. We can conclude that although the ancient Egyptians could not precisely define the value of *pi,* in practice they used it.

The subsequent stages were no less demanding than the preparations. The selection of the site of the future pyramid was very important, and Egyptologists are still trying to decide what actually influenced it. At this point, we do not always know exactly why one ruler had his pyramid built in Giza, while another from the same dynasty had his built in Dahshur. Different considerations probably played a role in the decision.

The importance of eāsy availability of limestone has already been mentioned. According to another view, expressed many years ago by the famed German Egyptologist Adolf Erman, the sites chosen for the construction of pyramids varied with the placement of the royal residences. The latter were in the Nile Valley, amid gardens and fields near the capital city, Memphis.* According to this view, the pyramid's construction was directed from the royal residence, imposing an enormously expensive burden and a complicated task on the state's administrative apparatus.

In a few cases, the selection of a site was also influenced by the insufficient amount of space remaining in the previous tomb area. Additional motives might be religious-political (for instance, having one's pyramid erected near the oldest step pyramid in Saqqara) and might also, of course, have to do with family relationships (for example, Neferirkare's family members had their own enclosed family cemetery set up near Abusir).

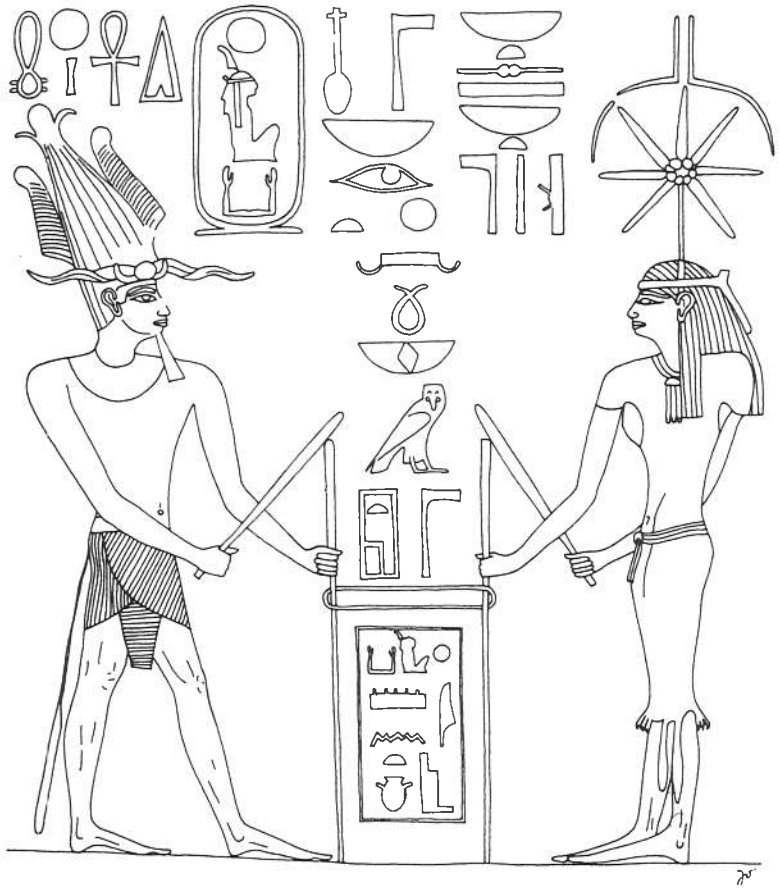
* Since no royal residence from the Old Kingdom has yet been found, the question arises whether it might be the other way around, that is, whether the construction of a pyramid was not a reason for constructing a royal residence nearby. We shall return to this problem later on, when we deal with the manner in which the pyramids were built.



Mathematical problems on the Rhind papyrus (Second Intermediate Period) concerning the calculation of the height of a pyramid (after Peet).

The chosen site was prepared and important foundation ceremonies were carried out before construction began. In the course of the foundation rituals a special role was played by Seshat, the goddess of writing and the protectress of scribes and master builders. In the extant depictions—which are not directly connected with the pyramids—Seshat and the ruler hold in their hands a pole and a loop of rope, both of which were important tools for measuring the foundation of the future pyramid. During the ceremonies, animal sacrifices were offered to the gods and then laid, along with other objects—such as vessels symbolizing additional offerings, small tablets with the names of the owner of the future structure, and models of the construction tools—in the foundations, usually in the corners of the structure, atop a layer of pure sand.

Determining the precise orientation of the pyramid was a very important and demanding operation. The axes of its sides were aligned with the four cardinal directions (a few small step pyramids built at the end of the Third Dynasty and the beginning of the Fourth Dynasty are exceptions to this rule, but they were not tombs). Egyptologists used to believe that the builders determined the pyramid's north-south axis by reference either to the Pole Star (then the star Alpha Draconis) or to other circumpolar stars. According to this view, a man stood in the middle of a simple circular structure made of mudbricks and observed the rise and setting of a given star in relation to this artificial horizon. The observations were carried out using a simple, fork-shaped sight called a *bay.* Then a second man, following the directions of the observer, used a plumb line, a *merkhet,* to mark on the top and bottom of the wall the precise points over which the star had risen and



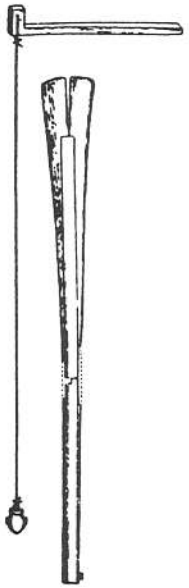
During the "stretching the cord" ceremony, the goddess Seshat and Queen Hatshepsut, represented as a male pharaoh, found the shrine by driving in the baseline stakes, to which a cord is tied. Egyptologists disagree regarding the precise technical meaning of this ceremony. Some think it had to do with the determination of the axis or corners of the planned structure, while others see it as a way of keeping the baseline stakes in a vertical position without using a plumb bob. Detail from the decoration of the so-called Red Chapel in Karnak (Eighteenth Dynasty).

set. The line connecting the midpoint between the two marks and the observer's standpoint thus determined the north-south axis. The measurement could be made more precise through observation of other stars.

Quite recently, a new theory was published by the British scholar K. Spence. According to Spence, the ancient Egyptians aligned the pyramids by using the simultaneous transit of two circumpolar stars (Delta Ursae Majoris and Beta Ursae Minoris or Epsilon Ursae Majoris and Gamma Ursae Minoris) in order to establish true north. On the basis of this hypothesis, Spence calculated the accession dates of some ancient Egyptian kings. This theory will certainly incite further scholarly debate.

However, it is just as possible that the orientation of the foundation was determined by observing not the stars, but the sun. As demonstrated, for example, by a Slovak Egyptologist, D. Magdolen, the east-west axis could be determined with the help of wooden stakes and ropes such as those the goddess Seshat and the ruler hold in their hands in the depictions of the foundation ceremonies. At the equinox, a stake driven vertically into the earth threw a shadow that pointed exactly to the west at the moment of sunrise, and at the moment of sunset pointed exactly to the east. This determination could

Offerings were made when important construction projects such as temples and pyramids were begun. A few symbolic objects, including certain sacrifices—so-called foundation deposits—were usually laid in a hole in the building's foundation. In a fragment of a scene from Niuserre's sun temple in Abu Ghurab, the ruler is shown kneeling while performing this rite.

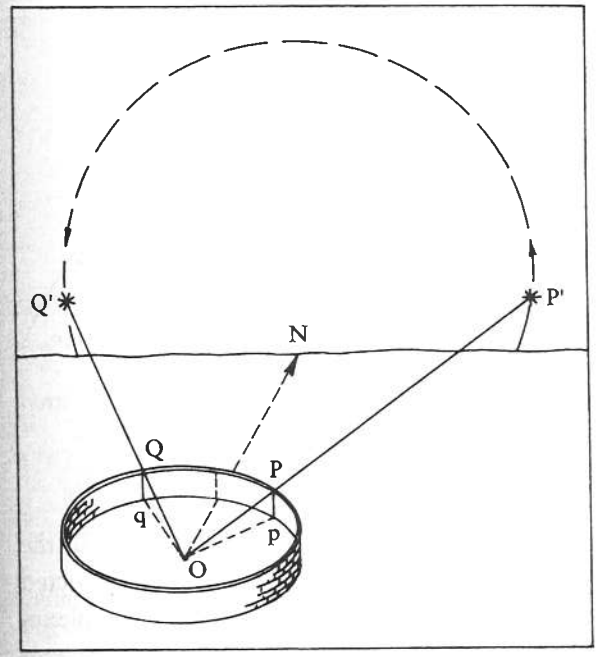


Merkhet and *bay*, tools used by ancient Egyptian astronomers and architects (after Borchardt).

be made not only at the equinox but at any time of the day or year; one had only to make additional measurements.

The pyramid's foundation had to be precisely level, and the architects made use of a simple method for determining it. They built a trough out of mudbricks and filled it with water. Marking the water level on the walls of the trough enabled them to obtain a precisely horizontal line. The remains of these clay structures, used to determine and inscribe a horizontal line on the east wall of the foundation platform, have been found in Neferefre's unfinished pyramid in Abusir. Our knowledge of this process helps explain a slight error made in determining the foundation level of the Great Pyramid in Giza, where the southeast corner is about two centimeters higher than the northwest corner. The prevailing wind from the north probably raised the water level by two centimeters at the south end of the trough on that side of the pyramid.

The angle of the pyramid's walls was not calculated but rather constructed with the help of a right triangle. The hypotenuse was always one ell long, whereas the adjoining legs of the triangle varied



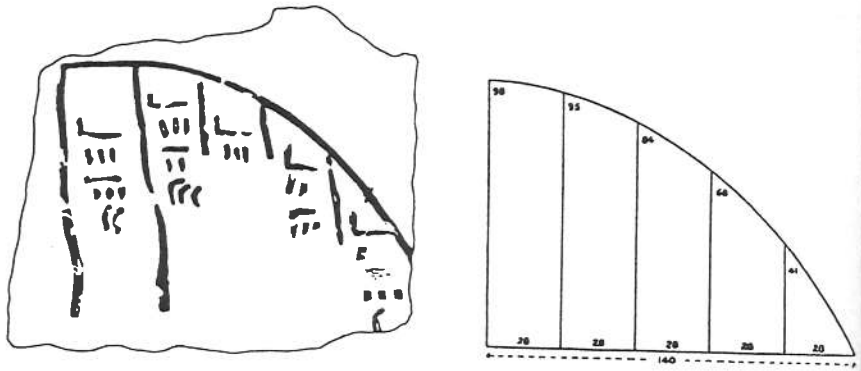
The determination of the north-south axis on the basis of observations of the rising and setting of a selected star on the artificial horizon (after Edwards).

in length. The relationship between the two sides was called *seked*. Using the angles determined in this way, the architects set up a simple wooden frame for the construction itself. Today Egyptian architects employ a similar tool in reconstructing monuments.

The completion of a pyramid was accompanied by celebrations and ceremonies such as those depicted in bas-reliefs on stone blocks from Sahure's causeway in Abusir; in them, workers pull a sledge bearing a gilded pyramidion (as the inscription over the scene allows us to infer, see fig. on p. 68), foremen and work teams render homage to the ruler, harem women perform ceremonial dances, and so on.

The Secret Lies in the Organization of the Work

The size of the pyramids and of stone blocks used to build them led the ancients to make fantastic estimates of the number of workers that had been involved. To a certain extent this is understandable. At the

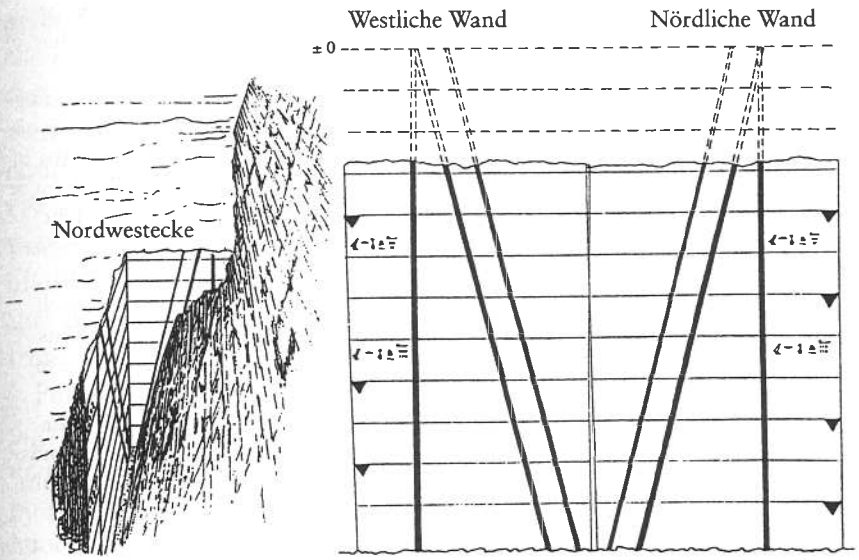


Limestone shard from the Djoser pyramid field with information on the construction of a vault (after Lauer).

beginning of the Fourth Dynasty, for example, King Snefru, in the course of his more than three-decade rule (cf. p. 179), constructed three pyramid (and, in addition, a small pyramid in Seila) complexes with a combined volume of about 3.7 cubic meters of stone. The volume of the masonry of all the royal structures built during the century and a half reign of the Fourth Dynasty is estimated to be about nine million cubic meters. These figures are all the more astounding when one considers that no more than one and a half million people lived in all Egypt at that time.

The Greek historian Herodotus wrote that during the construction of the Great Pyramid in Giza, 100,000 men worked for twenty years, three months at a time. (These work periods clearly correspond to the three seasons of the ancient Egyptian calendar.) Herodotus's view was considered plausible by even so experienced an archaeologist as Petrie. In his opinion, the main work was done during flood season, when the rural population could not work in the fields.

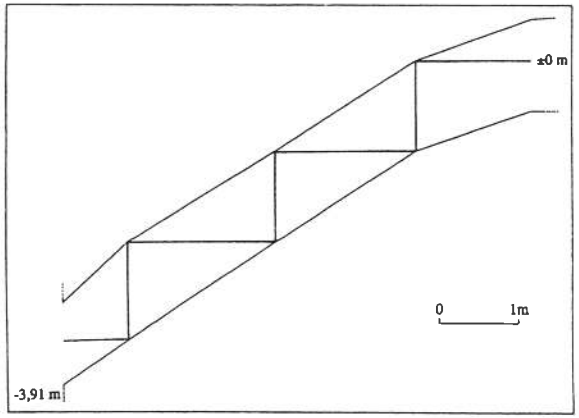
Other scholars have based their estimates on the construction work to be done. Ludwig Borchardt and Louis Croon assumed that the work could have gone on throughout the year. On the basis of research on the pyramid at Meidum, they came to the conclusion that about 10,000 men took part in its construction, including the transportation of materials. Extrapolating from this figure, they estimated that



During excavations in Meidum, Petrie discovered next to mastaba no. 17 (beginning of the Fourth Dynasty) an important measuring device that provides clear evidence of the procedure used by the ancient Egyptian architects to determine the gradient of the outer tomb walls and to check it during construction. On the northwest corner of the mastaba, where the structure was below the level of the surrounding terrain, a network of lines was inscribed on the side walls of the stone foundation—horizontal lines one cubit apart as well as vertical lines and sloping lines showing the gradient of the mastaba walls. These lines were accompanied by short, explanatory inscriptions with information concerning the distance from the side of the foundation.

for the Great Pyramid in Giza approximately 36,000 men would have sufficed. Yet even this figure ultimately seemed too high to them, given the limited area of the construction site and the difficulties connected with lodging and supply.

By calculating the work that must have been involved in transporting an object of a given mass over a given distance, Kurt Mendelssohn, an American mathematician and physicist of German descent, arrived at a figure of 50,000 workers and at most 70,000 helpers. The calculations of the Polish architect Wieslaw Koziński, who believes that it must have taken an average of 25 men to transport a block weighing one and one-half tons, led in an entirely different direction. Since he



The mason's drawing inscribed on the ceiling of the descending and bending corridor leading to the burial chamber of Ptahshepses's mastaba in Abusir shows a system of lines enclosing a right angle. By means of this simple procedure the precise alignment with the cardinal directions was also transferred to the burial chamber, which lay almost four meters under the foundation level of the mastaba.

estimates that there were 60,000 men outside the construction site and 300,000 inside it, he arrives at the same figure as Diodorus did in antiquity. However, Koziński based his calculations on the erroneous assumption that Egypt's population was between 5 and 10 million people at that time.

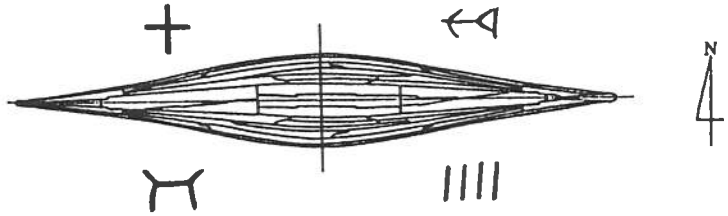
Recent discoveries suggest a new way of approaching this problem. In the mid-1980s a French and Egyptian team researching the Great Pyramid began to use ultrasound technology. Their measurements showed that in the core of the Great Pyramid large cavities had been filled with pure sand. During construction the "chamber method"* was probably used, which significantly accelerated the work and made it easier and less expensive. In the light of these discoveries, all the complicated calculations and estimates concerning how many million stone blocks make up the Great Pyramid, and the speculations based on them, are thus built on sand.

Another valuable source of information is provided by the signs, simple inscriptions, and sketches marked in red, black, and sometimes

* In this method, the perimeter walls were first built, and then the space within the structure was filled with sand or chunks of limestone held together here and there by mortar.

yellow on the pyramid's stone blocks and walls. In comparison with the monumental and artistically achieved hieroglyphic inscriptions, these are humble inscriptions, and for a long time they were considered historically insignificant—perhaps in part because they are often scraped away, difficult to access, and hard to read. Together with other inscriptions that have been discovered, and that generally have to do with state administration, they now allow us to reconstruct the mode of organization and direction of the work on the largest construction sites of ancient Egypt. In particular, they tell us what procedural systems existed at the time of the construction of the pyramids.

Part of the labor force was organized in accord with the ancient organizational principle originally used to direct a boat crew. The basic unit of the "team" included about two hundred men and was composed of five "phyloi" (from the Greek *phylē*: tribe, group, brotherhood), named after the different parts of the boat—bow–right side, bow–left side, stern–right side, stern–left side. The name given to the fifth and last group has not yet been satisfactorily explained; perhaps it was related to the helmsman's position. Each "phylē" was then divided into four (at a later time, two) groups. These also had names, which were sometimes related to the workers' geographical origin and sometimes to the required skills or virtues, such as endurance, strength, and a sense of teamwork. Apparently, no more than three teams, comprising six hundred men, worked on the project at any given time. Each unit—team, phylē, or group—had a leader. The question remains



The distribution of the labor force on the model of the organization of a boat crew is illustrated by the schema of Khufu's (Cheops's) death boat, with signs indicating the four different parts of the boat. The latter have been marked out by the master builders in order to organize the workers simply and quickly (after Abu Bakr and Ahmad Yousef).

what the workers directed in this way actually did. The origin of the system suggests that they were probably involved with transportation, since this work required that the strength of smaller groups of men be coordinated to ensure the smooth, rapid delivery of construction materials by both water and land.

In addition to the "team" system, another system was used in construction, which involved dividing up workers according to the cardinal compass points, north, south, and west. An eastern group is nowhere documented, and another term was used in its place, perhaps because in Egyptian *eastern,* like *left,* meant "bad." The four sides together made up a larger unit called a troop. Much evidence suggests that the craftsmen and specialized workers on the pyramid construction sites were organized in accord with this model. However, there is no indication in the extant documents of how many workers made up a side or a whole troop.

Workers divided into teams or troops represented only a minority on the construction site. These two categories of workers, although specialized and no doubt productive, could not have erected a pyramid by themselves. From the layout and volume of the masonry we can conclude that it constituted the largest part of the work required, but it is nonetheless certain that a significant number of helpers must also have been involved in the construction, although no extant written sources from the period give us any precise information about them. We can only infer their existence from the magnitude and complexity of the construction and from a few documents.

In Pepi II's decrees granting privileges to the Min Temple in Coptos, we find, in connection with the exemption of temple servants from the duty to work for the ruler, the expression "assignment to every task for the King." The text goes on to explain that this work duty includes "carrying" and "transport using wood." Other inscriptions inform us about additional kinds of heavy labor—for example, working in the fields or digging trenches for irrigation canals. These tasks were imposed in particular on the largest population group in ancient Egypt, the agricultural workers, who could not work in the fields during the annual flood season. During that season they were the only available source of unskilled labor large enough for the construction of pyramids.

It is not known how many rural people were involved in the construction. We also do not know how these seasonal workers were commanded, and it is possible that their work could not even be registered, among other reasons because doing so would have involved too great an administrative expenditure. Concerning the magnitude of the anonymous mass of people who worked on the pyramids, we have merely a few estimates. In the case of the Great Pyramid at Giza, the current consensus among Egyptologists sets the figure at a little more than 30,000.

Ancient Egyptian documents and depictions tell us nothing about the conditions under which the construction workers lived and how they were compensated for their labor. Herodotus asserts that "on the pyramids, the quantities of radishes, onions, and garlic consumed by the workers are written in Egyptian writing," but this assertion is not reliable. Against it speaks not only the fact that no such inscription has ever been found, but also and especially the ancient Egyptians' belief that such banal evidence of calculation would profane the pharaoh's tomb. However, it is fairly certain that the ancient Egyptian scribes did keep such records, and with their usual bureaucratic precision preserved them in the corresponding archives, which either have been destroyed or remain undiscovered.

Among the few extant documents relating to construction work in the era of the pyramids, a Sixth Dynasty papyrus text found in Saqqara is of particular interest. This is a letter from the foreman of a work party in the limestone quarry near Tura to the official entrusted with directing the construction work or with receiving deliveries of construction materials. In his letter, the foreman complains that clothes for his workers have not been received on time and that time has been lost waiting for them; thus he indirectly draws attention to the resulting delays in the planned work schedule. This text also suggests that the work party was staying near the royal residence. It can therefore be assumed that the state not only provided clothing for the workers, but also fed and lodged them. Naturally, this holds true only for large royal construction projects, whereas quite different conditions obtained in the case of smaller private projects, which became increasingly common, particularly in the later Old Kingdom.

Lifting Devices or Ramps?

Questions regarding the number of people involved in the construction of the pyramids and the conditions under which they worked constitute only one of the pyramids' riddles. No less important and interesting is the question of how heavy materials, sometimes stone blocks weighing several dozen tons, were lifted so high.

Two ancient historians attempted to answer this question. Herodotus (*Histories,* Book 2, chapter 125) provides the older of the two accounts: "At first, it [the pyramid] was built with steps, like a staircase. . . . The stones intended for use in constructing the pyramid were lifted by means of a short wooden scaffold. In this way they were raised from the earth to the first step of the staircase; there they were laid on another scaffold, by means of which they were raised to the second step. Lifting devices were provided for each step, in case these devices were not light enough to be easily moved upward from step to step once the stone had been removed from them. I have been told that both methods were used, and so I mention them both here. The finishing-off was begun at the top, and continued downward to the lowest level."

In his *Bibliotheca,* Diodorus Siculus offers another explanation: "It is said that the stone was brought over a great distance, from Arabia, and that the construction was undertaken with the help of ramps, since at that time cranes had not yet been invented."

These very different accounts provide the basis for modern approaches to the problem. Some researchers, relying on Herodotus, assume that the stone blocks were raised with the help of simple wooden structures, while others, following Diodorus, maintain that massive, elaborate ramps were used. There are other theories as well, ranging from the technically plausible to the highly fantastic, but they are contradicted by archaeological information concerning the ancient Egyptians' technical capacities.

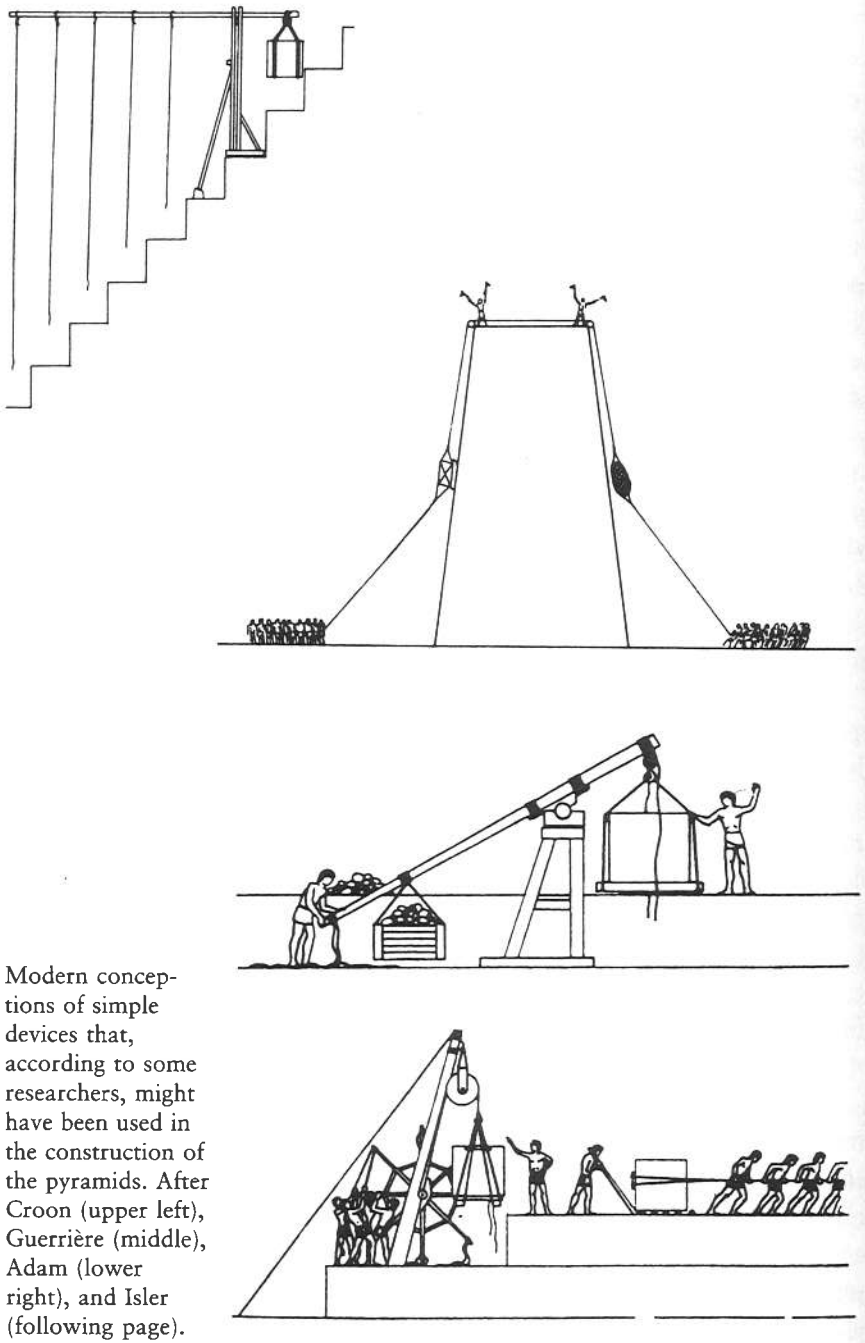
When miniature models of simple wooden "cradles" constructed of arched elements bound together with short poles were found during nineteenth-century excavations, it was suggested that they might be the "lifting devices" mentioned by Herodotus. (It should be noted that these discoveries were not made in the area around the pyramids,

but rather in Upper Egypt.) These devices consisted of slings and wooden wedges and could be used to lift small stone blocks. In no case, however, would they have been able to lift huge monoliths weighing several dozen tons, and so they do not provide an answer to the fundamental question.

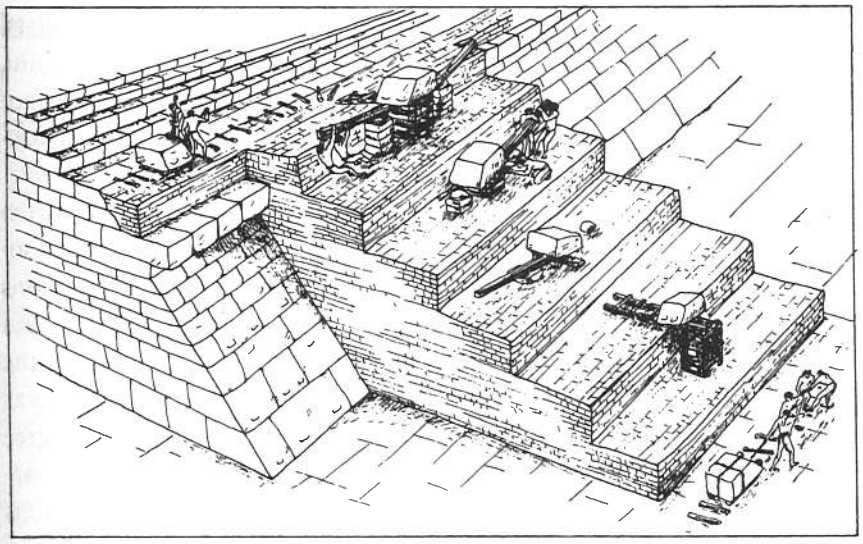
Herodotus's account also prompted other reflections. At the beginning of the twentieth century, Louis Croon imagined a simple water-scoop crane consisting of horizontal and vertical beams that worked like a lever. When a block had been raised to a higher level, the wooden structure was also moved to the next level. Croon's conception had one drawback, however: once again, such a device could have been used to raise only small blocks. Also, up to this point, no remains of such devices have been found in the course of excavations. Moreover, although the ancient Egyptians were acquainted with this kind of device, which they used to scoop up water and which is now known in Egypt as a *shadoof,* the first evidence of its existence dates from the New Kingdom, more than a thousand years after the pyramids were constructed.

Egyptologists have made further suggestions based on a similar principle. One of these assumed that a counterweight was used to lift heavy burdens. Others posited the existence and use of a winch, block and tackle, or pulley, but all these technical devices were unknown at the time of the construction of the pyramids. A discovery made in the 1930s by the Egyptian archaeologist Selim Hassan near the valley temple of the pyramid field in Giza reopened the debate. He found a large stone object that looked like a nail in whose hammered head three parallel notches had been cut. This object was probably once firmly anchored in some sort of structure, with a rope running through the notches. Therefore, it could have been a pseudo-pulley.

The use of a pseudo-pulley, or merely a simple round beam, is central to the theory proposed by the French architect Guerrière. His solution is based on the assumption that the central part of the core of the pyramid was first built up to a certain height and then broadened by means of "accretion layers" of stonemasonry constructed in separate stages. In his view, two groups of workers raised the blocks, using ropes thrown over the top of the central part of the core and

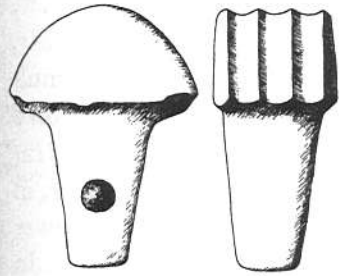


Modern conceptions of simple devices that, according to some researchers, might have been used in the construction of the pyramids. After Croon (upper left), Guerrière (middle), Adam (lower right), and Isler (following page).



running either over a round, greased beam or through the notches in a pseudo-pulley. A counterweight may have been used to make the task easier. The work was directed by means of flag signals given from the apex of the structure. However, grave objections have been raised against this theory. It remains unclear just how the tall central portion of the structure is supposed to have been constructed, and in any case even very strong ropes made of papyrus, grasses, or palm fronds could not have held the enormous stone blocks. Finally, archaeological investigations of pyramid cores that lie open in ruins have not provided any evidence to support Guerrière's suggestion.

Today, most conceptions of pyramid construction are based on Diodorus's account, which describes the use of inclined planes or



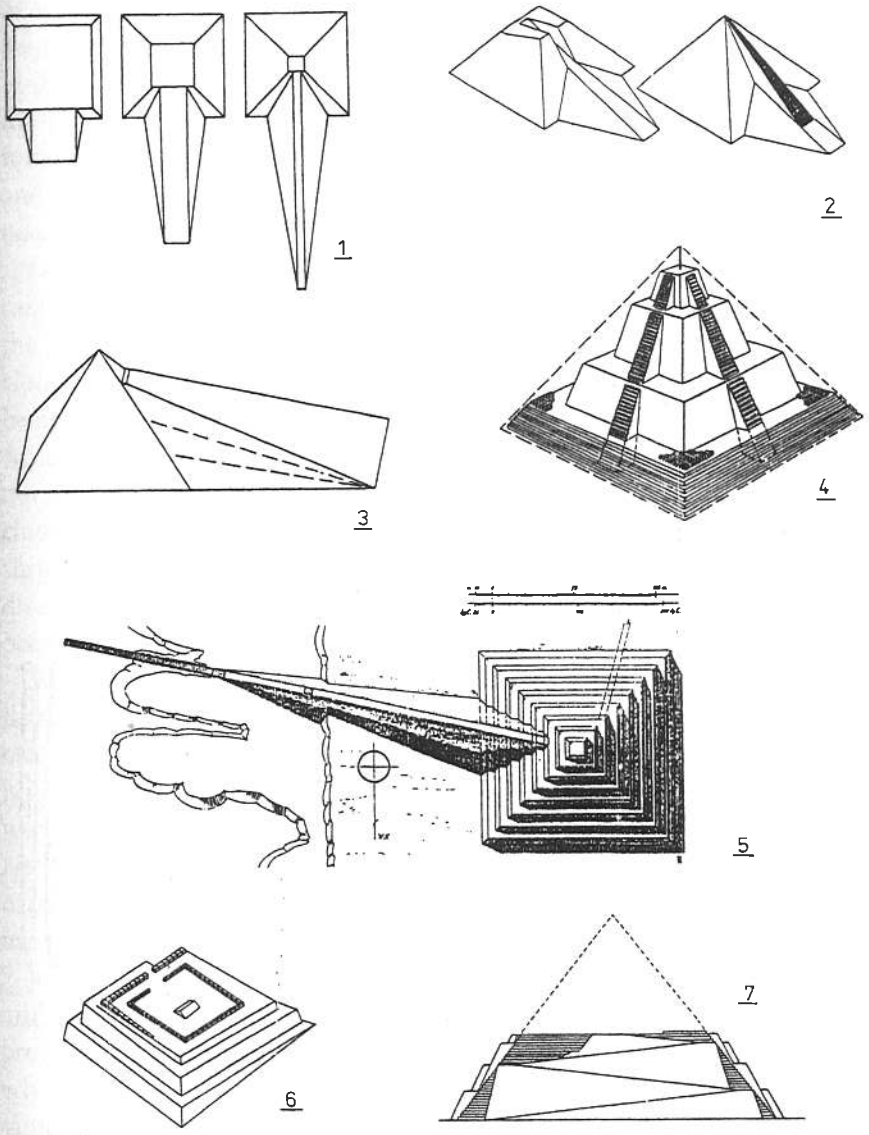
Stone pseudo-pulleys discovered in Giza by Selim Hassan.

ramps. His account has been lent some support by archaeologists' discovery of the remains of ramps, which have been found in Meidum, Dahshur, Abu Ghurab, and Abusir. However, it might be more appropriate to see these ramps as having been used for delivering construction materials.

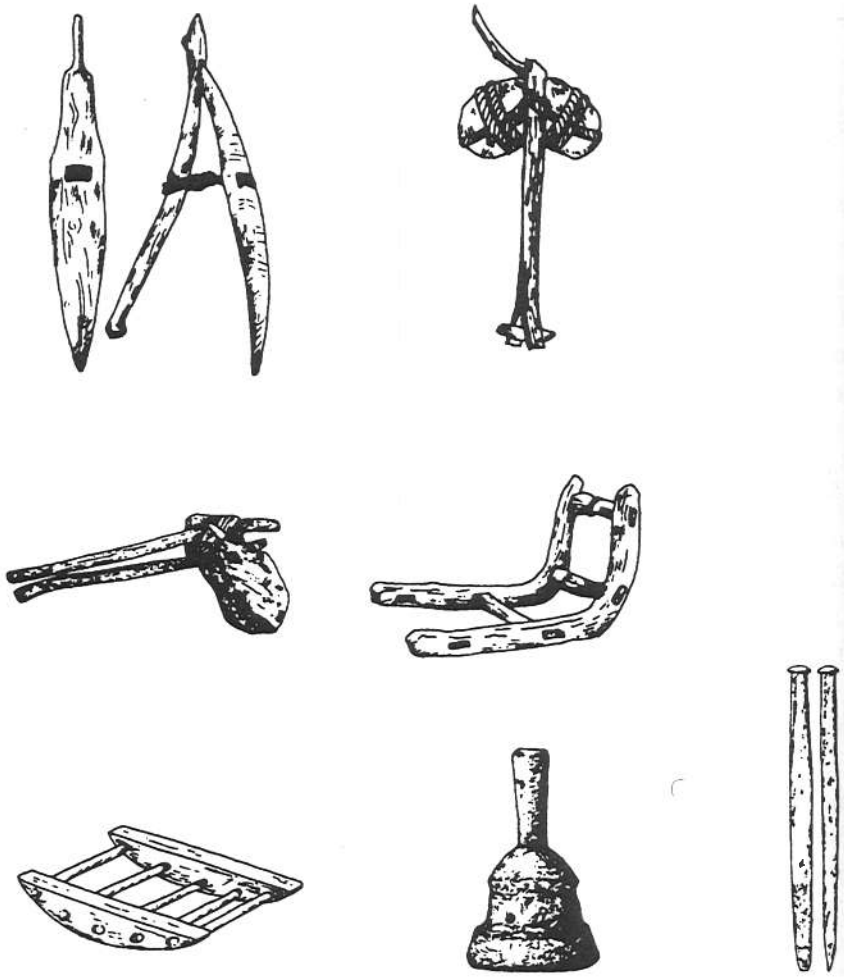
The ramp theory is also based on certain ancient Egyptian written documents, such as papyruses featuring mathematical problems connected with construction projects. The Anastasi I papyrus mentions an inclined plane that was 730 cubits long (1 cubit = 18 inches) and 55 cubits wide, and as high as 60 cubits. The outside walls and the framework of the ramp were made of bricks, while the inside was filled with sand. However, those who adhere to this theory disagree as to what such a ramp looked like. The German architect and archaeologist Uvo Hölscher (1878–1963), who conducted excavations at Khafre's pyramid complex in Giza, assumed that a ramp was constructed on each of the four sides of the pyramid, zigzagging upward from one corner to the other as building moved upward. However, this kind of ramp would not have provided an adequate means of delivering materials for the construction of the lower- and middle-level parts of the pyramid, since at those levels the amount needed was enormous.

The American researchers Dows Dunham and W. Vose assumed that a single ramp about three meters wide, which wound in a spiral around the whole structure, was used. But the previously mentioned objection is pertinent here as well: on such a small ramp—which would have grown narrower as the structure rose and grew narrower itself—the required materials could not have been delivered as quickly as written sources indicate they were.

Goyon's theory overcomes some of these objections. In his view, there was a single ramp, but it did not go around the whole structure, and it was so wide that several ox teams could have been used simultaneously to drag the stone blocks upward. In addition, Goyon's theory posits a ramp structure that left all four corners of the pyramid free so that ongoing measurements could be made. However, in this case as well, the ramps would necessarily have grown narrower as they rose, and they would also have had to be extremely long. In



Some types of ramps that are supposed to have been used on the pyramid construction sites (1 and 2 after Arnold; 3 after Petrie; 4 after Isler; 5 after Borchardt; 6 after Goyon; 7 after Hölscher).



Tools used by the builders of the pyramids: wooden pickaxes, stone-mason's flint drill, stone ax, wooden sledge, "cradle," wooden mallet, copper chisels.

other words, such ramps might have made it possible to build small pyramids, but not large ones.

The English archaeologist Petrie, who devoted a great deal of time to research on the pyramids, imagined that a single, vertical ramp was built on only one side of a pyramid and extended as the structure grew. According to Petrie, the ramp was built with bricks, clay, and sand,

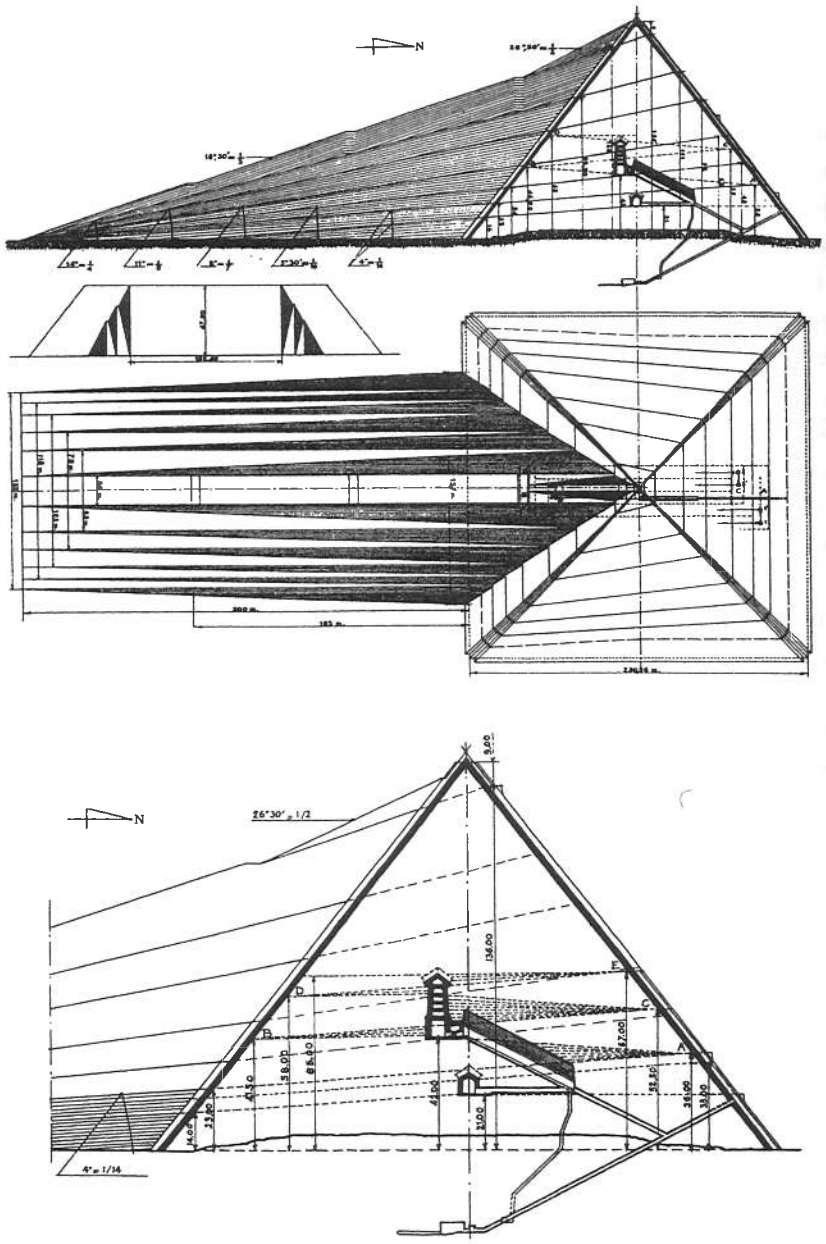
as well as with round wooden beams, and its overall volume would have been at least as great as that of the pyramid itself. A basic defect in this theory is the fact that the construction of such a ramp would itself have required an enormous amount of material. We are again forced to ask when and by whom the ramp would have been removed, and especially where it would have been placed. So far, no such huge mass of material has been found near the pyramids.

Dieter Arnold agrees with Petrie that there was a single, vertical ramp going up one side of the pyramid. However, he supposes that the ramp was considerably smaller and ended inside the pyramid. Construction material could thus have been used twice as effectively, being employed both for the ramp and for the pyramid itself. Although Arnold's theory seems fairly plausible, it also has a weakness: it does not explain how the upper part of the pyramid was finished off, including the installation of a monolithic pyramidion as the apex. Arnold surmises that this was managed by means of a steep staircase built directly in the center of the pyramid, but in practice that would have been difficult to achieve.

What can we conclude from all this? When we consider everything that has been written on this subject, and all that is known to archaeologists, a combination of the two basic methods seems the most promising explanation. To the question of whether lifting devices or ramps were used, we may reply simply: both. In addition, we should also recognize the importance of the highly effective organization and coordination of individual workers on the construction site, as well as the complete use made of the main source of energy: the workers' muscle power.

Jean-Philippe Lauer, the best-known expert on the Egyptian pyramids, has provided the most carefully thought out solution to the problem. He suggests that during construction a whole system of cleverly combined ramps of various sizes and gradients was built. At the same time, of course, additional tools and lifting devices were used—wooden levers, round beams, poles, and ropes. To illustrate his theory, Lauer chose the largest and most complex of the Egyptian pyramids, the Great Pyramid in Giza.

For the construction of the lowest part of the pyramid, four large frontal ramps were used, one running vertically up each side. There



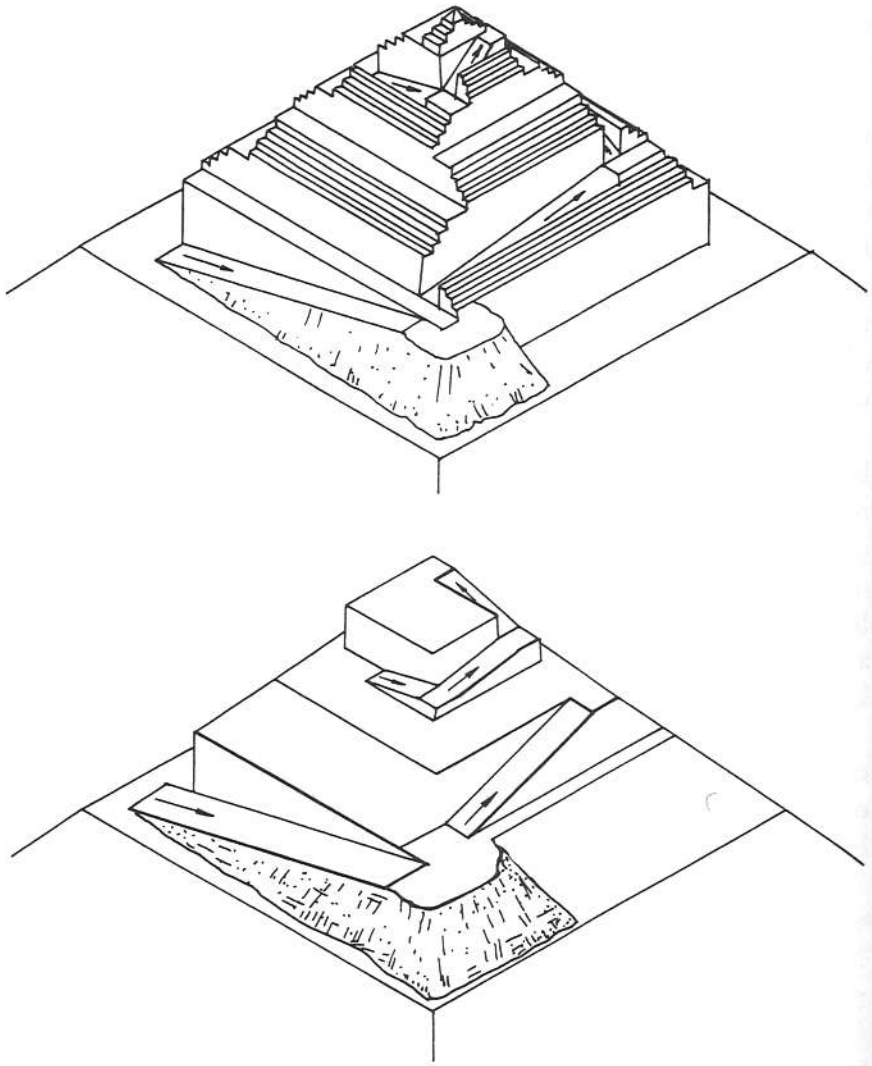
Reconstruction of a ramp used for the construction of the Great Pyramid in Giza (after Lauer).

was one further ramp, which ran southeast directly to the stone quarries in the area. The ramp was initially short; it ran into the pyramid and had a very slight gradient of about four degrees. Gradually, it was extended toward the south to a length of about three hundred meters, and at the same time toward the north, into the interior of the pyramid. When it reached that length, the ramp was about thirty-five meters high on the north side, and thus made it possible to erect the Great Gallery, the somewhat higher King's Chamber, and even the so-called relieve chambers built above that. To construct them, and to transport stone blocks weighing forty to sixty tons, a system of smaller ramps was built directly in the interior of the pyramid core.

According to Lauer, these enormous blocks of stone were set in place by means of a system of counterweights made of sacks of sand. The remaining upper part of the pyramid was finished off using the base ramp, whose gradient was gradually increased while its width was decreased. With an angle of about fourteen degrees, the ramp allowed blocks weighing as much as a ton to be raised to a height of 112 meters; and with an angle of eighteen degrees, blocks weighing around 700 kilograms could be raised to about 136 meters.

A special and particularly difficult task was finishing off the structure by placing at its apex the pyramidion, which weighed about five or six tons. Lauer assumes that large wooden trestles, heavy greased beams, thick ropes, and counterweights were used.

The overall volume of the base ramp, which was composed of unfired bricks, stone rubble, and sand, Lauer calculates to have been 1,560,000 cubic meters. If his views and estimates are correct, the volume of the ramp combined with that of the pyramid itself was 4,160,000 cubic meters—4,160,000 cubic meters of construction material that had to be found, transported, and raised to a height of as much as 146.6 meters! This would be an extraordinary achievement even with modern technical means. Moreover, Lauer's theory does not explain how the bulk of the ramp was removed. The American archaeologist Mark Lehner, who also has spent long years studying the pyramids in Giza, proposes, against Lauer's view, that the ramp was not linear but spiral in form, and began in the local stone quarries southeast of the Great Pyramid.



Two suggestions by N. Hampikian for how the pyramidion could have been laid in its position.

So much for the largest Egyptian pyramid. The question as to how the pyramids were built has still another dimension. Archaeological investigations clearly show that the ancient Egyptian pyramids differed not only in size, location, and period, but also in their basic construction plans, materials, and methods. The following section is devoted primarily to this subject, which is based on the results of Czech research.

Craftsmen's Guilds in Abusir

As a typical example of how the same or very similar construction methods were used in a given place at a given time, let us consider the case of King Neferirkare's family cemetery in Abusir. The group of trained master builders, artists, and workmen who labored there can to some extent be compared with craftsmen's guilds in the European Middle Ages.

During the excavations carried out in Abusir since 1960 by the University of Prague's Czech Egyptological Institute, a number of pyramids—many of them long known, and others discovered during the research work—were investigated. The results of this work offer a new, interesting view of the inner structure and mode of construction of the pyramids in Abusir.

NEFERIRKARE'S PYRAMID

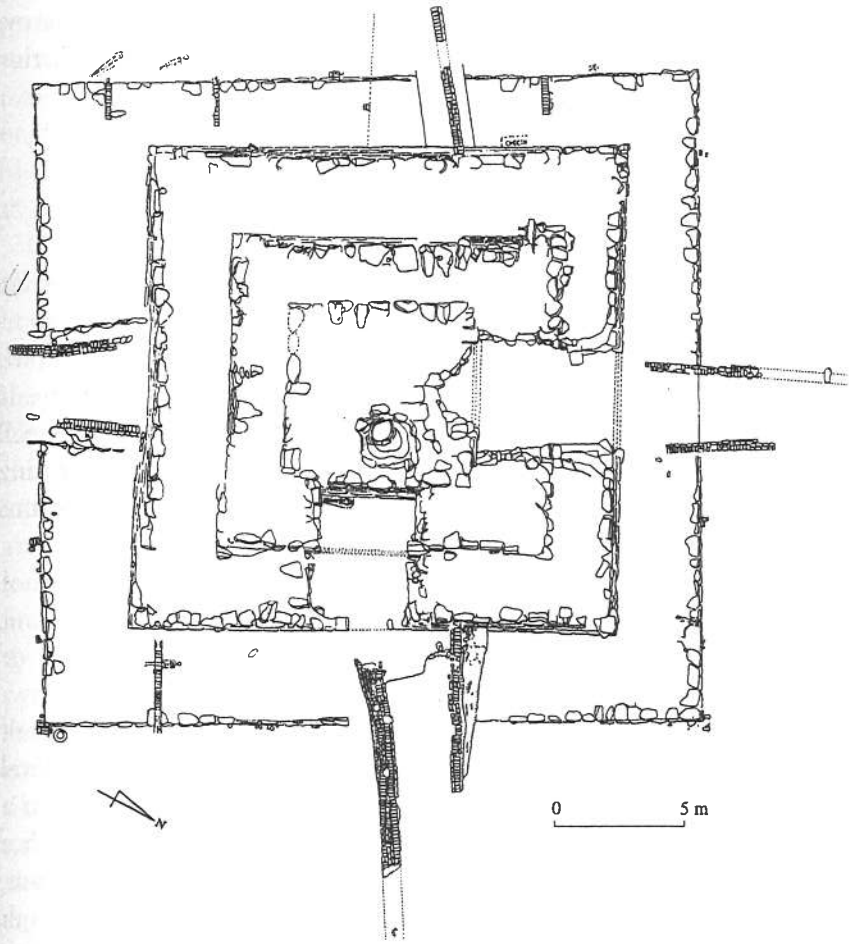
In the ruins of Neferirkare's pyramid we can discern two clearly distinct types of layers in the pyramid core, which differ both in the material used and in the method of construction. The inner layers consist of larger, qualitatively more valuable, well-aligned blocks that are carefully set in the corners, whereas the outer levels are constructed in a relatively careless way out of small and sometimes crudely dressed fragments of stone.

Lepsius, and later on Borchardt as well, thought that the core of Neferirkare's pyramid was composed of stone accretion layers set at

an angle of about seventy-seven degrees and supported by the massive, dense "spindle" of the core stone masonry. This mode of construction, the use of which has been proven in the case of the Third Dynasty step pyramids, is sometimes compared with the layers of an onion. Lepsius and Borchardt claimed that the cores of all the other pyramids in Abusir, and also to some extent in other places such as Meidum, were constructed in the same way. Closer examination of Neferirkare's pyramid shows that they were mistaken.

The Czech team's archaeological investigation of the pyramid's construction has shown that its core is composed of horizontal strata and is built in layers. Originally, there were six of these layers, constructed with high-quality stone blocks laid in regular rows. The pyramid was conceived as a step pyramid. When the inner core was completed, work began on the casing, which was to be made of white limestone. However, the outer shell had reached only the first level when the construction plan was changed to increase the size of the structure and to transform it from a step pyramid into a genuine pyramid. To this end, the core was broadened and its height increased by two layers, using small and roughly dressed stone fragments. Finally, work on the casing began again, though after the lowest level was finished off, it was made of pink granite—no doubt because in the interim the ruler had died. The structure was never completed.

It is hardly conceivable that at every stage in the construction a large ramp was built to deliver materials, but the size of the blocks that were used for the original six-layered step pyramid makes it clear that without them, or without a whole system of smaller ramps, the work could not have been completed. During the subsequent work—the casing of the six-level step pyramid and the broadening of the core—the casing slabs as well as the small stone fragments were probably lifted or dragged up the already completed wall by means of a simple wooden device resembling a block and tackle. To make it easier to drag these materials, slabs or small, round beams smeared with grease may have been used. Similar tools were probably used in building the casing of the true pyramid, and at the lowest levels a ramp may also have been used. The extant documents show that the size of the blocks diminished at successive levels of the pyramid.



Plan of the step pyramid in Sinki, with the remains of four ramps for the delivery of construction materials (after Dreyer and Swelim). This number and arrangement of the ramps allowed the lower half of the pyramid, which represented more than 80 percent of the overall volume of its masonry, to be quickly and efficiently built.

The Czech archaeological team has in fact recently discovered, while completing excavations in the nearby unfinished pyramid of Neferefre, the ruins of a construction ramp that was probably built for broadening Neferirkare's pyramid into an eight-layered pyramid. This ramp, which is about twenty meters wide, rises slowly from south to north. It consists of sand, and its surface was strengthened

by means of a layer of clay about ten centimeters thick. This discovery is an important contribution to debates about the construction of the pyramids.

KHENTKAUES II'S PYRAMID

The casing of Khentkaues II's pyramid was also installed after the completion of the pyramid's step-shaped core, or at least of its four-meter high first level. This is clearly shown by the stratification of the masonry in the mortuary temple that stands in front of the east side of the pyramid. The white limestone casing blocks were relatively small and became even smaller as the pyramid rose. Their superior fitting and the overall stability of the casing were strengthened by lock seams on the upper and lower sides.

NEFEREFRE'S (UNFINISHED) PYRAMID

The construction of Neferefre's pyramid was interrupted as a result of the king's untimely death, which occurred before the lowest level of the core was completed. The project was hastily converted to a stylized primeval mound with a square base, whose outer appearance was more like that of a mastaba. After the end of the New Kingdom, thieves dug into the substructure, which was about seven meters high high. There, in the open air, they set up a stone-cutting shop that specialized in removing the fine white limestone of the tomb's substructure. Today we have direct access to this area, and the knowledge gained from it is striking and certain.

Although it has been seriously damaged, the plan of the substructure of Neferefre's pyramid can now be reconstructed with relative precision. It consisted of a descending corridor, slightly curving from the north toward the southeast, which ended in the antechamber of the burial chamber. Both rooms were aligned with the east-west axis of the tomb and had gabled ceilings made of blocks of fine white lime-

stone. Thieves destroyed and removed the ceilings of both chambers as well as that of the access corridor, so that only a few blocks remain. Thus, the inner structure of the masonry of the core is revealed on the side walls of the enormous crater that now yawns over the ruins of the substructure. This makes it possible to reconstruct with precision the work methods used by the builders of the tomb.

Once again, the core consists not of embankments but of horizontal layers, each of which has a "frame" of regularly set, roughly dressed limestone blocks. The outer blocks are as large as 5 m. × 5.5 m. × 1 m., and are well fitted into the corners, whereas those laid around the pit for the burial chamber and the access corridor are much smaller. The space between two frames was filled with crude chunks of limestone, clay, pottery shards, and sand. The huge blocks were probably moved into place with the help of ramps. Distinct traces of broad paths are found in the desert south of the unfinished pyramid. About a kilometer to the south is also a rock ledge of yellow to greenish gray limestone where quarrying was done, and which Borchardt believed to be the site of the main stone quarry for the construction of the pyramid cores in Abusir.

To close up the gigantic, empty space that remained after the completion of the substructure, builders used stone rubble. As a foundation, a layer of smaller pieces of the same stone was laid over the gabled ceiling, bound together here and there with mortar and filled in with gravel. The upper, more or less horizontal, surface of this layer was made of large, flat limestone fragments, which often bore the cursive, semi-hieratic inscription *Hut Neferefre,* which can be roughly translated as "[burial] area of Neferefre." The remaining open space above this layer was filled with diagonally oriented walls made of stone rubble that intersected approximately in the middle of the structure. Here as well, gravel, sand, and mudbricks were used as filler. Finally, the flat roof terrace of the tomb was covered with a layer of clay a few centimeters thick and with rough gravel from the surface of the surrounding desert. The outside of the structure was covered with fine white limestone blocks. Neferefre's tomb, a stylized primeval mound, was completed.

THE PYRAMID "LEPSIUS NO. 24"

The extensive damage wrought during the Ramesside period (thirteenth century B.C.E.)—and especially during the Saite period (624–525 B.C.E.), in connection with the construction of shaft tombs—laid open this pyramid both inside and outside. The extant remains allow an instructive view of the work of the stonemasons who built not only this pyramid but apparently also other pyramids in Abusir during the time of Niuserre.

Thus we can follow the individual phases of construction almost step by step. First, the site had to be leveled, since the pyramid stood near the sloping edge of the western desert plateau. Then a cavity for the substructure was dug out and walled in, and around this cavity a square foundation made of limestone blocks was built for the pyramid.

The construction of the first step of the core, about five meters high, began with the erection of a perimeter wall, in which a gap was left on the north side. A regular opening as high as the wall was left for the delivery of materials for the construction of the burial chamber and the corridor leading to it, which began on the north wall some twenty centimeters above the base of the pyramid. Another opening, irregular and about three meters wide, was located in the south wall near the southeast corner. Through it a passageway probably led down into the inside of the pyramid, perhaps a ramp for transporting fill into the space, which was surrounded by a perimeter wall of the first layer of the core. The lower part of the fill, up to about two meters, was composed of a layer of pieces of limestone, over which builders apparently put sand, rubble, and construction waste. The second level of the core consisted of a system of diagonally aligned walls built of irregular stone fragments. The different construction methods used for the first and second levels significantly increased the stability of the pyramid core. The core of the whole pyramid probably had three levels.

The temple on the east side of the pyramid stood, just as in the case of Khentkaues II's pyramid, immediately on the wall of the core. The casing, which has been partly preserved on the north side, was installed after the completion of the first step, at the earliest. Given the small size of the blocks used, it might have been constructed in

a way similar to that already described in connection with Neferirkare's pyramid.

Recent research on the pyramids in Abusir has broadened our knowledge and made it more precise. It has confirmed the view that some construction methods were employed in ancient Egypt throughout the whole period of pyramid construction. For example, the stronger masonry of the core was first built of qualitatively inferior stone blocks and then sheathed with more valuable and well-dressed stones. The ancient Egyptians produced most of the compact masonry by building a perimeter wall and then filling the space inside it with construction waste and other less valuable materials. Unfortunately, these discoveries still do not provide conclusive answers to all questions concerning the construction of the pyramids in Abusir and elsewhere.

Outlook

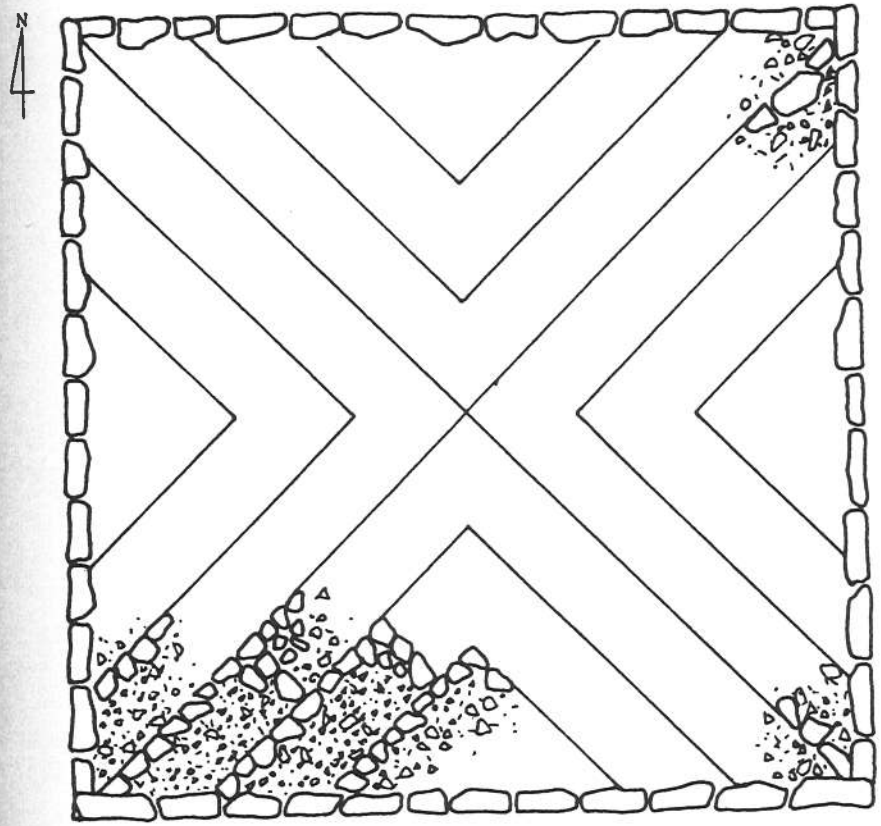
A reader who has sought in the preceding pages a simple, satisfying, and exhaustive explanation of how the Egyptian pyramids were built will probably be somewhat disappointed. Egyptology at the end of the twentieth century, after existing for nearly two hundred years, is still not really capable of providing such an explanation. This is the result of neither inadequacies in the approach to the problem nor prejudices against other untraditional or even unscientific views. The problem is far more complicated than it may at first seem.

The Egyptian pyramids were built over a period of more than a thousand years, in various places, from different materials, and in differing sizes. Thus we can scarcely expect to discover a single method that was always and everywhere used to construct them.

The evolution undergone by the Egyptian pyramids is characterized by their builders' efforts to learn from earlier mistakes and deficiencies, in order to find the optimal relationship between the materials used and the pyramid form, methods of construction, and other factors. Obviously, it also reflects the desire to surpass preceding works in size, richness of ornamentation, and the balance of the whole sys-

tem of structures represented by the pyramid complex. And this desire was pursued to a certain critical limit, beyond which serious conceptual changes had to be made, which in turn influenced work methods. The role of economics, religion, and aesthetics in this development must be emphasized, too.

To arrive at a genuinely fundamental and precise reconstruction of the methods used to build the pyramids, we would have to take them apart and put them back together again. Let us hope that archaeological research does not go to this extreme. Above all, further revisionary research must be undertaken on most of the pyramids, which up to now have unfortunately been inadequately investigated. This will involve using the increasingly powerful procedures borrowed from the exact sciences, and we can expect interesting discoveries to be made, but the goal of revealing all the secrets of the Egyptian pyramids will not be reached for a long time.



According to the views of earlier Egyptologists, the diagonal orientation of the brick walls became commonplace from the Twelfth Dynasty on, but in 1995 that method, which increased the cohesion of the core masonry, was also shown to have been used in the pyramid Lepsius no. 24, built in Abusir in the Fifth Dynasty.