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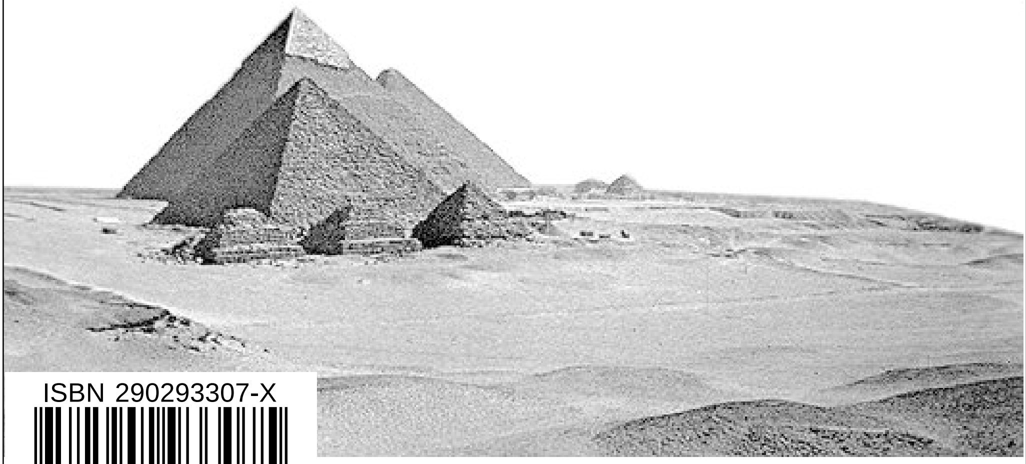
THE PYRAMIDS
AN ENIGMA SOLVED

2nd revised edition
based on the first edition (1988)
by Joseph Davidovits and Margie Morris.



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Two New Yorker publishers, Hippocrene and Dorset Marboro Books, first published the book The Pyramids: An Enigma Solved. They sold more than 45,000 copies from 1988 to 1995, and it is out of print since 1995. The American Library Association selected this book as a "Starred Review Title" in its 1988 booklist.

From 1991 to 1998, I concentrated on industrial applications mainly in Europe and in USA. Taking advantage of the newly acquired scientific and technological knowledges, I decided to resume the archaeological research in early 1999. My son Frederic, the linguist, who had been working since 1992 on the translation of technical ancient texts written in Latin and Greek, was of great help in the critical study of my previous work. After his Master Thesis on Ancient Roman Cement, he is becoming one of the world best experts on ancient technical texts dealing with mineralogy, geology and construction technology.

The book has been revised and edited with several new chapters, new facts, and new astounding discoveries. The revised edition adds up to 54% of new material.

The co-author of the first edition, Margie Morris, who edited and polished the work in plain American English, continued her research in Egyptology and wrote down her thesis in a manuscript titled The Egyptian Pyramid Mystery is Solved (see in her Internet site at <www.margaretmorrisbooks.com>).

Saint-Quentin (France), Jan. 03, 2001
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Chapter 1

Mysteries of the Ancient World

Egypt's legendary reputation as master of the masonry arts spans almost the entire history of civilization. At a time before hieroglyphs or numbers were written or copper was smelted, prehistoric settlers in the Nile valley either inherited or began a remarkable legacy that has survived for at least 6,000 years. During this era, hard stone vessels made of slate, metamorphic schist, diorite, and basalt first appeared. All but indestructible, these items are among the most unusual and enigmatic of the ancient world. In a later era, 30,000 such vessels were placed in an underground chamber of the first pyramid, the Third Dynasty Step Pyramid at Saqqara (Fig. 1).

" On examining them attentively, I only became more perplexed," wrote the renowned German scholar, Kurt Lange, after encountering these stone vessels [1].

" How were they made, the dishes, plates, bowls, and other objects in diorite, which are among the most beautiful of all the fine stone objects? I have no idea… But how could such a hard stone be worked? The Egyptian of that time had at his disposal only stone, copper, and abrasive sand… It is even more difficult to imagine the fabrication of hard stone vases with long narrow necks and rounded bellies. ”

The vessels do indeed present a problem that Lange's “ imagination could not handle ”.

Figure1: Stone Vases, 3000 BC

Metamorphic schist is harder than iron. The diorite used, a granitic rock, is among the hardest known. Modern sculptors do not attempt to carve these varieties of stone. Yet these vessels were made before the introduction into Egypt of metals strong enough to cut hard stone. Numerous vessels have long, narrow necks and wide, rounded bellies. Their interiors and exteriors correspond perfectly. The tool has not been imagined that could have been inserted into their long necks to shape the perfect, rounded bellies. Smooth and glossy, these vessels bear no trace of tool marks. How were they made?

An extraordinarily hard diorite statue of Pharaoh Khafra (Khefren or Chephren in Greek), builder of the Second Pyramid at Giza, was created during the Fourth Dynasty (Fig. 2). Acknowledged to be one of the greatest masterpieces of sculpture ever produced, it was found upside down in a pit in the Valley temple south of the Sphinx, which is associated with Khafra's (Khefren or Chephren) pyramid at Giza. Archaeologists confirm that during the Fourth Dynasty, the Egyptians did not possess metals hard enough to sculpt this diorite statue, and the Great Pyramids of Giza were also constructed during the Fourth Dynasty.

Figure 2: Diorite statue of Khafra (Khefren or Chephren) dates from about 2600 B.C (Cairo Museum 1988)

Similarly, small scarab amulets made of diorite date from early times and bear no tool marks. In other parts of the ancient world, tiny stone beads with ultrafine holes for threading defy explanation. Only the most current technology is capable of piercing holes of a comparably minute size in stone.

In Khafra's Valley temple at Giza, the blocks weigh up to 500 tons apiece. As will be explained, these blocks were not carved in situ from the bedrock as is generally assumed. Who were the men of Egypt who, without powerful machinery, placed 500 hundred-ton blocks in temples? How did they manage to place hundreds of fifteen- and twenty-ton blocks in tiers thirty stories above the ground in pyramids? Before pondering the technology of these ancient master builders, briefly consider some facts about the pyramids for which Egyptologists have no adequate explanation.

The Great Pyramid was built for a pharaoh named Khnumu Khufu (Kheops or Cheops in Greek) during his twenty-year reign. During those twenty years approximately 2.5 million limestone blocks, weighing from two to seventy tons apiece, were incorporated into his sacred monument. Large fossil shells make this stone material difficult to cut precisely. Enormous plugs of granite harder than limestone once blocked the ascending passageway. The walls of the so-called King's Chamber are granite, and the latter room contains a granite sarcophagus, which is curious in that it is too large to fit through the adjoining door and hallway.

Egyptologists claim that this unparalleled structure was built using primitive stone and copper tools. Flint tools, though they can be made with sharp cutting edges, are unsuitable for perfectly shaping millions of large blocks. Copper, which the Egyptians smelted and also mined in native form, is a soft metal. Copper saws are suitable for cutting wood, but not the type of hard granite found in the Great Pyramid, and copper implements are quite unsuitable for cutting 2.5 million nummulitic limestone blocks in twenty years. Bronze working was not introduced in Egypt until about 800 years after the Great Pyramid was built, during or slightly before the Egyptian period known as the Middle Kingdom. Iron came later to Egypt and was rare even during the New Kingdom.

If the blocks of the Great Pyramid, of a material of medium hardness, had been shaped using bronze tools, the labor involved would equal that required for shaping all the stone monuments built during the New Kingdom, Late period, and Ptolemaic era, periods which together span 1,500 years. How did Old Kingdom pyramid builders accomplish in twenty years what required successors 1,500 years of labor?

The Great Pyramid is not an aberration. Khnumu-Khufu's (Kheops or Cheops) son, Pharaoh Khafra (Khefren or Chephren), built the Second Pyramid at Giza, which is almost as large as that of his father, during a twenty-six year reign. Khnumu-Khufu's father, Pharaoh Sneferu, was the most prolific builder in Egypt's long history. He built two colossal pyramids, applied casing stone to another, and erected stone monuments throughout Egypt. It is estimated that Sneferu's workmen used 9 million tons of stone during the pharaoh's twenty-four year reign. All of this was expertly accomplished before the invention of the wheel as a means of transportation.

To raise a two-ton portcullis positioned in a narrow passageway in Khafra's (Khefren or Chephren) pyramid requires the force of at least forty men. The fact that the passageway allows room for no more than eight men to work at once has caused some archaeologists to admit that extraordinary means, about which they have no information, were employed for pyramid construction.

The casing blocks of the pyramids are made of fine-grained limestone that appears to be polished. The Great Pyramid originally possessed about 115,000 casing blocks, some weighing about ten tons apiece, and covering twenty-two acres of surface area. A razor blade cannot be inserted between any two remaining casing blocks. The noted Egyptologist, Sir Flinders Petrie, determined that some casing blocks in the Great Pyramid fit as closely as 0.002 inch. Those covering the pyramid of Khafra (Khefren or Chephren) also fit perfectly with an additional touch of expertise - they fit together with tongue-and-groove joints. How were these blocks prepared so perfectly? How did workers install them without chipping the corners even slightly?

Twenty-two steps near the top of Khafra's pyramid are unweathered and in good condition, since the casing blocks which covered them were removed as recently as 150 years ago. In a preliminary study in 1984, I measured the lengths of the thousands of blocks in these steps, which make up about ten percent of the area of the pyramid. The blocks all conform to ten uniform lengths. How could a civilization without the benefit of hard metals prepare many thousands of blocks with such precision? Limestone frequently splits during cutting, even with the most efficient modern tools. Faults and strata in bedrock assure that for every block cut to standard, at least one will crack or be improperly sized during quarrying, and this rate of breakage is far more optimistic than realistic. Given the many millions of blocks in the numerous pyramids, there should be millions of cracked blocks lying nearby or at least somewhere in Egypt, but they are nowhere to be found.

We know that millions of broken limestone blocks were not cut down and used for building monuments when bronze and iron were introduced. By that time only soft varieties of sandstone and granites were being used in monuments. Ancient historians who documented their visits to Giza have not mentioned heaps of broken blocks. So this is the technological paradox of Egypt: before Egypt possessed strong metals for stone cutting, hard varieties of stone were employed in monuments. As bronze and iron came into use, only the softest varieties of stone were used, with very few exceptions.

Rather than providing a logical solution to the riddle of pyramid construction, investigators so far have succeeded only in challenging the flaws in numerous proposed theories. There are far more complex and perplexing aspects of the pyramid puzzle. Before describing them, let us consider the knowledge of the solar priests responsible for pyramid construction.

The ancient Egyptian town of Anu, called On by the Hebrews and Heliopolis by the Greeks, was a great religious center for thousands of years. The city, located about twenty-five miles from Giza, was erected on holy ground, symbolizing rebirth and creation. Starting at the time of the great Imhotep, the Heliopolitan priest credited with inspiring and engineering the first pyramid, the priests of Heliopolis engaged in raising spectacular pyramids and temples for the Sun. These priests excelled in arts and sciences. They were considered to be the traditional wise men of Egypt throughout that nation's extremely long history. Religious philosophy, mysticism, mathematics, geometry, horology and astronomy were among the sciences piously fostered by the priests.

Their preoccupation with the heavens is reflected in the orientation of pyramids and temples and stemmed from great reverence for the Sun and other stars. The priests descended from an extremely long and learned line. During prehistoric times, their ancestors invented the first 365-day calendar.

Archaeologists assume that modern science is in every way superior to the science of antiquity. However, with technological and scientific possibilities being as limitless as the human imagination, it is unsubstantial bias to suppose that modern technology is all encompassing and always superior. The pyramids and other monuments provide a glimpse into a tremendous knowledge gap between ancient and modern science.

There are also astounding examples of long-term food preservation. Until recent years, few archaeologists acknowledged that ancient people successfully stored grain for long periods. In the 1800s European travelers discovered ancient grain silos in Spain. It has since been learned that grain was once universally stored in sealed subterranean silos. Ancient silos have been found in Hungary, Ukraine, Turkestan, India, and several regions of Africa. In Central and North America subterranean silos were built by numerous Indian tribes. In France and in England, subterranean silos were found in abundance. Agronomists were initially surprised to find that sealed silos can successfully store grain.

In the Nile valley, the inundating river made subterranean silos impractical and above-ground silos were constructed. They have been depicted in bas-reliefs and look like upside-down earthenware jars. In the pyramids, too, grain has been found free of mold and in good condition after thousands of years. Though germination was unsuccessful, the condition of the grain was so good that researchers attempted germination.

In contrast, using state-of-the-art technology, the U. S. Department of Agriculture can store grain for no more than four years before insect infestation and mold render it unfit for human consumption. Modern storage methods, based on ventilation, sharply contrast with the sealed systems used in antiquity, demonstrating the vast difference between ancient and modern technology.

Historically, the pyramids were called the storehouses of the Hebrew patriarch Joseph, son of Jacob. The biblical book of Genesis recounts that grain was stored in Egypt by Joseph from seven to perhaps as much as twenty years. The Genesis story has been discounted in modern times because historians are generally unaware that ancient peoples were capable of such technology. The account cannot be doubted in the light of the information already presented.

In the 1930s, Antoine Bovis, a Frenchman, observed that animals that wandered into the Great Pyramid and perished before finding their way out did not decompose. He began to investigate, and thus was born the theory of pyramid power. Its advocates attribute the Great Pyramid's ability to preserve organic matter to the alignment and shape of the pyramid itself. However, this theory does not explain why preservation can also occur in other tombs. Some theorists suggest that the pyramids and their surroundings are protected by a mysterious force, but no such force has prevented the pyramids from being raided during antiquity or excavated in modern times.

When tourists enter the Grand Gallery and the so-called King's Chamber of the Great Pyramid for the first time, most are surprised to encounter high humidity. In 1974, a joint research project carried out by Stanford Research Institute (SRI International), of Stanford (California) University, and Ain Shams University, in Cairo, indicated that while the bedrock of Giza is dry, the pyramid blocks are full of moisture [2]. The scientists attempted to locate hidden chambers in the Great Pyramids of Giza with electromagnetic sounding equipment but were prevented by the high moisture content of the blocks. The waves emitted by the equipment would not transmit through the pyramid stone. The waves were instead absorbed, ending any chance of a successful mission. The Great Pyramids attract moisture in the midst of an arid desert necropolis. Why? How can the atmosphere in their chambers be conducive to preserving organic matter?

In an attempt to discover ancient secrets of preservation, the Egyptian Antiquities Organization (AEO), in Cairo, has assembled an impressive team of scientists from the National Geographic Society and the National Oceanic and Atmospheric Administration. The scientists are studying the air sealed inside the rectangular pit in front of the Great

Pyramid-air which is 4,500 years old. Samples of air are being encapsulated using space technology developed by NASA for testing the atmosphere of other planets. Scientists hope to learn from ambient temperatures, pressure, and the air itself, how preservation was accomplished.

Because artifacts begin to deteriorate once they are excavated and exposed to the air, one of the most treasured items of antiquity was placed in jeopardy. In the 1950s, an excavation of one of the pits near the Great Pyramid yielded a sacred funerary boat of Khnumu-Khufu. To the delight of archaeologists, the acclaimed artifact was preserved in perfect condition. The boat, measuring more than 120 feet, had a displacement capacity of over forty tons.

The hull, composed of hundreds of pieces of wood shaped to fit together like a jigsaw puzzle, is cleverly sewn together with a single piece of rope. The boat does not require caulking or tar to be completely water-tight. The design principle is that when wet, wood swells whereas rope shrinks, producing an automatic seal impervious to water.

A specially designed museum was erected under the auspices of the Egyptian Antiquities Organization to house and display Khufu's boat. After the museum opened, serious problems were encountered. The atmospheric control system could not accommodate the vast number of tourists passing in and out of the building. The boat, which the ancient Egyptians had confidently called " Boat of Millions of Years ", rapidly began to disintegrate. The museum closed its doors to the public for some time. Subsequently, costly, energy-consuming devices were successfully substituted for the original cost-free, self-powered means that had so subtly and perfectly preserved the entombed boat for 4,500 years.

Khufu's boat is as seaworthy as any craft of Christopher Columbus's day. The famous mission of Thor Heyerdahl in 1970, from Morocco to Barbados in a papyrus reed boat, makes it clear that ancient Egyptian ships were capable of intercontinental travel. Their seaworthy craft is impressive, but crossing an ocean is a demanding venture. With their knowledge of the stars, it is likely that the Egyptians were excellent navigators, but how would they obtain fresh water at sea? In modern times desalination is achieved through several methods, including distillation, electrodialysis, freezing, ion exchange, and reverse osmosis, all requiring either high-energy input or advanced apparatus or materials. There is evidence that the Egyptians not only possessed technology for perpetually obtaining moisture in the desert, but were able also to extract fresh water from the ocean.

The ancient method was described by the Roman naturalist, Pliny (AD 23-79). In his Latin work *Natural History*, Pliny described curious ceramic vessels, which, during voyages, were tightly corked and immersed into the sea in nets-where they automatically filled with pure, fresh water [3]. When Pliny's text was translated from Latin to French in 1833 by the French Academy of Sciences (to compare ancient science with science of their day), the scholars could not believe the account. During their era, distillation was the only way of obtaining fresh water from salt water.

The Romans occupied Egypt from 30 BC to AD 395 and absorbed some of the technology developed in the country during more ancient times. It seems unlikely that the Egyptians would have built ships capable of crossing an ocean unless they also possessed technology that assured their survival.

Whether ancient Egyptian travelers, or those who may have inherited their technology, influenced other megalithic-building civilizations around the globe is a matter of debate. Enigmatic stone edifices, most often difficult to transport and place and bearing no tool marks, are found in numerous regions. Foundation blocks at Tiahuanaco, Bolivia, weigh 100 tons apiece. The Cuzco walls in Peru are made of enormous stones-spectacular because of their unusual jigsaw joints. The Easter Island statues were studied by a UNESCO-sponsored team, which reported that the oldest statues do not match mineralogically the stone of the quarries [4]. Standing stones of prehistoric Brittany tower over sixty-five feet high and one weighs more than 340 tons. Also curious are the Pyramids of the Sun in Mexico, numerous stone sundials in North America, and the stone calendar or observatory of Stonehenge, England.

Of all the mysteries of the ancient world, the Great Pyramids with their adjoining complexes provide the most obvious evidence of sophisticated technology very different from our own. Unlike the other megalith-building civilizations who left no written history holding relevant clues about the technology used, the ancient Egyptians left a wealth of information. Egyptian written history spans a 3,000-year period, and though much has been destroyed, surviving records are a treasure-trove of information on surgery, medicine, mathematics, the arts, topography, religion, and much more. Egyptologists have long claimed that no surviving records describe how the pyramids were built. They are incorrect in this assumption, as will be shown in a later chapter.

Considering the number of workers necessarily involved in pyramid design and construction, the actual building method employed was known or witnessed by enormous numbers of people. Their methods, therefore, could not have been secret and must have been documented. Most hieroglyphic and cuneiform texts were deciphered in the 1800s and have not been updated to reflect current archaeological finds or scientific developments. They cannot, therefore, be completely accurate; so accurate conclusions about ancient technology cannot necessarily be drawn from them.

To discover more about the level of ancient technology, pyramidologists focus their attention on the dimensions, design, orientation, and mathematical aspects of the Great Pyramid. These mirror the level of some of the science of the Pyramid Age, but pyramidologists have overlooked the most enigmatic aspect of the pyramids, the blocks themselves.

Much of the scientific research on the stone of the Great Pyramid raises more questions than answers. For instance, in 1974, geologists at Stanford University analyzed building-block samples from the Khafra (Khefren or Chephren) Pyramid [5]. They were unable to classify paleontologically the samples containing no shells. This raises the question: Where does the pyramid stone come from? A team of geochemists from the University of Munich, Germany, sampled quarries along the Nile and removed specimens from twenty different blocks of the main body of the Great Pyramid.

To determine the origin of the pyramid blocks, they compared trace elements of the pyramid samples with those of the quarry samples. Their interpretation of the test results is startling. The scientists concluded that the pyramid blocks came from all of the twenty quarries sampled [6]. In other words, to build the Great Pyramid, these geochemists say that the Egyptians hauled stone for hundreds of miles, from all over Egypt-an amazing feat for which archaeologists have no logical explanation.

Geologists do not concur with their findings. They can demonstrate that the source of stone is near the pyramid itself. Geologists and geochemists cannot agree on the origin of the pyramid blocks, and geologists cannot agree among themselves on the source of stone used for the wondrous statues built for the Eighteenth Dynasty pharaoh, Amenhotep III, in the Valley of the Kings. The awe-inspiring statues, the Colossi of Memnon, were originally monolithic and weigh

750 tons apiece. They rest on monolithic 550-ton pedestals. The structures are each seven stories high. They are made of hard, dense quartzite, which is almost impossible to carve. At the beginning of the nineteenth century, members of the Napoleonic Egyptian expedition remarked about these statues and Egypt's quartzite quarries in Description de l'Egypte [7]:

> " None of the quartzite hills or quarries show tool marks, as are so common in the sandstone and granite quarries. We have to conclude that a material so hard and unworkable by sharp tools must have been exploited by a process other than that generally used for sandstone, or even granite.... We do not know anything about the process used by the Egyptians to square this stone, to trim the surfaces, or to impart the beautiful polish that we see today on some parts of the statues. Even if we have not determined the means used, we are forced to admire the results.... When the tool of the engraver in the middle of a hieroglyphic character hit a flint or agate in the stone, the sketch was never hindered, but instead it continued in all its purity neither the agate fragment nor the stone itself was even slightly broken by engraving ".

This last observation has profound implications. What masonry process could possibly allow hieroglyphs to be inscribed in this manner? The beloved king Amenhotep III called the production of his statues "a miracle." Hieroglyphic documents written after his time refer to this type of stone as *biat inr* meaning "stone resulting from a wonder." What technological wonder did Amenhotep behold?

French and German scholars, who will be discussed later, claim that the Colossi of Memnon were carved from a quarry fifty miles away and hauled along the Nile by boat. English and American geologists advocate a feat bordering on the unbelievable. They claim that the statues were quarried and hauled 440 miles up river-against the flow of the Nile. As more sophisticated methods, such as atomic absorption, X-ray fluorescence and neutronic activation are used to study Egypt's most enigmatic monuments, more confusion arises.

The Great Sphinx in front of Khafra's pyramid has become more controversial than ever in light of recent geological studies. Based on the severe manner in which blocks covering the lower layers of the body and paws are eroded, the age of the Sphinx has, once again, come into serious question.

Today, the Sphinx is attributed to Khafra (Khefren or Chephren). Earlier Egyptologists believed it was erected a great deal earlier than his reign, perhaps at the end of the Archaic period. The Sphinx looks much older than the pyramids. No inscriptions connect the sacred monument to Khafra, but in the Valley Temple, a dozen statues of Khafra, one in the form of a Sphinx, were uncovered in the 1950s. Some Egyptologists claim a resemblance between these statues and the face of the Sphinx.

A document which indicates greater antiquity, however, was found on the Giza plateau by French Egyptologists during the nineteenth century The text, called the "Inventory Stele," bears inscriptions relating events occurring during the reign of Khafra's father, Khufu. The text says that Khufu instructed that a temple be erected alongside the Sphinx, meaning that the Sphinx already existed before Khafra's time. The accuracy of the stele has been questioned because it dates from the Twenty-first Dynasty (1070-945 BC), long after the Pyramid Age, but because the Egyptians took great pride in precise record keeping and the careful copying of documents, no authoritative reason exists to discount the text as inaccurate.

Fragments of early papyruses and tablets, as well as the later writings of the third century BC Greco-Egyptian historian Manetho, claim that Egypt was ruled for thousands of years before the First Dynasty-some texts claim as much as 36,000 years earlier. This chronology is dismissed by Egyptologists as legend. However, ancient Egyptian history is viewed by scholars mostly from a New Kingdom perspective because numerous documents have survived from Thebes. The capital of Memphis, founded during prehistoric times, was a vitally important religious, commercial, cultural, and administrative center with a life span of thousands of years, but unfortunately, it has not been effectively excavated.

The recent geological studies of the Sphinx have kindled more than mere debate over the attribution and age. The established history of the evolution of civilization is being challenged.

A study of the severe body erosion of the sphinx and the hollow in which it is situated indicates that the damaging agent was water. A slow erosion occurs in limestone when water is absorbed and reacts with salts in the stone. The controversy arises over the source of the vast amount of water responsible.

Two theories are popular. One is that groundwater slowly rose into the body of the Sphinx. This theory raises irreconcilable problems: A survey carried out by the American Research Center in Egypt (ARCE) determined that three distinctly separate repair operations were completed on the Sphinx between the New Kingdom and Ptolemaic rule, that is, during a period of roughly 700 to 1,000 years [8]. The study also indicates that the Sphinx was already in its current state of erosion when these early repairs were made. No appreciable erosion has occurred since the original damage, nor is there further damage on the bedrock of the surrounding hollow; an area that never underwent repair.

Knowing this, one must consider that the inundating Nile slowly built up levels of silt over the millennia, and this was accompanied by a gradual rise in the water table. During Khafra's time the water table was about thirty feet lower than it is today. For the rising groundwater theory to hold, an unbelievable geological scenario would have to have taken place. It would mean that from thirty feet lower than today's water table, water rose to about two feet into the body of the Sphinx and the surrounding hollow where it caused erosion for roughly 600 years, and then stopped its damaging effects.

Historians find the second theory that is offered more unthinkable. It suggests that the source of water stemmed from the wet phases of the last ice age - c. 15,000 to 10,000 BC- when Egypt underwent periods of severe flooding. This hypothesis advocates that the Sphinx necessarily existed before the floods. If it could be proven, well-established theories about prehistory would be radically shaken. The world's most mysterious sculpture would date to a time when historians place humanity in a neolithic setting, living in open camps and depending largely on hunting and foraging.

The age of the pyramids themselves has been challenged by a recent project carried out, in cooperation with the American Research Center in Egypt (ARCE), with radiocarbon (carbon-14) dating [9]. Although limestone contains no carbon for dating purposes, mortar found in various parts of the pyramids' core masonry contains minute fragments of organic material, usually calcined charcoal or reeds. Some fragments are too minute to be dated by standard methods, and therefore carbon-14 dating was also carried out with the aid of an atomic accelerator in Zurich, Switzerland. Seventy-one samples were collected from thirteen pyramids or their surrounding funerary monuments. From the core masonry of the Great Pyramid itself, fifteen samples were taken at various levels from bottom to top.

The test results announced by the research team are startling. The team claimed that their tests indicate that the Great Pyramid is up to 450 years older than Egyptology had established from the archaeological record. Most remarkably, the team also reported that the mortar at the top of the Great Pyramid was older than that on the bottom and that the Great Pyramid dated older than the Step Pyramid of Zoser, which Egyptologists have established as the first ever built.

All Egyptologists are in firm agreement that the Great Pyramid was built about 100 years after Zoser's pyramid. Those questioned about the recent carbon-dating project deny the possibility of the accuracy of the tests. The researchers, however, are confident that their sampling was careful and their methods effective. A German laboratory previously sampled tombs at Saqqara and their tests also provided dates of about 400 to 450 years earlier than established dates.

The baffling features of the Valley Temple near the Sphinx deeply impressed members of the Napoleonic expedition at the beginning of the nineteenth century. François Jomard, a member of the expedition, at first thought that the enormous temple blocks were protrusions of bedrock that had been rough cut and squared. As mentioned, the blocks are assumed today to have been carved in situ. But Jomard noticed cement between the blocks of the temple and realized he was observing deliberately placed blocks weighing as much as 500 tons. Reflecting amazement and admiration, he remarked in Description de l'Egypte, "I wonder who these Egyptian men that playfully moved colossal masses around were, for each stone is itself a monolith in the sense that each is enormous."

Engineers have not reconciled the logistical problems that would be encountered by raising stones of this magnitude. To shift them about manually and set them so perfectly in place with cement in their joints in the small work area would have been impossible. A remark that Petrie made when describing stones in the inner gallery of Khufu's pyramid makes this point clear: "To place such stones in exact contact required careful work, but to do so with cement in the joints seems almost impossible." Petrie was referring to stones that weighed sixteen tons-a mere fraction of the weight of these temple blocks.

The floor of the Valley Temple is made of white alabaster slabs. Interior walls are lined with precisely joined granite facing blocks. The curious tailoring of the corners in the interior is unlike anything found in modern architecture. Blocks curve around the walls and join in a diverse interlocking jigsaw pattern. These hard and beautifully crafted stones exemplify an extraordinary masonry method.

Petrie introduced the puzzles of pyramid construction with the publication of Pyramids and Temples of Giza in 1883. The topic simmered in the public mind until the writings of amateur archaeologist Erich von Daniken caused the controversy to explode in the 1970s. In his book *Chariots of the Gods?* von Daniken sought the solution to the numerous engineering enigmas of the past. He wrote, "The Great Pyramid is (and remains?) visible testimony of a technique that has never been understood. Today, in the twentieth century, no architect could build a copy of the Pyramid of Khufu (Kheops or Cheops) even if the technical resources were at his disposal. How is anyone going to explain these and other puzzles to us?"

Our book reveals what I believe to be the true method of pyramid construction, and, as I will explain, most of the mysteries of the ancient world are finally solved by one major scientific breakthrough. The discovery is so dramatic and far reaching that many important aspects of ancient history will be reconsidered. First, a deeper look at the unresolved problems of pyramid construction is required.

Chapter 2

A Close Look at the Problem

Generally, people believe that the pyramids were built by primitive methods of quarrying, carving, and hoisting huge limestone blocks because they have been conditioned thus. They have accepted their conditioning because it is handed down through the authority of scholarship. What they generally are not taught is that the evidence against the accepted theory is flagrant.

About forty theories attempt to explain how the Great Pyramid may have been constructed by carving and hoisting stone, all proposed by intelligent people with academic backgrounds. Yet something is wrong with a reasoning that spawns such technological profusion. Nothing is wrong with the logic itself, it is the premise of the logic that is erroneous. Traditional theory has simply not resolved the problems of pyramid construction.

Common sense rejects as illogical any conclusion accompanied by blatant flaws. And the more closely we examine the issue, the more blatant those flaws become. In my own process of discovering the true method of pyramid construction, my first step was to examine closely the accepted theory. I found myself embarked on a fascinating analytical journey, one that began with a close look at the unresolved problems of pyramid construction.

As mentioned previously, the labor involved in cutting the amount of stone in the Great Pyramid equals that required to cut all of the stone used in the monuments produced during the New Kingdom, Late period, and Ptolemaic period combined, a span of about 1,500 years (1550-30 BC). A calculation of the amount of stone used during this 1,500 - year period was made by de Roziere, a geologist with the Napoleonic expedition.

Napoleon's army was stranded in Egypt for fourteen months during the French Revolution. An army of 50,000 men was accompanied by 150 scholars, among them Geoffroy Saint Hilaire, a naturalist; de Dolomien, the mineralogist who lent his name to dolomite; Dominique Vivant Denon, an artist and engraver; Claude Bertholet, a chemist; Dominique Larrey, a surgeon; Guillaume Villoteau, a musician; Marie Jules de Savigny, a botanist; Nicholas Conté, the inventor of the lead pencil; Colonel Coutelle, a geometrician; and de Roziere, a geologist. The academics among the group produced the most impressive study ever of Egyptian monuments.

Between 1809 and 1813, François Jomard, general commissioner for the scientific expedition, produced his great work, *Description de l'Egypte,* based on the research of the Cairo Institute, which was founded by Napoleon. In this work de Roziere reported his volumetric approximations of stone used in Egyptian edifices [10].

> " Using approximations, I have estimated that the surviving sandstone edifices might represent a total surface area of about one and a half million square meters [125.5

acres], which are covered with bas-reliefs, including columns, pylons, and enclosure walls. This does not include the monuments which were demolished, of which vestiges can still be seen, and those which must have been destroyed completely, which would perhaps form a very considerable amount. And this estimate does not include Nubia, where the sandstone monuments are hardly less numerous and widespread than those of the Thebaid. By similar means, I have estimated the total volume of surviving sandstone monuments to be more than one million cubic meters [35,314,475 cubic feet]. The total would not be doubled by adding those which have disappeared because part of this material was used in succeeding edifices. If we take into account the material used in foundations, floors, roads, quays, and hydraulic constructions, we can estimate at a glance that there must have been at least three or four million cubic meters [141,257,950 cubic feet] of carved sandstone from quarries simply for those constructions in the Thebaid that can be estimated. However large this quantity, it still does not equal half of the material that exists merely in the pyramids of Giza or those at Saqqara."

The following calculation demonstrates the inefficiency of the accepted method of pyramid construction. My calculation is based on the amount and hardness of the stone used and the time required for construction. To balance the equation we will assume that bronze tools were used to prepare the blocks for the Great Pyramid even though they were unavailable. For a given amount of labor, using the same bronze tools as were used to build and decorate the sandstone edifices of the New Kingdom and later periods mentioned, all that could be carved would be the amount of a medium-soft limestone, such as that used in the Great Pyramid. Only a quarter of this amount could have been carved of Carrara marble, and scarcely a sixteenth of this amount of basalt. In other words, the labor required to cut, haul, and hoist the 4 million cubic meters (140 million cubic feet) of limestone for the two Great Pyramids alone, during forty years of work, equals the labor used to carve and erect the 4 million cubic meters (141,257,950 cubic feet) of sandstone used for all the monuments built during the 1,500 years of the New Kingdom, Late period, and Ptolemaic period combined (Fig.3).

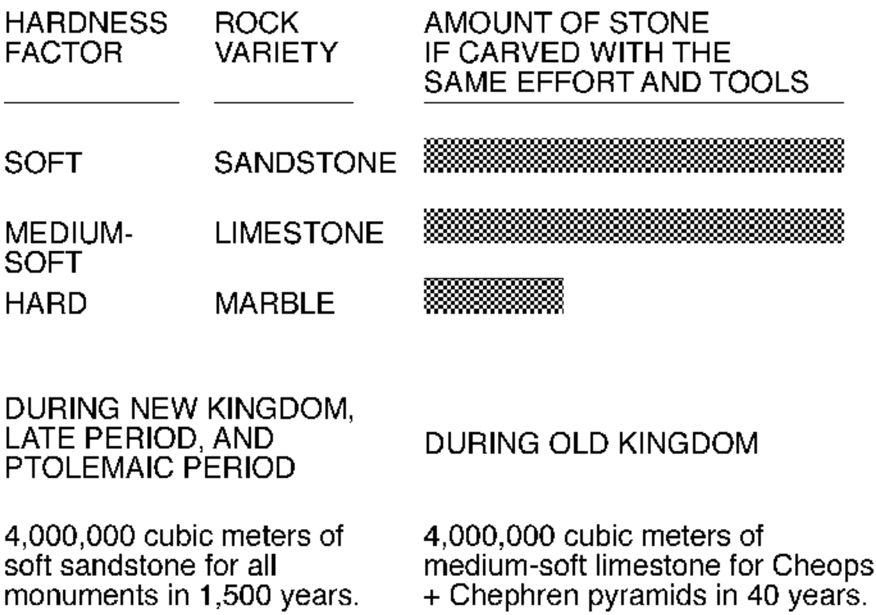


Figure 3: Construction of the Great Pyramids required the same efforts as the construction of all monuments in the 1,500 successive years.

I use a twenty-year construction period for each pyramid in this calculation for two reasons. First, each pyramid was built during the reign of the pharaoh for whom it was constructed. The reign of Pharaoh Khufu (Kheops or Cheops) was from 2551 to 2494 BC, or twenty-one years. Second, when the Greek historian Herodotus (c. 484 - 425 BC) visited Egypt, he was told that the Great Pyramid was constructed in twenty years.

During the combined New Kingdom, Late period, and

Ptolemaic period 4 million cubic yards of sandstone monuments were prepared in 1,500 years. During the Old Kingdom, about 4 million cubic yards of stone for the two Great Pyramids were prepared in forty years. As mentioned, this production period is no aberration because the two pyramids of Sneferu (2575 -2551 BC), which have a total volume of 3 million cubic yards, were produced during this king's reign of twenty-four years.

Because the Old Kingdom limestone in the Giza quarries is as soft as the sandstone used during the New Kingdom and later periods mentioned, the Old Kingdom could have produced 4 million cubic meters of sandstone in forty years. Therefore, to show how much more productive the Old Kingdom was compared with the New Kingdom and later times, we divide 1,500 years by 40 years, yielding 37.5 years. Assuming that during the New Kingdom and later as few as 20,000 workers were continuously involved in such labor, then 750,000 workers (37.5 x 20,000) would have been required to work on the great Pyramids to achieve the same productivity.

It is ridiculous to suppose that the 750,000 men required could effectively labor together in the work area at Giza; and Egyptians of the Old Kingdom, without bronze tools, accomplished in twenty years what took Egyptians of the New Kingdom, Late, and Ptolemaic periods together 1,500 years. This calculation makes it obvious that the standard construction theory is unacceptable.

Egyptologists are able to make only a poor attempt to settle this issue. Egyptologist Dieter Arnold, in an attempt to reconcile the vast number of blocks that would have to have been set per day, proposed to expand the life span of the pharaohs far beyond that provided for by Egyptology. D. Arnold calculated that from Sneferu to Khafra (Khefren or

Chephren), a period he calculated to be eighty years, 12 million blocks were used in pyramids, yielding a minimum of 413 blocks set per day [11]. He recognized that the number of blocks would not begin on the first day of the pharaoh's reign. A site had to be chosen, plans drawn, and the leveling work completed. Depending on when work began on the pyramid itself, the number of blocks would exceed 413 and possibly become two to three times as high, leading to, as Arnold said, " astronomical numbers ". Arnold therefore proposed, " There can only be one solution… namely to increase the lifetime of the pharaoh… " He proposed life spans which are two or three times as long as those established by Egyptologists from existing records.

It is abundantly clear, however, that even going against the grain of established Egyptology and vastly lengthening life spans, no appreciable dent is made in the enormous problem. Arnold admitted, " But we cannot deduce from the records how the Egyptian workers managed to accomplish this task. But the fact that they were able to solve the hard problems they were facing is beautifully exemplified by the pyramids of Khufu (Kheops or Cheops) and Khafra (Khefren or Chephren) ". In this last statement, one begins to see the futility of the typical response to this puzzle. Instead of considering that a different method must have been used, experts throw up their hands and admire the monument in question.

The same type of response has been provided for the problems of quarrying hard varieties of granite and other hard rocks with primitive methods. We have already seen a passage from *Description de l'Egypte* mentioning that the means for quarrying the hard quartzite used for the Memnon Colossi had not been determined. A substantial number of finely jointed blocks of hard granite appear in the Egyptian pyramids. In *The Pyramids of Egypt,* I. E. S. Edwards, retired Keeper of Egyptian Antiquities for the British Museum, writes [12]:

> “ The methods employed in the Pyramid Age for quarrying granite and other hard stones are still a subject of controversy. One authority even expressed the opinion that hard stone quarrying was not attempted until the Middle Kingdom; before that time, the amount needed could have been obtained from large boulders lying loose on the surface of the ground. It seems difficult, however, to believe that a people who possessed the degree of skill necessary for shaping the colossal monoliths built into the granite valley building of Khafra (Khefren or Chephren) were not also able to hew blocks of this stone out of the quarry ”

In other words, because beautifully formed granite blocks appear in the pyramid complexes, the Egyptians must have quarried such stone even though expert opinion denies the possibility. Here, results are used as proof of method. This is a useless process when it ignores well-founded arguments to the contrary. Worse, the it-must-have-been-so approach does not settle the issue because the method by which hard granite blocks were shaped for construction remains unsettled.

Although it is taken for granted that the pyramids were erected by workers using simple stone or copper hand tools and primitive quarrying techniques, an examination of these methods will help to show how really limited they are. French archaeologist and architect Jean Pierre Adams remarked on the amount of surface area of stone that would have to have been cut for pyramid construction [13]:

> “ It is easily imagined from this, that to obtain one cubic meter [35 cubic feet] of building stone it was easier to make it in one single piece than from a number of smaller blocks which would considerably multiply the number and extent of surfaces to

> be worked. But before the carving, there was the extraction. Nowadays, it is difficult to imagine workers attacking a rocky cliff with stone axes. It is, however, in this way that numerous megaliths were detached and squared. ”

Assuming that the builders aimed for maximum efficiency when carving stone, the first pyramids should have been made of enormous blocks with a relatively low surface-to-volume ratio. As tools improved, the dimensions of the blocks forming the monuments should have diminished, yielding a higher surface-to-volume ratio. The opposite happened. The pyramid of Zoser (c. 2670 BC), the first ever erected, was made entirely of small stones, 25 centimeters (9.8 inches) high, weighing only several dozens of kilograms (50 -100 pounds) apiece. Blocks in the Great Pyramid, the seventh or eighth in chronology, are larger, weighing at least two tons apiece. Beams forming the vaults of the inner chambers of the last pyramids of the Fifth and Sixth Dynasties weigh from thirty to forty tons apiece. Monolithic burial chambers produced during the Twelfth Dynasty weigh seventy-two metric tonnes and more. We see that the size of stones gradually increased. Accordingly, the conventional theory does not accommodate the evolution of pyramid construction.

Dressing or knapping blocks with stone or copper tools would pose serious problems, and more acute problems would be encountered if another, still cruder, method advocated by Egyptologists was used to produce pyramid blocks. Adams remarked:

> “ When dressing the surfaces was necessary, two techniques could have been used. The first, already described, consisted of dressing with the aid of hard stones or metal tools, the art of knapping being quite well known at the time. The second method described in Egyptian documents, among other sources, consisted of heating the surface of the stone very

strongly with fire, then spraying on water to make it split. ”

Heating stone and applying water is applicable for reducing large pieces of sandstone, granite, or basalt into small aggregates. But granite blocks, for instance, in the base of Khafra's (Khefren or Chephren) pyramid have only one flat side, perhaps the result of splitting by the water and heat method. The other surfaces of the stone are irregular, demonstrating that this technique is not applicable for making perfect blocks (Fig.4).

Figure 4: Irregular granite blocks on the west side of the Second Pyramid suggest builders of the Fourth Dynasty were unable to quarry regular granite blocks, if these were part of the original masonry.

In addition, blocks of the dimensions used for the pyramid of Zoser (25 x 15 x 10 centimeters, or 9.8 x 5.9 x 3.39 inches) cannot be dressed by heating and applying water without reducing them to debris. Moreover, heating with fire transforms limestone into lime, because the transformation to lime occurs at 704°C (1,300°F). This completely disqualifies the use of the heating operation for producing pyramid blocks.

How efficient are flint and copper tools for shaping pyramid blocks? Tools made of hard stone are useful for working softer varieties of stone but are not applicable for producing 2.5 million blocks for the Great Pyramid in twenty years. Copper is a soft metal. Because it is unsuitable for cutting hard stone, a popular theory proposes that the ancient Egyptians mastered a process for giving copper a high temper. This surmise has never been proved, and there is no evidence to support it. No such highly tempered copper has ever been found. It is difficult to believe, when considering the billions of dollars of research money spent on metallurgy in modern times, that the technique would not have been rediscovered.

Although the Great Pyramids were erected during historic times, technically they belong to the Chalcolithic (copper-producing) period, which marked the end of the Neolithic Age. The only metals known in Egypt were gold, copper, silver, and lead, which are all quite malleable. Native copper was available in the eastern desert, and copper was smelted from ores since prehistoric times. A copper arsenate alloy, considered as bronze, was used in Egypt during early times. This, however, was not a hard product.

The type of bronze required for cutting rock of medium hardness is an alloy of copper and tin, such as that introduced at either the end of the Middle Kingdom or in the early New Kingdom, about 1900 BC. In other words, hard bronze was introduced 800 years after the Great Pyramid was built. Some scholars estimate the appearance of iron at about 1400 BC, and others place it as late as 850 BC.

I am not suggesting that stone and copper tools were not used in pyramid construction where applicable. These primitive tools were used for leveling and tunneling work and for sculpting the *in situ* body of the Great Sphinx. Whereas fossil shells in the upper Giza bedrock make it difficult to cut into blocks, the bedrock itself is loosely bound and easily disaggregated (see more details in Appendix II: The Circuit at Giza).

However, shaping the Sphinx cannot be compared with building the Great Pyramid. We must appreciate the vast difference between using stone and copper implements for hollowing out tunnels and sculpting *in situ* monuments, and for using these same tools to produce 2.5 million blocks for the Great Pyramid in twenty years. Stone and copper tools are not applicable for producing the approximately 115,000 casing blocks that were fitted together with tolerances averaging 0.02 inch and as small as 0.002 inch in the Great Pyramid. The scale and precision of the Great Pyramid is simply too grand for primitive tools to have been applicable.

The problems of logistics are far more mysterious and complex than has been realized. The logistical studies established so far have never even considered certain germane issues. The geochemical study mentioned earlier, for instance, by D. D. Klemm, a German geochemist from the University of Munich, presents an unusual new dimension to the puzzle [14].

Klemm presented data at the Second International Congress of Egyptologists, held in Grenoble, France, in 1979. As mentioned, he attempted to determine which quarries provided blocks for the Great Pyramid. His team sampled twenty different building blocks from the Great Pyramid. The team also sampled twenty geological sites along the Nile, excluding those of Tura and Mokattam on the east bank, which are in a restricted area. The team then compared trace elements in the pyramid samples with those of the quarry samples.

Based on his analyses, Klemm reported that the twenty pyramid blocks he sampled came from the different geological sites he visited. In other words, he concluded that blocks for the Great Pyramid were hauled from sites hundreds of miles away from the pyramid itself. This presents a dramatic conflict. Legend has it that the blocks came from Tura and Mokattam (not tested by Klemm). Geologists who have performed petrographic analyses affirm that the blocks for the Great pyramid were quarried at Giza. Now a geochemist has determined that the blocks came from sites hundreds of miles away. The paramount problems Klemm's study poses threaten all logistical studies made so far on the Great Pyramid. In 1988, at the Fifth International Conference of Egyptologists, Cairo, Egypt, Klemm presented new data obtained with different and less sophisticated tools. He was able to show that the stones match those of the Giza quarries (see for more details in Appendix II: The Circuit at Giza).

As mentioned, the same sort of scientific dilemma is associated with the Memnon Colossi in the Theban necropolis. These remarkable monuments were built during the New Kingdom a period during which the quality of architecture declined in comparison with that of the Old Kingdom. The colossi are two gigantic seated statues of the great Eighteenth Dynasty Pharaoh Amenhotep III. They adorned the entrance of his funerary temple, which is now demolished but which must also have been spectacular.

The colossi were originally monolithic and are made of exceptionally hard quartzite, a type of stone that is almost impossible to carve. The statues weigh 750 tons a piece and rest on 556-ton pedestals. Including their pedestals, they each originally stood sixty-three feet high or the height of a seven-story building. The width at the shoulders is twenty feet. The length of the middle finger of the hand is 1.35 meters (4.5 feet).

A legend is associated with the statues. The northernmost of the colossi was damaged during an earthquake around 27 BC. After the earthquake, reports say that every morning when sunlight struck the statue, musical tones, like those of a harp, were emitted. The statue was repaired about 250 years after the earthquake by a Roman emperor, Septimus Severius, during the Roman occupation of Egypt. His men repaired the statue by adding blocks, so it is no longer made of a solid piece of stone. From the day of the repair forward, the statue remained silent.

Even more interesting are the features that have mystified those who discovered the colossi and modern scientists alike. The passage from *Description de l'Egypte* describes the fact that none of the quartzite deposits, where the stone had to have originated, exhibit tool marks, and that it was the opinion of members of the Napoleonic expedition, that because the quartzite is so hard, an unknown process must have been used on this unworkable type of stone. Members of the expedition were amazed by the fact that the flint and agate aggregates constituting the stone were never disturbed by the engraving process.

In 1913, French scholar M. G. Dofressy and German scholar G. Steindorff proposed that the 750-ton statues were transported along the flow of the Nile from around Edfu or Aswan to Thebes [16]. In 1965, L. Habachi, Chief Inspector of Antiquities of Egypt, concurred [17]. In 1973, a team from the University of California, Berkeley, proposed a more incredible feat. Based on the team's studies, it was proposed that the statues were quarried at Gebel el-Ahmar, not far from Cairo. In other words, they say that the 750 ton colossi were floated 440 miles along the Nile against its flow! [18]

To determine the source of the quartzite, the French and German teams made petrographic analyses. They analyzed flint, agate, and the other components off the stone. The Berkeley team studied the geochemical aspects of the quartzite, performing analyses on infinitesimal quantities of trace elements with neutronic activation, a method allowing the quantity and type of minerals occurring to be measured.

After comparing the quarry samples with samples of the colossi, the team concluded that indeed the stone originates from Gebel el-Ahmar. However, the French and German scientists interpreting these scientists' data arrived at their original conclusion, that the stone came from Syena (Aswan). Even expert scientists with the most sophisticated modern equipment and methods cannot agree on the origin of the stone for the Colossi of Memnon.

The list of anomalies about the Great Pyramid lengthens when we consider the dimensions of the blocks. There is a misconception about the blocks of the Great Pyramid which archaeologists perpetuate. They advocate that the heights of the blocks at the base are always greater than those near the summit. If accurate, this would make logistical problems far less complex.

It is true that the height of the blocks at the base is 1.41 meters (1.54 yards) and that the heights of blocks progressively diminish to 0.59 meter (1.93 feet) in the first seventeen steps. With the exception of the huge cornerstones, the weight of blocks in the first seventeen steps diminishes from approximately six to two tons. Beyond the seventeenth step, however, blocks weigh from fifteen to thirty tons apiece, showing that block size does not consistently diminish as the pyramid ascends.

What most people fail to recognize is that at the nineteenth step the height of the blocks increases suddenly to 0.90 meter (2.95 feet). This is not obvious when you are standing at the bottom of the pyramid looking up because the heights of blocks forming the tiers appear to diminish. From a distance it is difficult to make an accurate assessment. The only way to determine the exact heights of the steps is by measuring them. Because it is difficult and potentially dangerous to climb to the top of the pyramid, it is likely that most specialists have mounted only the first few steps.

MM. le Pere and Colonel Coutelle of the Napoleonic expedition very carefully measured the heights of the steps of the Great Pyramid one at a time and recorded the exact measurements in feet and inches in *Description de l'Egypte.* I transposed their measurements onto Graph I in Fig.5 and have made the following observations:

1. Stones more than 1 meter (1.09 yards) high are equally distributed throughout the pyramid.

2. Except for the cornerstones, the largest stones of all are located about thirty stories high in the pyramid, at about the level of the King's Chamber.

3. Small stones are distributed between several successive series of larger stones throughout the pyramid, with many situated near the base.

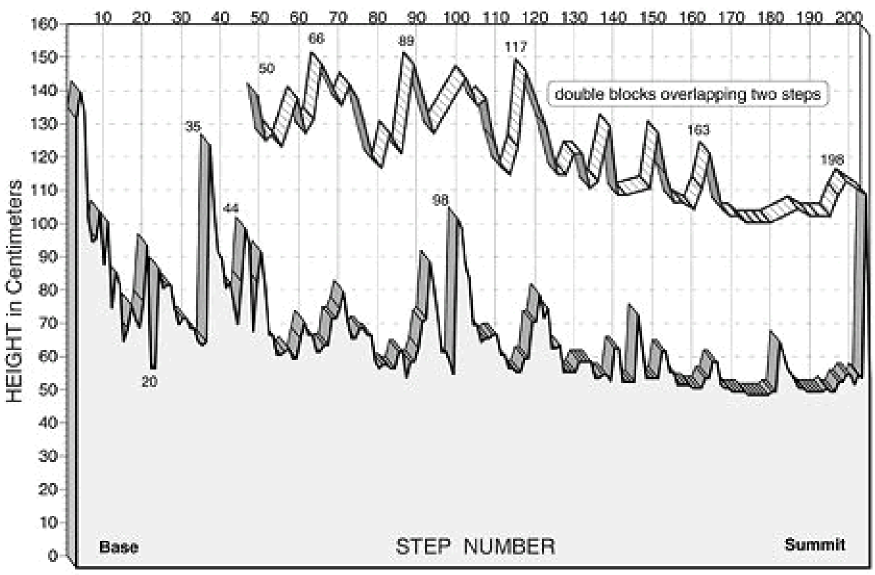


Figure 5: Height variation for Khufu (Kheops or Cheops) Pyramid layers.

Why is the misconception perpetuated? Egyptologists rely on the following general remarks by Jomard from *Description de l'Egypte,* which they consider, without further verification, to be precise [12]:

> “ Finally, in 1801 MM. le Pere and Coutelle measured all of the steps of the pyramid with the utmost care, using a specially designed instrument. The number of steps counted was 203 and the height of the pyramid itself was 139.117 meters (152.14 yards]. . . It is perhaps worth taking note of the agreement which exists between our measurements and those of le Pere and Coutelle, not only regarding the height, but for the number off steps. Among the various travelers, some have counted 208, others 220, etc.…The perfect agreement on this point, together with that of our measurements of the base and height, is important proof (if proof were necessary) of the scrupulous care with which the engineers and artists of the expedition made their observations. Before deducing measurements other than the base and height, I should point out the differences in the heights of the steps from bottom to top. As is natural, the heights continuously decrease from 1.411 meters [1.54 yards] down to 0.559 meter [1.83 feet], with the smallest stones of all 0.514 meter [1.68 feet] high. The average height is 0.685 meter [2.24 feet]. ”

Jomard’s remark that, “ As is natural, the heights continuously decrease ” was meant as a general statement which was not intended to account for all blocks in the pyramid. It certainly does not apply to hundreds of blocks weighing from fifteen to thirty tons situated near the King’s Chamber. Blocks of this size, represented in Graph I and shown in Figure 6, are so large that they occupy the space of two tiers. Nevertheless, Jomard’s general statement is always cited, whereas the precise, detailed reports of le Pere and Coutelle are rarely, if ever, taken into consideration. Because of the difficulty of raising such large stones to great heights, their detailed report poses a serious threat to the accepted theory.

In November 1984, I made an on-line search in the French archaeological data bank, Francis-H, using the key words PYRAMID and QUARRY. I discovered that in 1975, at the same time I was transposing le Pere and Coutelle's measurements for Graph I, Georges Goyon, a French Egyptologist published a report after climbing the northeast corner of the Great Pyramid and carefully measuring the steps [20]. Comparing his results with the measurements of 1801 reveals that the Great Pyramid has lost steps 202 and 203. The peaks and plateaus charted by Goyon compare exactly with all other data established in 1801. Step heights suddenly increase and diminish in nineteen sharp fluctuations. Goyon could not account for the dramatic fluctuations except to propose that they must conform to the heights of the geological strata of the Giza plateau. His assumption is incorrect. The blocks of both the Great Pyramid and the Second Pyramid of Giza are smaller than the heights of the strata at Giza.

Almost none of the pyramid blocks matches the Giza bedrock. The strata appearing in the body of the Great Sphinx are 1 meter (1.09 yards) high. Those in the quarry near Khafra's pyramid are more than 4.5 meters (4.90 yards) high. Realizing this, we might begin to feel sympathetic toward some of the wildly conjectural pyramid construction theories presented in recent years.

Having been impressed by the heights of the double blocks measured by le Pere and Coutelle, as can be deduced from Graph I, I decided to make a preliminary study of the lengths (or widths). The lengths have never been measured, and I therefore photographed the area below the top thirty levels of the south and west faces of the Second Pyramid of Giza. The blocks in the Great Pyramid itself are too eroded to afford accurate overall measurements. The area I photographed is unweathered and in very good condition because the casing blocks previously covering it were removed only within the last 150 years (see in the Giza Circuit, Appendix II). The area encompasses twenty-two steps, or -1,000 surface blocks per face. The steps photographed represent about ten percent of the area of the pyramid.

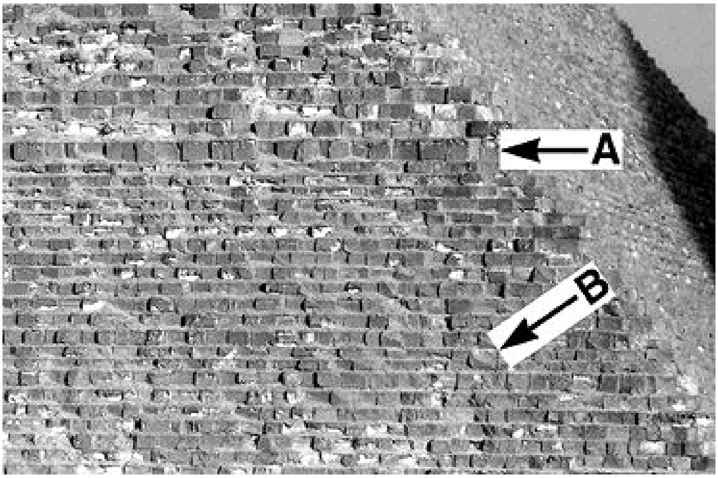


Figure 6: Large blocks at Step 35 (A). Isolated large block spans Steps 20 and 21 (B).

I had slides produced and projected them onto a screen, and then I measured the length of each of the 2,000 blocks. I transposed the measurements onto graphs to analyze structural features of the pyramid. Slides made with conventional photographic equipment do not allow the actual dimensions of blocks to be measured in feet and inches. Having used standard equipment, I made relative measurements. I considered that strata and defects make it impossible to cut stone to perfectly uniform dimensions with primitive tools. Therefore, if a low occurrence of uniform block lengths appeared, it would support the traditional carving hypothesis. A high occurrence of uniform lengths corroborate a method affording more precision.

I found that blocks do conform to the same lengths, and not to a moderate degree. Surprising as it may seem, almost all 2,000 blocks conform to ten perfectly uniform lengths. These lengths are distributed in diverse patterns throughout the twenty-two steps. Any possibility that the blocks were cut to the random sizes that would be dictated by cracks and other features of bedrock is eliminated. Anyone attempting to explain the preparation and use of blocks of such highly uniform dimensions based on the carving hypothesis would encounter serious difficulty. This degree of uniformity makes the possibility of carving with primitive tools out of the question.

It might appear that the Egyptians had a taste for performing bizarre and impossible tasks. Another example is the placement of monolithic sarcophagi in confined or otherwise difficult spaces. We can, for instance, appreciate the emotion of Cotaz, a member of the Napoleonic expedition, as he discovered the numerous tombs in the Valley of the Kings. Cotaz entered the valley on the one road that passed through a narrow access gorge situated between two steep mountains. Cotaz reached the area consecrated to the Ramses pharaohs. He reported [21]:

> " The gate through which one enters the valley is the only opening in its entire contour. As this opening is man-made, the valley must previously have been shaped in the form of an isolated basin which could only be reached by climbing the steep mountains. It was perhaps this remoteness which gave them the idea of placing the royal sepulchers there to make them safe from robbery, which the ancient Egyptians so much feared.... High mountains crowned with rock are hemmed in on all sides from the horizon, allowing only part of the sky to be seen. Towards midday when the bottom of the valley has been in the sun for a few hours, the heat becomes concentrated and excessive. Any tempering wind can find absolutely no way into this enclosure. It is like an oven. Two men from the escort of General Desaix died from suffocation. I do not think that it would be possible to remain there for twenty-four hours without the shade provided by

> the catacombs which offer protection from this overwhelming heat. ”

Most of the sarcophagi Cotaz discovered in the various tombs had already been destroyed. He described one, belonging to Ramses III, which was still intact and is now in the Louvre:

> “ Imagine a large oblong chamber made of pink syenite granite, ornamented inside and out with hieroglyphs and paintings. Its dimensions are such that a man standing inside can hardly be seen by anyone outside. A blow with a hammer makes it ring like a bell.... The sarcophagus must previously have been closed by a cover which has since disappeared.... The cover would have formed a considerable mass which was very difficult to move.... A comparison between the dimensions of the sarcophagus to those of the entrance to the valley yields a big surprise and a new example of the Egyptian's taste for difficult tasks. The entrance of the Valley of the Kings is not wide enough to allow the sarcophagus through, so that the huge mass must have been hoisted with a crane or pulley up the hills which surround the valley and then brought down along their sides. ”

The sarcophagus in the King's Chamber of the Great Pyramid is another example of unusual placement. It does not fit through the doorway or adjoining hallway. Egyptologists surmise that it must have been placed before the pyramid was completed. Although this goes against what is known about Egyptian funerary customs, the carving and hoisting theory offers no other alternative. Cotaz suggested the use of pulleys for raising sarcophagi, although Egyptologists have discovered since that pulleys were not known to the Egyptians until the Roman occupation. The matter in which sarcophagi were placed will be tentatively discussed as we progress.

Chapter 3

The Technological Paradox

When considering the historical overview of Egyptian art and architecture, one can clearly distinguish the existence of two distinctly different masonry methods. One was used primarily during the Old Kingdom, and the other, carving with hard bronze tools, was introduced during the late Middle Kingdom or perhaps a little later, about 800 years after the Great Pyramid was built. The distinction between the two methods can be made based on quality of workmanship, the hardness of the stone materials worked, and the design and structural features of buildings.

The contrast between the two methods is apparent in large monuments and small works of art. The quality of sculpture declined dramatically in the later periods. Nestor l'Hote (c. 1780 - 1842), an artist who worked with the founder of Egyptology, Jean François Champollion (1790 -1832), was ecstatic about the artwork found by Karl Lepsius (1810 - 1884) and Auguste Mariette (1821-1881) in three particular mastabas of the Old Kingdom. Describing the sculptures in one of the most ancient, that of the vizier Menefra of Memphis, l'Hote remarked [22]:

> “ The sculptures in this tomb are remarkable for their elegance and finesse. The relief is so light that it can be compared with one of our five franc coins. Such perfection in something so ancient confirms the observation that the further one goes back in antiquity towards the origin of Egyptian art, the more perfect are the results of this art, as if the genius of these people, unlike others, was formed in one single stroke. Of Egyptian art we only know of its decadence. ”

Egyptian sculpture was so degenerated by the New Kingdom that it fell into irredeemable decadence. Neither artists of Saite nor Thebes produced such masterpieces as the more ancient diorite statue of Khafra (Khefren or Chephren) or the Kneeling Scribe now exhibited in the Louvre. Remarks by archaeologists and architects Georges Perrot (1832-1914) and Charles Chipiez express awe of the Old Kingdom sculptors [23]:

> “ How did the sculptors manage to carve into these rocks which are so hard?… Even today it is very difficult when using the best tempered steel chisels. The work is very slow and difficult and one must stop frequently to sharpen the edge of the chisel, which becomes dull on the rock, and then retemper the chisel. But the contemporaries of Khafra, and everyone agrees on this, had no steel chisels. ”

On a grand scale we observe the same scenario. The blocks of the Old Kingdom pyramids exemplify a peerless fit, and Old Kingdom monuments exhibit hard stone materials prepared with ultimate care and perfection. Egyptians of the New Kingdom and later times were incapable of comparable workmanship when using bronze tools. In New Kingdom and later monuments, precision joints and the regular dimensions of blocks disappears. The degradation that occurred after the introduction of bronze tools astonishes architects and archaeologists who have studied Egyptian architecture over the last two centuries. Champollion, for instance, was astonished by the poor quality of the New Kingdom structures erected for Theban kings at Wadi Esseboua. He commented [24]:

> " This is the worst piece of work from the epoch of Ramses the Great. The stones were poorly masoned, gaps are hidden by cement upon which decorative sculpting continued, and this was bad workmanship.... Most of these scenes are unrecognizable because the cement onto which large parts were carved has fallen and left numerous gaps in the inscriptions. "

The Theban kings of the New Kingdom built a prodigious number of edifices from Nubia to the Mediterranean beaches. Surfaces of the walls were nearly always covered with richly colored polychrome decorations that masked imperfections. Perrot and Chipiez commented about this technique:

> " But why would they have prolonged their work by patching up, with infinite patience, joints that had to be hidden? Was the purpose of the stucco and paint to hide imperfections? In these edifices we do not see certain combinations of stones which the elegant building civilizations who left the stone undecorated were happy to use.... You will search in vain for regularity of construction, perfection in joints, and the perfection of carving and fitting which gives the face of a wall in the fortification of Mycena, even when separated from all to which it belongs, its own nobility and beauty. At Thebes the worker relied on fillers and was content to say, 'That should do the trick'. "

It is assumed that the use of stucco and paint made it unnecessary for joints to be perfect. In my opinion, it was because the carving method was used, and I think that it was to mask imperfections that the polychrome coating on a stucco base was developed. There was no question of laziness. Ramses II drafted masses of Asian and African slaves in order to dot the land with temples, palaces, and cities bearing his name. As frantically as he built, he simply could not compete with his illustrious ancestors.

Egyptologists usually explain the difference between the workmanship of the New Kingdom compared with that of the Old Kingdom by saying that Theban kings built more edifices than did their ancestors. I have already shown that by de Roziere's estimates there is far more stone in the Giza pyramids alone than in all the construction built during the New Kingdom, Late period, and Ptolemaic period combined, that is, in 1,500 years.

Furthermore, New Kingdom and later monuments were made, with few exceptions, of very soft varieties of stone, but since the inception of Egyptology, a common misconception has been widely perpetuated in literature, which is that monuments built during the New Kingdom and later are made of hard stone materials. De Roziere commented [25]:

> " It would be hard to believe that such famous monuments, famous for their age, richness, and the multiplicity of their ornamentation were built with rough, common materials. Most travelers, using their imaginations more than their eyes, believe that they have seen in the layers of the land, and in the monuments themselves, hard, precious granites from the Syene environment, the porphyries and variegated rocks of Arabia, and sometimes even basalt. Others are content with the use of marble, inspired by what they have seen in the ancient

monuments of Greece and Italy. The truth is that there exists in these quarries, and in the edifices of the upper Thebaid, neither porphyry, nor basalt, nor marble, nor any kind of limestone. All that can be found in this entire area, on both banks of the Nile, are layers of sandstone… and it is with this stone that, almost without exception, all of the still surviving monuments from Syene to Dendera were built. ”

When making the latter remark, de Roziere was not referring to hard sandstone such as that in the pavement of Fontainebleau, near Paris, withstanding generations of wear. He was talking instead about a particular soft variety called monumental sandstone. To avoid confusion, he distinguished it as psammite, since, having been a Parisian, the word sandstone suggested to him a dense material consisting of grains of tightly bound quartz, material comparable to the Fontainebleau sandstone. Psammite sandstone adheres poorly and will easily disaggregate under very light pressure. He mentioned its structural tolerance:

“ Egyptian sandstone is, in general, not very hard and it can often be scratched with a fingernail. The hardness is, at any rate, very uniform throughout each block and so is the breaking strength, which is low but equal throughout. This stone contains neither cavities nor blow holes [holes where a tool can be inserted]. ”

Practically all of the New Kingdom temples and those built later were made of this psammite sandstone which is so soft that one can scratch it with one's fingernails. This includes the temples of Luxor, Karnak, Edfu, and Esna. Even the more recent temples erected during Egypt's Iron Age, such as the Temple of Dendera built by the Ptolemies (c. 250 BC), are composed of extremely soft stone. De Roziere described this temple:

“ One surprising fact is that the stones of the Temple of

> Dendera, one of the most admirable for the execution of its sculpted ornamentation, are precisely the roughest of all. One finds there several varieties of fine sandstone but, in general, the grain is rather coarse, unequal, and can be disaggregated with a fingernail. ”

Many New Kingdom and later structures, the famous Abu Simbel Temple for example, were hollowed directly into hills of very soft sandstone, so no heavy lifting or hauling was necessary for construction. After the Aswan Dam was constructed, the Abu Simbel Temple was moved in its entirety by a team sponsored by the United Nations (1964 -1966) to avoid inundation by Lake Nasser. The operation was far more difficult than anticipated because of the weakness of the sandstone, which is so fragile that it was necessary to cut very deep into the cliff to obtain a mass strong enough to withstand the move from the edge of the lake to the top of the hill. De Roziere commented on the ease with which this material is carved:

> “ From Philae to Dendera, a distance of about fifty leagues in which the most important and best preserved edifices of ancient Egypt are found, nearly all are made of sandstone. Even though limestone mountains reign over the two sites of the Thebaid in more than three-fifths of this area, hardly any ruins made of limestone are found, and the few that exist are the least significant. That alone is proof enough of the preference shown by the Egyptian architects for sandstone over all of the several fine varieties of limestone found in their country.... But what must have, above all, met their approval was the extreme ease with which it could be chiselled, its docility, if we may use the term, to yield in every sense to the tool and to receive on its different faces the numerous figures and reliefs with which Egyptian architects felt compelled to decorate all the walls of these great edifices. ”

Because the limestone of the Theban landscape is hard, it was not used during the New Kingdom. Instead, a soft grade of limestone found at Tura, devoid of fossil shells, was employed. This limestone is unlike that used for the core blocks of Old Kingdom pyramids, which is relatively hard and difficult to carve because it contains large fossil shells. The French Egyptologist Gaston Maspero (1846 - 1916) described the type of soft limestone used for the New Kingdom temples of Memphis [26]:

> " The Tura quarries enjoyed the privilege of furnishing choice material for the royal architects. Nowhere else could such white limestone be seen, so soft for carving, so perfect to receive and preserve all of the finesse of a bas-relief. "

The casing blocks of the Great Pyramid and the Step Pyramid at Saqqara, reputed to come from Tura, are very much harder than the soft Tura limestone used even in today's restorations (see for example later in the restoration at Saqqara). It seems logical that soft materials, such as psammite sandstone and this very soft limestone to which Maspero refers, should have been used during the Old Kingdom when only modest stone or soft copper tools were available, but the opposite occurred.

Furthermore, unlike the Old Kingdom workmen, those of the New Kingdom and later periods rarely used large building units. A few obelisks and colossal statues are exceptional cases. Only the lintels and architraves of some New Kingdom and later temples have lengths comparable to those of the more ancient temples, but those of the later ones were less massive. The temples of Karnak are characterized by huge pylons, but all were made of small blocks.

The front pylon of the Temple of Dendera has a width of 110 meters (370 feet), a thickness of 15 meters (49 feet), and a height of 42 meters (138 feet). The first pylon of the Temple of Luxor, built by Ramses II, is a more modest 27 meters (88.5 feet) high, with each of its towers 30 meters (98 feet) in width. Although their dimensions are impressive, these giant monuments composed of small stone blocks cannot compare with the superstructures of the Old Kingdom, where monolithic beams in late pyramids weigh eighty tons and the Valley Temple of the Second Pyramid of Giza exhibits blocks weighing at least 500 tons.

Most of the colossal statues built during the New Kingdom and later, the remains of the great obelisks built by Theban and Greek rulers, those made during the later periods which were transported to Rome, during the Roman occupation, and Paris, London, and New York during the nineteenth century, were cut from a type of granite known as oriental red granite or pink syenite, a material relatively easy to carve. It cannot be scratched with one's fingernails like psammite sandstone, but it will easily disaggregate when hit with a pointed instrument.

There has been great confusion over this material. Pink syenite has two principal components: large, elongated, pink to brick-red feldspar crystals that are truncated at the corners, and extremely soft black mica. This type of mica has a hardness of 2.5, according to Mohs' scale, which is the same as plaster, and it makes an ideal point of attack for a tool. The pink feldspar crystals are also fragile, making this variety of granite easy to carve. However, since the inception of Egyptology, pink syenite has been confused with harder types of granite because its soft mica has been mistaken for an amphibole that requires a tempered steel tool to be sculpted. The main reason for the confusion is that today the word syenite indicates a hard hornblende, whereas in literature written before the nineteenth century the word syenite was used to describe soft granite from Syene (Aswan).

Most syenite monuments are found in northern Egypt, mostly in the Delta, and were erected during the Late and Ptolemaic periods. They have been discovered in Bahbeht, Canope, and the greatest accumulation is found in the Ptolemaic capital of Alexandria, where the entire land is scattered with the ruins of syenite statues, walls, and obelisks.

The overview permits assessment of the paradoxical and dramatic contrast. The pyramids of the Old Kingdom consisted essentially of fossil shell limestone, a heterogeneous material very difficult to cut precisely. Temples dating to the end of the Eighteenth Dynasty (1400 BC) are found over the entire face of Egypt. Some were made of very soft white limestone, even when constructed in entirely granitic regions in southern Egypt. After the Eighteenth Dynasty, the use of soft limestone eventually gave way to soft sandstone. The sandstone of Silsilis, in southern Egypt, was used to build the New Kingdom temples of Karnak, Luxor, and Edfu; it is homogeneous, soft, and easy to sculpt. Therein lies the great technological paradox of Egypt: at a time when tools were made of stone and copper, a tremendous amount of hard varieties of stone were used in monuments, but when bronze and iron were introduced, only the very softest stone material was used. There is more than ample evidence to support the existence of two different masonry methods used in different epochs and yielding very different results.

Chapter 4

The False Proofs of Egyptology

Even though the traditional explanation of pyramid construction is illogical and remains unproved, it has been accepted as a matter of faith, reinforced and protected by the sheer weight of scholarly opinion. What proof has Egyptology offered to support the accepted theory? Logistical studies are generally used as proof even though they are highly speculative and prove nothing. The great efforts made over a long time to explain construction problems in no way mean that basic theoretical assumptions are correct, especially since problems remain unresolved, despite the numerous studies, and important facts remain unconsidered. Despite the efforts of experts, the construction method is still a matter of legitimate debate.

If logistical reports are used as proof of construction, they constitute false proofs. There are six additional false proofs. The rest of this chapter explains why each one is either erroneous or open to interpretation.

1. Quarried Blocks

There are a few remains in a trench on the north side of the Second Pyramid of Giza, and Egyptologists use them as evidence to support the traditional carving and hoisting theory. The northern vertical face of this quarry bears inscriptions and a large cartouche containing the name of the New Kingdom pharaoh, Ramses II (1298-1235 BC), who demolished numerous monuments to obtain ready-made blocks for his own constructions. The inscriptions honor Mey a chief architect of Ramses II, who, according to the inscriptions, removed casing blocks from the Second Pyramid and dismantled a temple of the complex. This occurred 1,400 years after the pyramid was built. There are no other inscriptions by which to date the quarry (see more details in the Circuit at Giza, Appendix II).

Ramses II and other pharaohs took a number of ready-made blocks from various pyramids, but they were incapable of producing a monument or any combination of monuments equivalent in volume to the Great Pyramid. This holds true even though Ramses II used enormous wealth and manpower endlessly to rob ready-made blocks from existing monuments over his sixty-five year reign.

The pattern of chisel marks also in the trench near the pyramid has been dated to the time of Ramses II. It is relevant to consider what has been determined historically about Egypt's quarry methods. Klemm and his wife made a complete dating of the sandstone quarries of Gebel el-Silsila and presented a paper at the Second International Congress of Egyptologists in 1979. Their study dated the various quarry methods used historically in Egypt. The following is an abstract of their paper [27]:

“ Most quarries were dated to well-defined historical periods with the aid of chisel marks, block technique, inscriptions, and pottery shreds. The most anciently quarried areas are at the northern edges of Gebel el-Silsila. These were quarried prior to the New Kingdom, perhaps in the Middle Kingdom. The chisel marks of this period are irregularly oriented (Fig.7) . The northern part of Gebel el-Silsila was exploited during the New Kingdom, in about the Eighteenth Dynasty, and chisel marks form a herringbone pattern. In the Nineteenth Dynasty, Ramses II introduced a fine parallel pattern that still prevailed when the Ptolemies exploited large quarries at the site. At the southern end of Gebel el-Silsila are the Roman quarry sites. No chisel marks of the previous types are found, but only wedge marks made by wooden dowels. ”

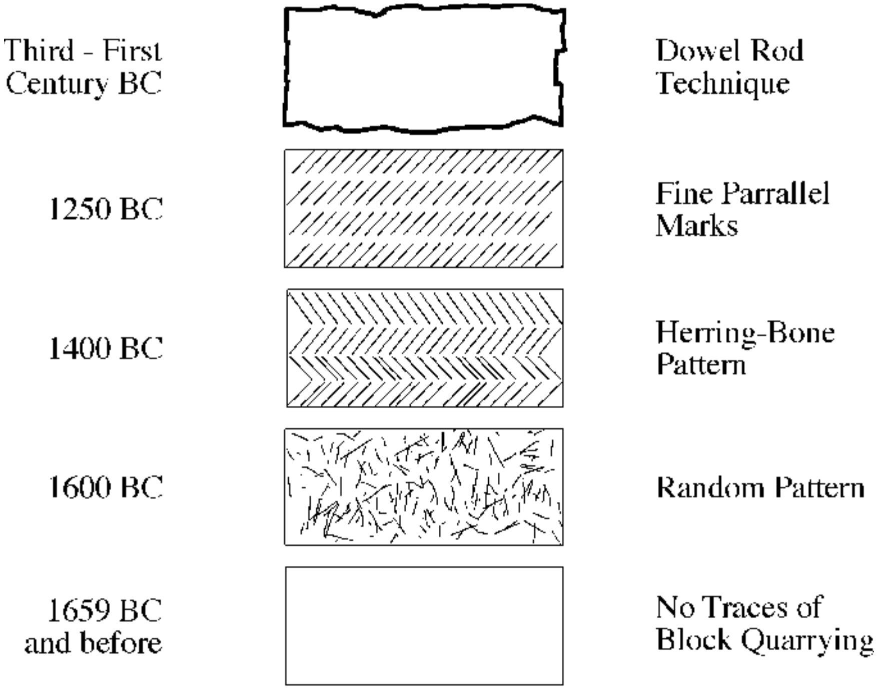


Figure 7: Datation of the quarry marks at Silsilis, adapted from D. Klemm et al. [27]

The Egyptians carefully cut stone from quarries, continually refining their chisel strokes because during the

Middle and New Kingdoms the quarry was considered to be the eternal body of the god Amun. Treating Amun's body haphazardly was an act of sacrilege, so quarrying was piously conducted to remove blocks in finished form. The Egyptian method of quarrying would not have been efficient for constructing the Great Pyramid.

On the southern end of Gebel el-Silsila, only the traces of wooden dowels appear. Dowels were inserted into the quarry and wetted with water, so that when the wood swelled, the stone cracked. This method is frequently shown in books depicting pyramid construction, but the Klemms' dating shows that this primitive method was never used by the Egyptians. It was exclusively a Roman technique dating to the Roman occupation of Egypt.

If this crude Roman method had been used for pyramid construction, as is advocated, the amount of general debris at Giza would be staggering, including countless millions of unusable cracked blocks. Before the Klemms' presentation, it was assumed that because doweling is a primitive quarrying method it is also the oldest. One sees that the remains of quarrying in the trench near the Second Pyramid of Giza cannot be used as evidence to support the accepted theory.

Although the Klemms did not date limestone quarries, a general dating of quarrying in Egypt is established nevertheless. The implications are profound. From 27 BC to AD 379, the Romans quarried stone with wooden dowels. From 332 to 1250 BC, fine, parallel chisel strokes were used in Egyptian quarries. In 1400 BC Egyptians were making herringbone chisel patterns when cutting. During 1600 BC, they cut stone using random strokes, and before that time, there is no trace of block quarrying at all in the sandstone quarries at Gebel-el-Silisila. How did the Egyptians remove stone in more ancient times for pyramid construction?

2. The Transport of the Statue of Djehutihotep.

A Twelfth Dynasty (1800 BC) bas-relief from the tomb of Djehutihotep depicts the transport of the colossal statue of this ruler of Hermopolis (Fig.8). It was produced about 800 years after the construction of the Great Pyramid, yet it is used as evidence to support the traditional theory of pyramid construction.

The colossus no longer exists, but it stood 6.50 meters (21.32 feet) high and weighed about sixty tons according to what can be determined from inscriptions. The bas-relief depicts the colossus being hauled on a sledge to which it was solidly attached with thick cords. Protective bands can be seen under cables at the corners of the statue. In four lines, 172 men are pulling the colossus. Three workers carrying a liquid, presumably water, are shown. A worker is pouring the liquid in front of the sledge to ease its movement over the surface of Nile silt. Adams remarked about the bas-relief [28]:

> " The existence of a document of this order (and there exist others both in Egypt and Mesopotamia) allows us to throw into the wastepaper basket, without hesitation, all of the fantastic propositions too often made about the transport of the ancient Egyptian megaliths. "

Is this method applicable for constructing the Great Pyramid? We know that sixty tons can easily be hauled over a flat terrain. An experiment carried out by Henri Chevrier, a French architect, showed that 25 kilograms (55 pounds) of force are exerted to pull 150 kilograms (330 pounds), indicating that 400 men were required to pull the colossus (60 tons or 132,000 pounds divided by 330 pounds). In other words, each man would be required to pull only one-sixth of the load (150/25 = 6). Using the system for an average six-ton block from the Great Pyramid on flat ground would require only forty men. But the same operation on a ramp would be

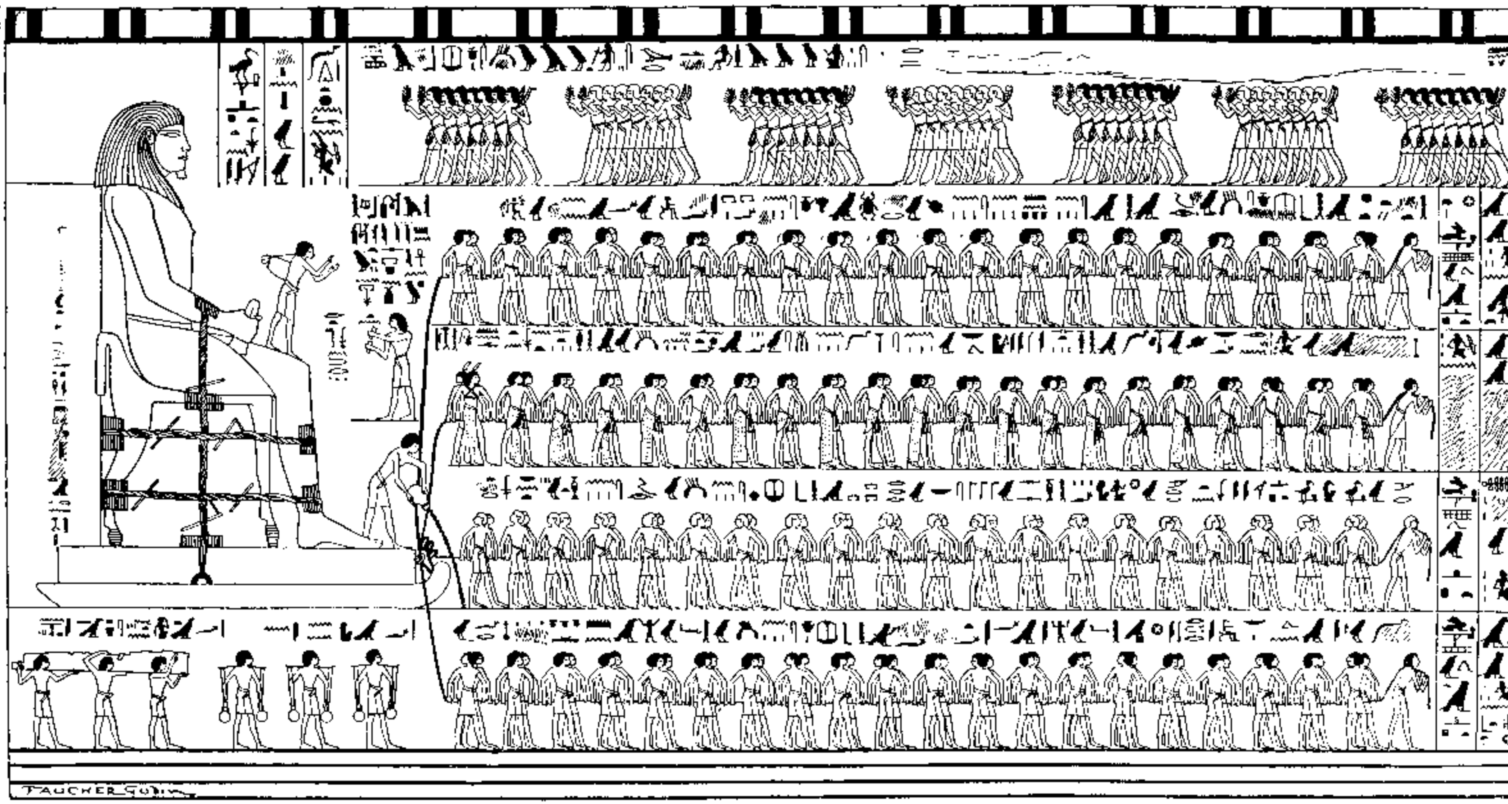


Figure 8: Detail from tomb of Djehutihotep depicts transport of a colossal statue (Faucher Godin).

extremely complex.

The noted French Egyptologist Jean-Philippe Lauer suggests that inclined ramps of 3:1 and 4:1 were used. If this were the case, from 140 to 200 men would have been required to raise one block, and the operation was presumably conducted with men pushing and hoisting the blocks as high as the 450-foot summit of the Great Pyramid. How does this comply with the number of blocks which would have to have been set per day?

According to Herodotus's account, 2.6 million blocks were transported to the foot of the Great Pyramid during a twenty-year period, which is the approximate length of Khufu's (Kheops or Cheops) reign. The number of blocks moved per year would have been 130,000. This means that an average of 1,400 blocks would have been hauled per day. This would have required 250,000 men making one journey per day, if we allow for a 150-man team per block (1,400 x 150). If the team made two journeys per day, 105,000 men would have been required. Four journeys per day per team would required 52,500 men working together at one time. Yet, it would have been impossible to get the job done. This enormous number of men would have been squeezed together shoulder to shoulder at the work site, an area about the size of a large sports arena.

3. The Clay Ramps

The principle of this wet-silt track could not apply to ramps for pyramid construction. It would create a ridiculous scenario, 52,500 men working in an area the size of a sports complex, with many treading and sliding in mud while hazardously maneuvering extremely heavy blocks at great heights.

This is not to say that ramps were never used at all. Because pulleys were not known in Egypt until Roman times, the only option archaeological evidence provides for raising blocks is ramps. For the Great Pyramid, it is estimated that any straight-slope ramp would have been a mile long, containing an enormous amount of material. Its great breadth and length would have covered the quarry. Helicoidal ramps have been suggested, but many Egyptologists offer several well-founded arguments against their actual use, including the fact that no wrap-around ramp has ever been found.

At Saqqara, a mud ramp was found *in situ* at the pyramid usually attributed to Pharaoh Semkhemkhet of the Third Dynasty but this small pyramid is not composed of large blocks. Carrying small blocks up a ramp was the most sensible and obvious way of producing this type of pyramid, affording a scenario very different from the one just described. Whereas there are remains of ramps at Giza, the tremendous amount of material called for by the standard theory does not exist, and while it might be expected that an earthen material would degrade, a small amount of remains nevertheless suggests the use of small ramps of the size useful for climbing the pyramids.

It has been proposed that pyramid blocks were hauled on sledges with wooden rollers attached. No evidence exists to support this hypothesis. The wheel was introduced as a transportation means by the Hyksos when they brought chariots to Egypt during their takeover at the end of the Middle Kingdom. The oldest surviving document implying the use of the wheel for hauling stone is a bas-relief from the palace of Sennacherib at Nineveh, now in the British Museum. It dates to 750 BC or 2,000 years after the Great Pyramid was built. The Great Pyramid, the most impressive monument of the ancient world, was built before the introduction of the wheel as a means of transportation.

4. The Tura Stele

A stele discovered in the Tura quarries is attributed to the Eighteenth Dynasty pharaoh Amosis (1580-1558 BC) [29]. The stele itself disappeared during the nineteenth century, and only a sketch remains (Fig.9). The sketch shows a stone block placed on a sledge being pulled by oxen. Although the wheel had been introduced in Egypt by this time, this bas-relief indicates that it was still not being used for hauling stone.

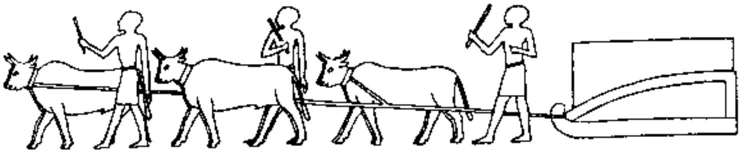


Figure 9: Tura detail adapted from Vize-Perring

Pharaoh Amosis opened the Tura quarries to obtain soft stone for the temple of the god Ptah of Memphis. The Tura stele is not acceptable as evidence to support the traditional theory of pyramid construction because it was produced almost 1,000 years after the Great Pyramid was built.

The Tura stele and the other documents used to support the traditional theory are the product of a society fostering different technology from that of its ancestors. Any long and successful civilization is bound to have emerging and declining technologies. Although archaeologists refrain from wild conjecture, there are vague admissions that some advanced technique was known to the builders of the Great Pyramids. According to Edwards [30]:

> “ Cheops (Khufu), who may have been a megalomaniac, could never, during a reign of about twenty-three years, have erected a building of the size and durability of the Great Pyramid if technical advances had not enabled his masons to handle stones of very considerable weight and dimensions. ”

Edwards implies that a clever method was used, but historians, with few exceptions, view ancient civilizations as though they were technologically inferior to our own in every respect. Many factors contributed to the general destruction of Egyptian technological information. During periods of anarchy, the Egyptians destroyed much of it themselves, and, too, Egypt suffered invasion by the Ethiopians, Assyrians, Persians, Romans, Nubians, and Mohammedans. The information lost when fire completely destroyed the great library of Alexandria by the end of the third century was also devastating. The Mohammedans viewed Egypt's wondrous architectural achievements as deeds of the devil and exploited blocks for their own buildings, ravaging tombs in search of treasure wherever possible. The Napoleonic expedition inspired a frenzy of interest by antique dealers, and many precious artifacts were removed during the 1800s. An untold number of relics were damaged or destroyed during their exploits as gunpowder and battering rams were used to open tombs. Numerous written records became rubble and statues were fragmented, their remains divided among different museums.

All contribute to the fact that scientific knowledge has not been transmitted flawlessly from antiquity to our time. One has only to read Herodotus's *Melpomene* to realize that it was proved long before this historian's time that the earth is round. Yet this fact had to be painstakingly rediscovered in more modern times.

A modern superiority complex prevails in scholarly literature despite the weight of evidence of a great forgotten technology used for pyramid construction. This ancient science is explored in the coming chapters and highlights the technological differences between the Old and New Kingdoms.

5. The Bas-Relief of Rekhmire

The wall paintings in the New Kingdom tomb of the official Rekhmire (1400 BC) are famous for their illustrations of the period's technology One painting shows blocks being carved with bronze tools. This painting was produced 1,300 years after the construction of the Great Pyramid, and, therefore, is not relevant.

6. The Bas-Relief of Unas

A bas-relief on the wall of the causeway approaching the pyramid of pharaoh Unas (2356 - 2323 BC) of the Fifth Dynasty is the last of the false proofs. The bas-relief depicts the fact that Unas dismantled a temple in the pyramid complex of this predecessor, Djedkara-Isesi, and reused the blocks for his own pyramid. The has-relief shows a boat transporting huge temple columns along the Nile River to the Unas pyramid complex (Fig.10). About two miles separate the two pyramids. I observed these columns among the ruins. Instead of being monolithic as depicted in the bas-relief, they consist of units held together by tongue and groove joints, and the units weigh no more than a half-ton each.

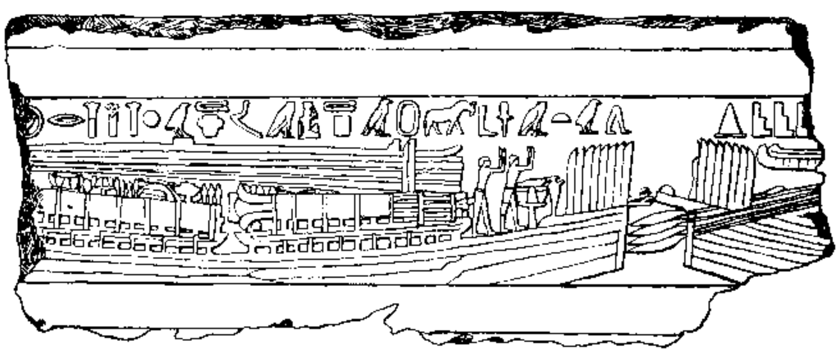


Figure 10: A bas-relief engraved on wall of causeway of the pyramid of Unas dates to about 2350 BC, adapted from J.P. Lauer.

This bas-relief is used to make a sweeping generalization about pyramid construction. It is used to explain that casing blocks were transported from across the Nile and that granite blocks came from 400 miles downstream from Aswan. It will become clear that this bas-relief was made during a period which was critical for the technology used to build the Great Pyramids. The fact that Unas reused pyramid blocks has nothing to do with how those blocks were originally produced and placed in Djedkara-Isesi's pyramid. The false proofs of Egyptology will soon appear as transparent as Egyptian royal linen.

Egyptian history is viewed by scholars mostly from a New Kingdom-Theban perspective as a result of the numerous documents that have survived from the New Kingdom capital of Thebes. The more ancient capital of Memphis has not been excavated effectively, limiting information about the most important urban center of the ancient world before the prominence of Thebes.

Scholars have sufficient information only to speculate about the culture of the Pyramid Age. Scientific data and archaeological evidence can be compared to empty urns into which scholars pour the elixir of their own theories, attitudes, and beliefs. Although an interpretation of test results and data may be required, scientists and historians have the responsibility of maintaining a critical spirit when encountering irreconcilable flaws of theory. Certainly, the lingering problems associated with the construction of the Great Pyramids and other incredible ancient feats of engineering are too great to ignore. In recent years the enigmas have given rise to fantastic theories. Adams commented on some of the most popular [31]:

> " On the chronology of monumental art one sees, throughout the planet, that the first examples of architecture are often megalithic edifices, or even isolated megaliths. Then, with the appearance of iron, this megalithism disappears suddenly with few exceptions.... The occultists conclude from this that in bygone epochs, a mysterious knowledge based on a very advanced science, but known only to a few initiates, allowed the extraction, transport, and placement of huge stones. Generally, such propositions are accompanied by a notorious "aging" of the edifice under consideration. Sometimes the

> Atlanteans and their teaching tradition are of definitive help, but the most effective aid in all circumstances is extraterrestrial….Another proposition, or even affirmation, has recently been added to the others: it is the simplest, the most naive, and also the oldest: giants. ”

Though these various theories are amusing and intriguing, they offer no definitive solution. The secret science speculated upon is never specifically identified, and baffling ultramodern technology, such as antigravity machines and antediluvian Atlantian crystal generators, never address all of the anomalies we have explored. The fantasy theories are based on conjecture as opposed to actual archaeological evidence, and both the fanciful and traditional theories will continue to thrive until the actual solution being presented here is firmly established. Let us now explore Egypt's fabulous Stone Age science used to build the Great Pyramids-lost but now recovered.

Chapter 5

The Solution

The great pyramids reflect a technology of the ancient world that yielded a sophisticated product or result but has no relationship to what we think of today as advanced or high technology. To visit the Pyramid Age would be to enter a world in which our objective, secular view of science does not exist. Anciently in Egypt, science and religion were part of one body of knowledge, and the priests were responsible for fostering and preserving that knowledge. Particular arts and sciences were attributed to particular gods. Ptah was the god of craftsmen, and Khnum, the Divine Potter, was a god worshipped by the pharaohs of the Pyramid Age. As will be further discussed, it was Khnum to whom the technology in question was attributed. Thoth was the god of writing, and the knowledge of Khnum was written in the Books of Thoth.

We know that the ancient priest-scientists of Heliopolis fostered the sciences of engineering, mathematics, and astronomy, and that all played a role in pyramid construction, but the science most germane to pyramid construction is overlooked. The mystery science has nothing to do with the classical physics of electricity, heat, optics, or mechanics, or anything in common with quantum physics-atomic, nuclear, or solid state. The science that made pyramids possible was chemistry or, more precisely, its forerunner, alchemy. Just how were stone monuments built with ancient chemistry?

Alchemy evokes images of medieval pursuits in mysticism and magic. Old alchemical notebooks depict vain searches for the ever-illusive Philosopher's Stone, reputed to be empowered to transform base metals into gold and provide an elixir of eternal youth. As will be discussed, the legendary Philosopher's Stone represents the last misinterpreted vestiges of the alchemical science that flourished during the Pyramid Age and was known in Egypt more than 6,000 years ago.

When the Egyptian alchemists developed glassmaking during the New Kingdom, it was to carry on the old religious tradition of making synthetic stones. This age-old tradition reveals the very heart of the remarkable alchemical invention central to the riddle of pyramid construction: the priests of Khnum had long been adept at the art of making extraordinary cements. Cement found in various parts of the courses of the Great Pyramid is about 4,500 years old, yet it is still in good condition. This ancient mortar is far superior to cements used in construction today. The modern Portland cement used to repair ancient Egyptian monuments has cracked and degraded after only about fifty years (see Chapter 8, The Proof at Giza, Fig. 26).

If the ancient Egyptians had the ability to produce exceptionally high-quality cement, what prevented them from adding natural aggregates such as fossil shells to their cement to produce high-quality limestone concrete? The answer is that nothing prevented them. I will demonstrate that the pyramid blocks are not hewn stone; the blocks are actually high-quality reconstituted limestone cast directly in place.

The blocks consist of about:

- ninety to ninety-five percent natural limestone rubble (fossil shells),
- and five to ten percent geological glue (geopolymeric cement).

They are re-agglomerated natural limestone, made in the age-old religious tradition of alchemical stonemaking. No stone cutting or heavy hauling or hoisting was ever required for pyramid construction. This type of fossil-shell limestone concrete would have been cast or packed into molds. Egyptian workmen went to outcrops of relatively soft limestone, disaggregated it with water, then mixed the muddy limestone (including the fossil-shells) with lime and zeolite-forming materials such as kaolin clay, silt, and the Egyptian salt natron (sodium carbonate). The limestone mud was carried up by the bucketful and then poured, packed or rammed into molds (made of wood, stone, clay or brick) placed on the pyramid sides. This re-agglomerated limestone, bonded by geochemical reaction, thus hardened into resistant blocks.

Advanced technology plays no part in the alchemical stonemaking. This is the most basic prerequisite if the theory is to be feasible. An individual of the Stone Age could produce re-agglomerated stone if they astutely applied the knowledge that comes from intelligent, repeated observation and experimentation with substances found in the environment. Only theoretical knowledge about mineral elements, how to distinguish them and how they can be chemically manipulated, must be acquired.

Although medieval alchemy was accompanied by esoteric teachings, because it derived from an era that united science and religion, technically, alchemy encompasses historical chemical developments. The word alchemy is the source of the modern word chemistry, the latter appearing about 250 years ago. There were great alchemical achievements during antiquity.

One can appreciate the ingenuity of the researchers of antiquity who first extracted copper from an ore of malachite, malachite having no metallic appearance whatsoever. This great alchemical discovery elevated Stone Age man to the Chalcolithic period. For some time historians thought that the melting point of copper, 1,083°C [1,981°F], was reached with great difficulty by using a hand bellows. Then it became apparent that the task was probably accomplished in an easier way, through chemistry.

Temperatures can be raised with energy released during exothermic (heat-producing) chemical reactions. Copper and lead are commonly located in close proximity, and lead played a fundamental role in primeval copper extraction. Lead can be oxidized easily with the aid of a hand bellows. A mixture of copper ore (malachite) and lead ore (galena) heated in a hearth to only 700°C (1,290°F) automatically reaches a temperature, through a heat-producing chemical reaction, that is close to that required for extracting copper. The addition of a flux, which in Egypt was a native salt called natron (sodium carbonate), lowered the fusion point sufficiently for copper extraction. Silver can be smelted similarly.

Egyptian alchemists developed vibrant blue enamel in pre-historic times at about 3800 BC. The discovery was a by-product of copper smelting. Appendix I discusses the fact that, contrary to popular belief, enamel production was no accident. Instead, an experimenter mixed a powder of chrysocolla with natron and applied a flame. The result was hard, glossy blue enamel that was then melted and applied to beads and pebbles.

The ancient Egyptians are well known for using minerals such as chrysocolla and lapis lazuli to produce enamels, which for them were imitations of these minerals or stones. They had a word for such products: *ari-kat*, meaning man-made or synthetic (see Chapter 11, It is written in Hieroglyphs). They sought to imitate stones because the highest spiritual influence was attributed to stone. The early priests learned to identify rocks and minerals and classified them according to the spiritual beliefs. In Egyptian mythology carnelian and other red stones represented the blood of Isis, a goddess of fertility. Lapis lazuli was associated with daybreak. Chrysocolla was associated with what was called the " First Time " event of Creation. It is not surprising to find that minerals and rocks had divine properties in a world where all of nature was revered.

All available stones, both nonprecious and semiprecious, possessed sacred, eternal qualities. It must have been known from ancestral lore that even though all living things perish, even trees, the imposing rocks and cliffs stood eternally. Almost everything was depicted symbolically and stone was symbolic of the eternal realm. Knowing this, one can understand why stone materials were devoted exclusively to religious monuments and sacred funerary paraphernalia. These were intended to survive for eternity, whereas earthly dwellings, even royal palaces, were composed of perishable sun-dried mud brick that needed to last only a lifetime.

So that there will be no doubt about what gives me the authority to make this rather astounding claim, I will explain my background as it relates to this research. I am a research scientist specializing in low-temperature mineral synthesis and geosynthesis. In 1972 I founded the private research company CORDI (Coordination and Development of Innovation), and, in 1979, the Geopolymer Institute, both based in France. At the Geopolymer Institute I founded a new branch of chemistry that I named geopolymerization for polymerization resulting from geosynthesis and applied geology. Since 1972, my partners and myself have filed several dozen international patents for geopolymeric products and processes. My products are made in the United States and Europe by large manufacturers. The products have many diverse applications (see more details in the Geopolymer Institute Internet WEB site) [32].

Geopolymeric products range from advanced materials to simple, yet highly sophisticated cements. The geopolymeric cements are made with inorganic chemical reactions involving clays and silicates in which alumina and silica materials are integrated to form synthetic zeolites, secondary rock-forming minerals. There is no way of distinguishing a synthetic zeolite from a natural one. And geopolymeric cements are chemically comparable to the natural cements that bind such stones as sandstone, puddingstone, and also fossil-shell limestone, the later being the main material constituting the pyramids blocks.

Geopolymers are revolutionary for the concrete industry. Any type of rock aggregate can be used, and concrete made with the geopolymeric binder is practically indistinguishable from natural stone. Geologists unfamiliar with the technical possibilities afforded by geopolymerization have scrutinized geopolymeric concrete and have mistaken it for hewn stone. Geologists do not recognize any geopolymeric stone because their method of analysis is based on investigating the bulk of the crystalline materials. They generally classify the 5-10% by weight of geopolymer as being impurities! Only modern methods of analysis, not used by geologists but developed by chemists, provide insight into the geopolymer matrix. This is unprecedented technology; no tremendous heat or pressure is required to produce this synthetic stone. Geopolymeric concrete sets rapidly at room temperatures to form synthetic stone, beautiful in appearance and abundant with unprecedented properties. Archaeologists and egyptologists misunderstood the meaning of synthetic stone when it was brought up to their attention. Partial critique of the concrete (cast-stone) theory made by egyptologists generally reads as follows: " ... Davidovits argues that geopolymer (ie. synthetic stone) would explain how the Egyptians were able to move and shape stone. But I don't believe he has ever said or proved that Giza stone really is geopolymer. In fact, the limestone blocks at Giza have intact fossil remains, which proves that they are not synthetic stone or geopolymers but are natural stone… " This sentence shows how hard and frustrating it is to bring new ideas to the archaeological community. I presented several lectures at international archaeological and egyptological conferences, had papers published in scientific, technical and archaeological journals, in vain! The reader will find some important references to my scientific work in Chapter 7, The Hard Scientific Proof, as well as in Appendix II, The Circuit at Giza.

In 1988, the American egyptologist Mark Lehner used this very same argument to convince American TV producer NOVA that the cast-stone theory is bunk. Even as late as the filming of " This Old Pyramid " in 1991-1992 when Lehner and his colleagues on the NOVA staff were busily trying to discredit the cast-stone theory, they still did not understand the basis of the theory. Their lack of knowledge is demonstrated by the fact that when I went to the Giza quarry to examine the limestone samples I wanted to show in the film, I was driven to the spot by one of Lehner's assistants.

This assistant turned to me as we were driving along and said: " We know you are wrong. " I replied by saying something like, " Oh really? I have researched and studied for over 20 years and you know I am wrong. How is that? " The assistant said " Because there are fossil shells in the pyramid blocks, just as there are fossil shells in the quarries. " I replied by saying something like; " Well, where do you think the aggregates (fossil shells) for the pyramid-concrete-blocks came from, the Moon? No, the shells came from the quarries. " The assistant's eyes opened wide and he said nothing. The fossil shells would remain intact for the most part but would be jumbled in pyramids blocks (see Chapter 7, The Hard Scientific Proof, Fig. 15). Why would the pyramid builders make more work for themselves by crushing them?

To develop a new branch of chemistry is one thing, but to apply that chemistry to ancient history is quite another. How did I learn that the pyramid stone is also geopolymeric? Any theory must be feasible; then, there must be evidence; and ultimately, hard scientific proof is required. All mysteries associated with pyramid construction must be resolved.

I found that some suitable ingredients were available in quantities of millions of tons. The natron salt, which contains mainly sodium carbonate, is extraordinarily abundant in the deserts and salt lakes. Natron reacts with lime and water to produce caustic soda, the main ingredient for alchemically making stone.

Natron was a sacred product used not only for flux, but also for mummification and deification rites. The following excerpts from the Pyramid Texts, found on the walls of the burial chamber of the Fifth Dynasty pyramid of Unas, show the sacred value of natron:

> Thou purifiest thyself, Horus is purified: One pastil of natron
>
> Thou purifiest thyself, Seth is purified: One pastil of natron

> Thou purifiest thyself; Thoth is purified: One pastil of natron
> Thou purifiest thyself; God is purified: One pastil of natron
> Thou purifiest thyself; that thou rest thyself among them: One pastil of natron
> Thy mouth is like that of the milk calf on the day of his birth: Five pastils of natron from the north, at Stpt.

The mouth of the newborn milk calf was considered to be clean because the calf had never eaten; and Stpt, a place where natron was gathered, is now called Wadi el-Natron.

Many of the same elements applicable for alchemical stone-making later played a role in glassmaking. By studying the ecology and the ancient products and documents of the Egyptians, I was able to trace the basic alchemical inventions that led to the development of the pyramid stone. These inventions are discussed chronologically in details in Appendix 1. An abundance of lime would have been available by calcining limestone in simple hearths. In ancient times, the Sinai mines were rich in deposits of turquoise and chrysocolla, needed for the production of synthetic zeolites. The mines also contained the arsenic minerals of olivenite and scorodite, needed to produce rapid setting and hardening.

But most important, Giza's geological limestone would have provided the bulk of the materials. The ancient Egyptians found at Giza a limestone that was soft (not hard), easily quarried (not hewn) and disaggregated (not crushed) into loose aggregates and was rehardened (reconstituted) in large concrete blocks. Yet, above all, this particular limestone had to contain a certain amount of natural reactive geopolymeric ingredient, such as clay, needed for the in-situ fabrication of geopolymeric cement. The uniqueness of Giza's geology is exemplified by the deteriorating body of the Sphinx, in opposition to its hard and unweathered head. A general overview of the limestone geology at Giza is described in some details in the following Chapter 6, The Feasibility of the Theory, and also in Appendix II: the Circuit at Giza.

A fascinating view of the pyramids never imagined in modern times emerges. These alchemical discoveries address an exotic facet of pyramid construction. Next, we will explore feasibility.

Chapter 6

The Feasibility of the Theory

Through chemistry the task of pyramid construction was easily accomplished with the tools of the Pyramid Age. With no carving or block hoisting required, the implements needed were simply those used to lay sun-dried mud bricks: a hoe to scrape up fossil-shell limestone, a basket to transport ingredients, a trough in which to prepare reactants, a ladder, a square, a plumb line, a level, a builder's trowel, and wooden molds (Fig.11).

These tools were found in the Sixth Dynasty pyramid of Pharaoh Pepi II. Because the molds found are only small scale models, there is no way of determining whether or not they were intended for mud bricks or large stone blocks. Pepi II's pyramid was made of both.

Whereas the precision cutting of about 2.5 million nummulitic limestone blocks for the Great Pyramid with copper tools would be a formidable chore, copper implements

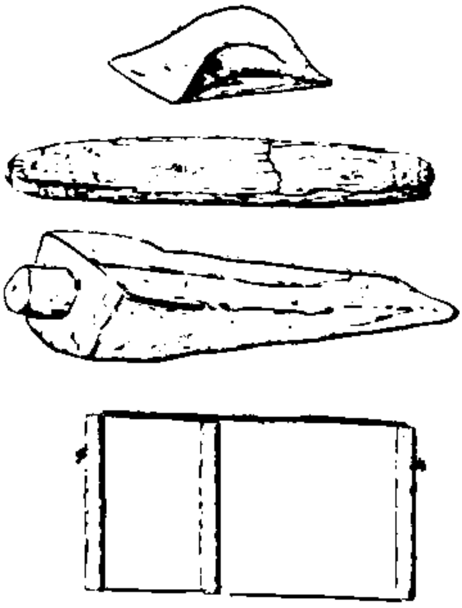


Figure 11: Implements of Sixth Dynasty are typical of Old Kingdom tools.

are quite suitable for sawing and planing tree trunks into planks for molds. The ancient Egyptians excelled in carpentry and were the inventors of plywood. According to the Dictionaire des Techniques Archéologiques [33]:

> " Carpentry appeared in Egypt at the end of the pre-Dynastic period, around 3500 BC, when copper tools were sufficiently developed to enable them to be used in woodworking. Throughout all epochs, the Egyptian carpenter was a remarkable craftsman. He invented all manners of preparing wood joints and made them with skill: doweling, mortises and tenons, dovetails, gluing, veneering, and marquetry. Wood being scarce in his country, he was the inventor of plywood. In a sarcophagus made during the Third Dynasty [around 2650 BC] there was actually a fragment of plywood found which was made from six layers of wood, each about four millimeters (0.15 inch) thick, held together by small flat rectangular tenons and tiny round dowels. Where two pieces had to be joined side-by-side, their edges were chamfered so as to unite exactly.

The grain direction in successive layers is alternated, as in modern plywood, to provide greater strength and to avoid warping. "

As early as the First Dynasty (3200 BC), carpenters assembled planks with perfect right angles. They made round dowels of ivory or wood. The flat rectangular wooden dowel appeared during the Fourth Dynasty. A wall painting from this period illustrates the use of copper saws and the preparation of mortises and tenons using copper chisels (Fig.12). The exquisite furniture placed in the tomb of Pharaoh Khufu's (Kheops or Cheops) mother, Queen Hetepheres, exemplifies how cleverly carpenters prepared dovetails and mortises and tenons. The magnificent funerary boat of Khufu (Kheops or Cheops), mentioned earlier, is another example of remarkable craftsmanship.

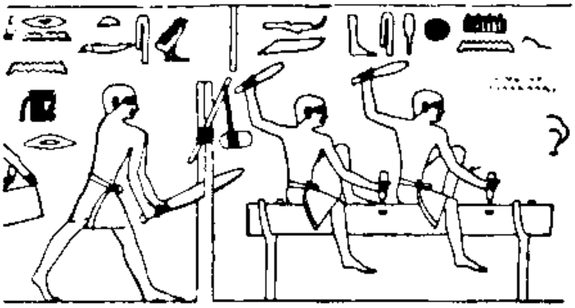


Figure 12: Mastaba from the tomb of Ti, about 2550 B.C., shows carpenters sawing planks and preparing mortises.

The Palermo Stone, fragmentary remains of royal annals, indicates that Sneferu, of the Fourth Dynasty assigned a fleet of ships to import cedar from Lebanon. The trees of Egypt are not hardwood and do not yield planks of the appropriate dimensions for molds. Egypt began to import cypress, cedar and juniper from Lebanon as early as the pre-dynastic epoch. One variety of juniper reaches a height of 20 meters (21.8 yards), excellent for making molds which must measure from 1 to 1.5 meters (1.09 to 1.64 yards) wide.

Once set up, the molds were waterproofed from the inside with a thick layer of the cement itself. The cement became part of the block and can be seen at the bottom of blocks in the Great Pyramid. Wooden braces were suitable for stabilizing packed molds. Oil makes a suitable mold release, and Herodotus reported that the builders of the Great Pyramid smelled of rancid oil.

Because hard wood was so scarce, the remains of large wooden molds no longer exist. There is, however, a bas-relief that may depict a large stone block being cast. Wall paintings from the tomb of the Eighteenth Dynasty official Rekhmire (1400 BC), are precise illustrations of the technology of the New Kingdom. Although alchemical stonemaking is primarily Old Kingdom technology, we shall learn in later chapters how it was used during the New Kingdom on a smaller scale.

The molds would have been easily disassembled so that one or more faces of a block could be used as a partial mold for casting the next block, producing the close fit. One of the characteristics of geopolymeric concrete is that there is no appreciable shrinkage, and blocks do not fuse when cast directly against each other. Although it would have been impossible to achieve the close fit (as close as 0.002 inch) of the 113,000 casing stones originally on the Great Pyramid with primitive tools, such joints are easily achieved when casting geopolymeric concrete.

Once cast (probably rammed with a pestle), within hours or even less, depending on the formula and ambient temperature (minutes using today's formulas), a block hardened. The mold was removed for re-use while a block was still relatively soft. A covering of reeds or palm leaves was probably applied to the blocks, affording an optimum amount of ventilation. This was required to harden (carbonate) the lime and protect the blocks from becoming brittle from evaporation. When the covering was removed, the blocks continued to harden in the sunlight, the heat accelerating setting.

As statues and sarcophagi were produced, finishing touches would have been made with copper tools during the early stages of setting. I have observed marks on core masonry of the Great Pyramid unlike those made with a chisel. Some appear to be impressions made by reeds. I also noticed long, sweeping impressions that fan out exactly like a palm leaf. Using a microscope, I was clearly able to see wood-grain impressions on a sample from the ascending passageway of the Great Pyramid.

It would be impossible for such an enormous cement industry to have left no traces of its existence, but those traces would never be recognized by anyone unaware of this technology. The most obvious traces are the tremendous quantities of minerals excavated from the Sinai mines, blue minerals such as turquoise and chrysocolla, generically known as mafkat during the Old Kingdom (Fig.13). Egyptologists are well aware of the industrial quantities of mafkat mined in the Sinai, but they cannot account for its consumption in such enormous quantities.

The mining expeditions of the pharaohs correspond exactly with the construction of the pyramids. Pyramid-building pharaohs are depicted in large reliefs in the cliff faces at the Sinai mines, where they are shown protecting mineral deposits from invading bedouins. There is no doubt about what was sought. Expeditions led by the archaeologist Beno Rothenberg (1967-1972), demonstrate that mineral veins containing turquoise and chrysocolla had been primitively excavated, whereas veins of copper carbonate ore were left unexcavated [34].

The most basic product to any cement industry is lime

Figure 13: Fifth Dynasty stele on wall of Sinai mines shows the pharaoh Sahure symbolically smiting an intruder.

(CaO). To produce lime, limestone or dolomite was calcined in kilns. No distinction was made between limestone, dolomite, and magnesite, each a white stone yielding different limes and, therefore, different qualities of cement. It is well established archaeologically that the production of lime itself is the oldest industrial process of mankind, dating back at least 10,000 years. Lime mortar in the ruins of Jericho, in the Jordan valley is still intact after 9,000 years. Some wood and plant ashes contain a very high amount of lime (between 50 and 70 per cent by weight of CaO). These ashes could have been used for producing cements or mortars.

Herodotus reported that canals once connected the Great Pyramid to the Nile River. Egyptologists suggest that if these canals existed at the site, they were used to transport casing blocks from Tura, across the river. How would a canal serve the cement industry? A canal makes an ideal reaction basin for the on-site production of enormous quantities of cement.

I can envision two methods for the on-site production of the cement. One would entail placing suitable quantities of natron and lime (calcined limestone or plant ash) in a dry canal. Nile mud (Clay + silt) or the local *Tafla*, and water, could easily have been captured in the canal during the annual flood period. The water dissolved the natron and put the lime in suspension, forming caustic soda. Caustic soda reacted with the clay to produce a triple alumino-silicate of sodium, calcium, and magnesium. When the water evaporated, an activated substance would remain. The addition of siliceous minerals and another quantity of natron and lime produced a silico-aluminate, resulting in a basic geopolymeric cement. Other products were added, and, if necessary, the material could be stored. The resulting cement would have been used to agglomerate loose limestone rubbles and chunks, yielding reconstituted limestone blocks.

Another method is even easier and is possible due to the nature of the Giza limestone.

The Giza Plateau is an outcrop of the Middle Eocene Mokattam Formation (Fig. 14). A second outcrop of the Upper Eocene Maadi Formation borders the Pyramids Plateau on the South-South West. A large sandy wadi separates the Mokattam Formation from the Maadi Formation, created by the South-East dip of the Mokattam Formation (see on the general map of the Giza Plateau in Appendix 2). The North side of the wadi, or the southern line of the Mokattam

Formation outcrop, and the South side of the wadi, or the northern line of the Maadi Formation outcrop, where both Formations dip into the wadi, were extensively quarried during the erection of the Giza pyramids.

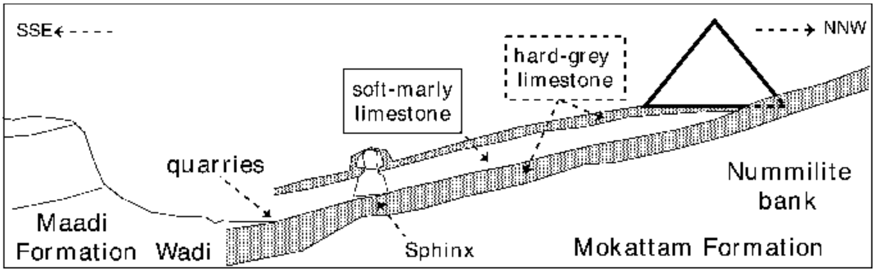


Figure 14: Simplified NNW-SSE cross-section of the Giza Plateau. The soft-marly limestone bed that was extensively quarried (Sphinx, Wadi quarries) is sandwiched between two hard-grey limestone beds.

According to the geologist Aigner [116] and the egyptologist Lehner [117], the original ground surface of the Mokattam Formation that constitutes the basement of the pyramids, is made of a very hard and massive limestone bank of the nummulite type. On the other hand, the outcrop that dips into the wadi, where the quarries are located, consists of softer thickly bedded nummulite layers (see in Fig. 14 the location of the quarries, and also the trench around the Sphinx) with a relative high amount of clay. Concurring to the traditional carving theory, Lehner states " ... the builders took advantage of the thickly bedded softer limestones of the south part of the Mokattam Formation, while founding the pyramids on the hard nummulite bank to the north…" [118]

Lehner postulates that the builders did not use the nearby hard limestone but favored the softer material. In other words, Lehner's remark suggests that quarrying and carving the hard Mokattam limestone would have required more labor than the transport of the softer material from the wadi upwards to the pyramid plateau. This raises the question that has not been tackled by egyptology so far, namely why did the Khufu (Kheops or Cheops), Khafra (Khefren or Chephren) and Menkure (Mykerinos) architects refrain from using the limestone located up hill, nearby on the west, taking advantage of the natural inclination of the plateau, and the ease of transport? Why did they select the limestone from the wadi edges, downhill, with the supplementary burden of having to carry the blocks to a 40-50 meter height upwards on long ramps, in opposition to traditional quarrying methods? In general, during antiquity, quarries where chosen because of the ease with which the blocks could be transported, downwards, from the top of the hill down to the valley. The Aswan granite quarries, the Silsilis sandstone quarries, south of Thebes, or even the Tourah quarries located on the opposite side of the Nile Valley, in front of the Giza Plateau, are typical examples for this theorem.

The agglomeration theory provides a good answer to this issue, namely:

a) - the hard limestone nearby the basement is not suitable for the production of agglomerated blocks because it does not disaggregate easily in water;

b) - on the other hand, the softer marly limestone of the wadi edges is a suitable raw material for agglomerated limestone blocks because part of it disaggregates in water, within a short period of time. The disaggregated muddy limestone (including the fossil-shells) would be further mixed with other limestone aggregates, lime and zeolite-forming materials such as kaolin clay, silt, and the Egyptian salt natron (sodium carbonate).

In October 1991, during the shooting of the TV production " This Old Pyramid " by NOVA, aired on the

American PBS network on September 1992, I had the opportunity to present this unique property of the Giza limestone. A chunk of limestone taken in the Wadi quarry and soaked in water was very easily disaggregated within 24 hours, leaving the nummulites and the clay gently separated from each other, whereas a chunk of the hard Mokattam limestone did not disintegrate at all (see for details in Appendix 2, the Giza Plateau Circuit).

The vast amount of limestone rubble required to make pyramid blocks was easily obtained. Water, probably brought as close as possible by canal, was used to flood the soft marly limestone of the Wadi quarries to saturate it for easy disaggregation. The body of the Great Sphinx was sculpted as muddy limestone rubble was scooped into baskets for use in pyramid blocks. Men wading in wet, muddy limestone while working in the desert heat makes more sense than men banging away at quarries in a hot, dusty desert, as called for by the accepted theory. By agglomerating stone, a better building material resulted because the blocks of the Great Pyramid are more strongly adhered than is the natural bedrock.

It is assumed that the head of the Sphinx was carved in an isolated knoll belonging to the upper weathering resistant hard-grey limestone Mokkatam layer. It brilliantly withstood 4,500 years of harsh weathering conditions. The Sphinx body is the remains of stone excavation in the softer marly layers (Fig. 15). It is assumed that the quarried stone material was used in the making of the Khafra (Khefren or Chephren) Valley Temple as well as for the Sphinx Temple. For certain experts, the strikingly obvious degradation of the Sphinx body would have resulted from " erosion due to rain and flooding ", i.e. disaggregation through water soaking. It has been subject to intensive restoration work during the last decades and also during Antiquity. Although it was for thousand years covered with sand and therefore protected against weathering, it underwent severe degradation. The differential water erosion has sculpted 7 sequences of projected and recessed layers. In order to explain what causes the degradation of the rock, L. Gauri made a thorough petrographic and chemical analysis of the six layers featured in Fig. 15. He measured the content of the water-soluble salts and of the non-carbonate clastic materials (clays, silt and sand). These elements - water-soluble salts plus clastic - are sensitive to water. They either become soluble (the salts) or expand when wet (the clay and the silt). I called them water-sensitive parts in Fig. 15. The amount of water-sensitive parts, expressed as weight percent of stone, is strikingly very high [127]. The soft marly limestone of the Sphinx body is widespread in the pharaonic Wadi quarries. A similar analysis

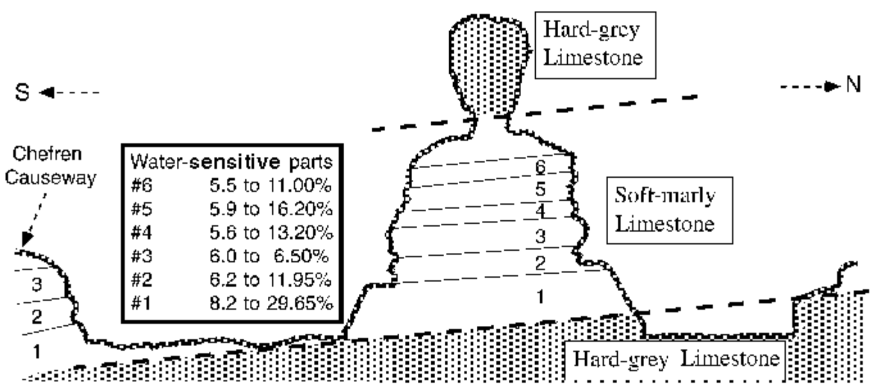


Figure 15: North-South vertical profile of the front of the Sphinx. Layers #1 to #6 analyzed by L. Gauri [127] and amount of water-sensitive parts (salt + clastic material) for each layer.

of the equivalent layers has not been carried out so far. However, it is reasonable to assume that these limestones do contain the same range of water-sensitive parts.

Today, civil engineers often use the ASTM D4843 Code to evaluate the water disaggregating long-term behavior of building materials. A procedure adapted from ASTM D4843 requires that the stone be soaked for 24 hours in water, then dried out at 60°C (140°F) for 23 hours, followed by a 1 hour rest at room temperature. If, after this first cycle, the stone or the concrete remains intact, it is subjected to a second and more cycles, until it disintegrates. The 60°C (140°F) drying temperature is relevant for temperatures reached during summer time in the quarries at Giza (in the sun).

Modern Geopolymeric concretes do not disintegrate even after more than 300 cycles. As for the soft natural marly limestone of the Sphinx body, I expect that only 1 to 3 cycles would be necessary. The ancient Egyptians could have installed soaking/reaction ponds at the bottom of the quarries. These ponds would have been flooded then followed by a drying period and flooded again, in order to achieve the appropriate disaggregation. Chunks that do not disintegrate easily (dependent on the water-sensitive parts amount) would be packed into the muddy limestone matrix.

The kaolinitic limestone requires only the addition of lime (calcined limestone or plant ash), natron, and water for a geopolymeric reaction to occur. The landscape is also scattered with considerable quantities of loose shells, camites, strombites, turbinites, helicites, and especially nummulites. In ancient times there were hills of loose shells at Giza. The Greek geographer Strabo (64 BC) observed them [35]:

> " We cannot allow ourselves to remain silent on one thing that we saw at the pyramids, namely, the heaps of small stone chips in front of these monuments. There we find pieces, which, from their shape and size, resemble lentils. Sometimes they even look like half-threshed seeds. It is claimed that they are the petrified remains of the food of the workers but this is most unlikely, for we too have a hill at home set in the middle of a plain which is filled with small calcareous tuffs similar to lentils. "

The more loose material naturally present, the less rubble excavation required. Loose material remaining at the site today is incorrectly assumed to be debris from stonecutting.

Agglomerating stone is far, far easier than cutting and hoisting massive blocks. To imagine the difficulty of building a pyramid by way of the accepted theory, one needs only to see how difficult it is to destroy even a small pyramid. It is much easier to destroy than to create almost anything, and Abd el-Latif (AD 1161-1231), a physician of Baghdad, described the difficulty encountered by a team that set out to destroy the Third Pyramid of Giza, which is only seven percent of the volume of the Great Pyramid [36]:

> " When Melic Alaziz Othman Ben Yussuf succeeded his father, he allowed himself to be persuaded by several persons of his court, people devoid of common sense, to demolish certain pyramids. They started with the red pyramid, which is the third of the Great Pyramids and the least considerable. The sultan sent his diggers, miners, and quarrymen, under the command of several of the principal officers and emirs of this court, and gave them the order to destroy it.
>
> To carry out their orders they set up a camp near the pyramid. There they assembled a large number of workers and housed them at great expense. They stayed for eight entire months with everyone doing his allotted task, removing, day after day with the expenditure of all his force, one or two stones. Some would push from the top with wedges and levers while others pulled from the bottom with cords and ropes. When one of the stones eventually fell it made an appalling noise, which could be heard from a great distance and shook the ground and made the mountains tremble.
>
> In falling, it became embedded in the sand and pulling it out required great effort. They forced in wedges, thus splitting the stones into several pieces, then they loaded each piece onto a chariot and pulled it on foot to the mountain a short distance away where it was discarded.

After having camped for a long time and using all of their money and strength, their resolution and courage diminished daily. They were shamefully obliged to abandon their work. Far from obtaining the success for which they had hoped, all that they did was damage the pyramid and demonstrate their weakness and lack of power. This occurred in the year 593 [AD 1196]. Today, if one looks at the stones that were discarded, one has the impression that the pyramid must have been completely destroyed. But if one glances at the pyramid itself, one sees that it has undergone no degradation and that on just one side part of the casing stone has become detached. ”

Table 1. Number of Carriers Required to Built the Great Pyramid (2.6 Million Blocks)

Construction Period	**Four Blocks/ Day Carrier**	**Two Blocks/ Day Carrier**	**One Block/ Day Carrier**
Twenty Years			
300 days/year	196	392	784
200 days/year	294	588	1,176
100 days/year	588	1,176	2,352
Fifteen Years			
300 days/year	260	520	1,040
200 years/day	392	784	1,568
100 days/year	784	1,568	3,136
Ten Years			
300 days/year	392	784	1,568
200 days/year	588	1,176	2,352
100 days/year	1,176	2,352	4,704

Casting pyramid blocks in situ greatly simplified matters of logistics, enabling the construction of the Great Pyramid without doubling or tripling the life span of the pharaohs. Instead of 100,000 workers per year at Giza as called for by the accepted theory, as few as 1,400 workers could carry enough material to build the Great Pyramid in twenty years based on the following calculation: In Cambodia, during the

Khmer revolution in 1976, men each carried about 3 cubic meters (3.9 cubic yards) per day to construct dams. One man, therefore, in one day can carry enough material to produce a block weighing from four to six tons. This would provide for 1,400 blocks set per day the number reported by Herodotus. The number of men required, of course, depended on how many days were worked, which might depend on how many religious holidays were celebrated (see for details in Table I).

Assuming that each man carried one basket per hour and worked about three months a year, or perhaps 100 days, the maximum number of carriers needed for a twenty-year period was 2,352, for fifteen years, 3,136 workers; and for ten years, 4,704 workers. Assuming that each excavator was attended by three carriers and one stone caster, then three carriers represented five men at work. This would place between 1,000 and 3,000 men on the work site during a three-month work period per year, or 400 to 1,000 during a ten-month-per-year work period, in order to complete the Great Pyramid in fifteen to twenty years.

Men could easily have carried one 22.5 kilogram (50-pound) basket every fifteen minutes to the base of the pyramid, one basket every thirty minutes to the middle, and one basket to the top of the pyramid on a ramp every hour. If a basket contained 0.3 cubic meter (0.039 cubic yard), then per day each man could have carried: one basket in fifteen minutes for a total of 1.42 cubic meters (1.87 cubic yards) or one basket every thirty minutes for a total of 0.71 cubic meter (0.94 cubic yard) or one basket per sixty minutes for a total of 0.36 cubic meter (0.47 cubic yard).

Additional workers were required for mining, transporting and crushing minerals, gathering natron, oil, wood, and other necessary products, preparing ingredients, digging canals, carrying water, making tools and molds, providing food and other personal needs, and performing miscellaneous chores. This might raise the total of men required by an additional few hundred. Total figures allow for freedom to maneuver at the work site and are considerably more reasonable than the 100,000 men per year at the site called for by the standard theory. The casting theory is quite feasible and easily settles problems of logistics.

The objections to my theory

In this chapter we focussed on the two different limestone outcrops of the Mokattam Formation: a hard grey superior bed on which the pyramids are founded, and a soft yellowish (with clay beds) where the pyramids core materials were extracted. Notwithstanding the basic and visible geological knowledge on the two different outcrops within very close range of the monuments, the American geologists Harrell and Penrod challenged the casting and packing theory. In a paper published in *Journal of Geological Education* in 1993, they state:

> " ...Our objection to the geopolymeric process [agglomerated stone process] has to do with disaggregating limestone by soaking it in water - it does not work! We soaked the Mokattam limestones whose composition is given in Table 1 for seven weeks and after this time the samples were just as hard and solid as the day we first immersed them.... " [134].

They never mentioned noticing any difference between the pyramid blocks and the hard Mokattam Formation that constitutes the surrounding plateau. Harrell and Penrod, who published on ancient Egyptian limestone quarries, ignored the presence of the two different outcrops. They relied only on the generic denomination of the Giza Pyramids bedrock, namely the name Mokattam Formation. Mokattam is the name of a Cairo suburb in the vicinity of the Citadel, made of hard limestone. The quarry at Gebel Mokattam supplies squared stones for the Cairo monuments. In the cited Table 1 of their publication, Harrell and Penrod provide the location of their tested samples, namely: Gebel Mokattam, Tura and Masera. There is no mention of any Giza sample.

For their demonstration, Harrell and Penrod deliberately took hard Mokattam limestone instead of the soft material from the wadi quarries or the Sphinx trench. In addition, the soaked sample did not come from the Giza Pyramids site at all. These ancient Egyptian quarries specialists ironically collected this piece of hard limestone from the modern quarry behind the Citadel on Gebel Mokattam, Cairo, 20 km (15 miles) east of the Giza Pyramids, on the other side of the Nile.

Other individuals who published statements against the cast and packing theory, made the same mistake than Harrell and Penrod did. For example, Moores states in a Letter to the Editors published in *Concrete International* [135]:

> " ...In October 1987 I was a member of the National Geographic sponsored team that non-destructively revealed the entombed second wooden ship of Khufu (Kheops or Cheops). I designed and operated the drilling system that obtained air samples and photographs of the pit interior [hard Mokattam Formation].... I have had a chunk of nummulitic limestone, that I personally detached from the Giza plateau, soaking in water for five months now, and it exhibits no change in hardness... "

Moores soaked in water a chunk of limestone for a long period of time, which he removed from the hard Mokattam Formation, near the Khufu (Kheops or Cheops) Pyramid base, not from the soft formation(wadi quarries or Sphinx trench), where it is agreed that the bulk of the stony material is coming from.

Two other American geologists, R. Folk and D. Campbell, vigorously challenged the theory essentially in publications that do not have the " Peer review " system and therefore were not edited, such as *Journal of Geological Education* or *The Epigraphic Society Occasional Papers* [126]. There are several statements made by Folk/Campbell in these papers that demonstrate their lack of knowledge on the geological uniqueness of the Giza Plateau. Yet, they wrote with arrogance:

> " …we feel it is the duty of professional geologist to expose this egregiously absurd archeological theory before it becomes part of entrenched pseudoscience… We believe that had Davidovits had any understanding of basic geologic principles and understood the implications of simple geological evidence at Giza, he would have realized that this geopolymer theory had no basis in fact.…We have also shown how geologic commonsense can destroy archaeological quackery, but not, unfortunately, before it has enjoyed widespread publicity among the gullible and sensation-minded.... The geopolymer theory is defunct; we still remain in awe of the enigma of Egyptian skill and engineering. "

They did not study the soft marly limestone bed and its peculiar property, at all:

> " … A fundamental and obvious objection to the geopolymer theory is that, had the Egyptians wanted to make " permastone ", why would they have gone to the excessive labor of crushing limestone and gluing back together when it would have been much easier to use the abundant, nearby, loose desert quartz sand that would have surely made a more homogeneous concrete… "

The theory never states that the limestone has to be crushed. It is obvious that Folk and Campbell did not understand the feasibility of the system based on water disaggregation. The use of sand would have required an astronomically high amount of artificial geopolymeric cement. The ancient Egyptians used this technique to manufacture their first artificial stone for statuettes 5,600 years ago. See for more details Appendix I, the *Alchemical Inventions*. The reason why it was not used for pyramid construction will become obvious in the next chapters.

Chapter 7

The Hard Scientific Proof

Though I am the first to apply this technology to the pyramid construction theory, another French chemist, Henry le Chatelier (1850 - 1936), was the first to discover that the ancient Egyptians produced man-made stone. Le Chatelier was also a metallurgist and ceramist. He worked with newly developed micrographic techniques, glass slides, thin section analysis, and photography in combination with the microscope. He was the first to examine enameled funerary statuettes from Egypt's Thinite epoch (c. 3000 BC) with these techniques and to see them as they had never been seen before [37].

As Le Chatelier studied enameled funerary statuettes, he found that his observation methods led him to notice that the enamel was not a coating applied to the surface of the statuettes. Instead, the enamel was the result of minerals which migrated from within the stone itself. He cut thin sections with a diamond-tipped saw and observed a gradually increasing concentration of minerals that had migrated to or near the surface of the stone to form enamel. The process is like that which occurs with Egyptian faience, a self-glazing ceramic. Le Chatelier was astonished to realize that the statuettes were man-made stone.

He and his colleagues tried in vain to duplicate the process. The method that produced the statuettes is one of my chemical discoveries discussed in Appendix 1. Le Chatelier's research took place in the early 1900s and his revelation should have raised debate about other stone artifacts, especially the pyramids with their numerous enigmatic features.

Academics, however, are not necessarily innovators. And scholars involved with the soft sciences, such as history, may not necessarily be scientifically minded. In fact, during my presentation at the Second International Congress of Egyptologists, I used le Chatelier's work to make the Egyptologists who were present aware that science had already shown that the Egyptians produced man-made stone. Acknowledging that, they were still unwilling to concede that the pyramid stone might be man-made.

It was not until some years after I devised my theory that I analyzed actual ancient geopolymer. In 1981, Liliane Courtois of the Center for Archaeological Research, in Paris, and I carried out an X-ray chemical analysis on fragments of lime vessels from Tel-Ramad, Syria, dating from 6000 BC. The vessels were made of a white stony lime material. In other words, they are classified as being made primarily of lime. We made a presentation at the Twenty-First International Symposium on Archaeometry, held at the Brookhaven National Laboratory in New York [38]. We reported that the samples contain up to forty-one percent of analcime (analcite), a zeolite that is easy to produce. This high amount of zeolitic material is not found in the raw material from which the vases were made and could only be the result of geopolymerization. The fact is that synthetic zeolites had been produced 8,000 years ago in the Middle East. In modern times they were first produced by an English scientist named Barrer in the 1950s.

Knowing that it would be impossible to prove my theory without samples of pyramid stone, in 1982 I made an appointment to visit Jean-Philippe Lauer at his home in Paris. Lauer, now over ninety years old, is eminent among European Egyptologists. He spent sixty years of his career restoring the pyramid of Zoser. He has his own conservative views on pyramid construction based on more than fifty years of study, and his attitude about my research is reserved. In a letter I received before I visited him, he said, " I defy you to prove that the pyramid stone is synthetic. "

That, of course, was my intent. During our visit, he gave me samples from the pyramids of Khufu (Kheops or Cheops) and Teti. The sample from Teti came from an outer casing block and the one from the Great Pyramid came from the ascending passageway (Fig.16). I had X-ray chemical analysis performed on the samples by two different laboratories to be sure that there would be no analytical discrepancies. I presented a paper on the test results at the International Congress of Egyptologists held that same year in Toronto [39]. The title of my conference was " *No more than 1,400 Workers to Build the Pyramid of Cheops (Khufu) with Man-Made Stone* ". At the congress, Lauer and I each made separate presentations about our theories of pyramid construction. Despite knowing that I was making a presentation using his samples, Lauer did not attend my presentation because he did not take my theory seriously. The Toronto Star newspaper covered the congress and published Lauer's following response to my research (September 7, 1982): " There are many

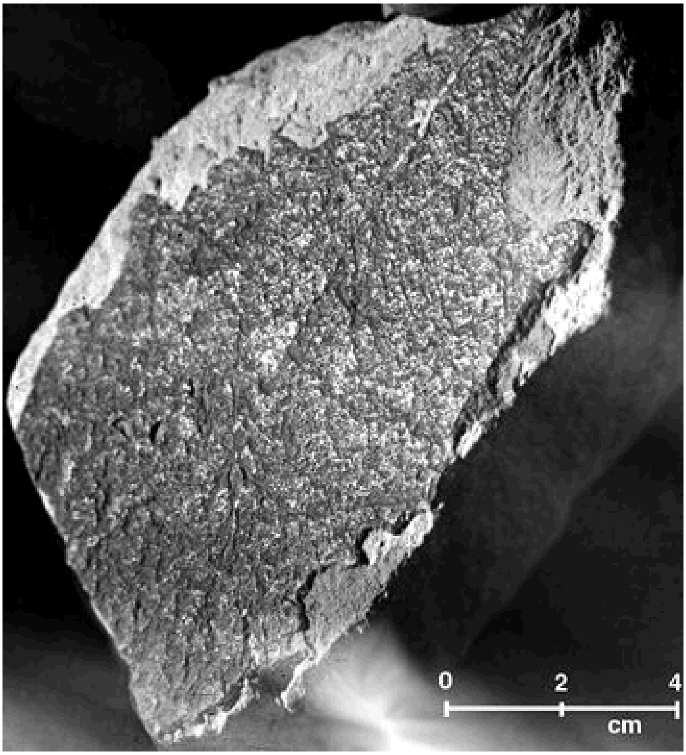


Figure 16: The Great Pyramid Lauer sample with coating.

ridiculous surveys, not stupid, but impossible. Not many are serious. "

X-ray chemical analysis detects bulk chemical composition. These tests undoubtedly show that Lauer's samples are man-made. The samples contain mineral elements highly uncommon in natural limestone, and these foreign minerals can take part in the production of a geopolymeric binder.

The sample from the Teti pyramid is lighter in density than the sample from Khufu's (Kheops or Cheops) pyramid (the Great Pyramid). The Teti sample is weak and extremely weathered, and it lacks one of the minerals found in the sample from the Great Pyramid. The samples contain some phosphate minerals, one of which was identified as brushite, which is thought to represent an organic material occurring in bird droppings, bone, and teeth, but it would be rare to find brushite in natural limestone.

The presence of such organic materials in the pyramid stone affords new possibilities for a better understanding of ancient culture. If bird droppings were a source of the brushite, this might explain a function of the large place known as Ostrich Farm, which was not far from Giza. It is well known that in ancient Egypt, bird droppings, urine, and animal dung were added to straw and mud to increase the cohesiveness of mud brick.

If bone were a source of brushite, this could shed new light on the mysterious sacrificial rites of antiquity. The sacred animals would have been slaughtered and burned on the sacrificial altars, their bones calcined to ashes. The ashes would have been powdered and used as an ingredient of the religious monument. The vestiges of this alchemical knowledge may have influenced customs and inspired mythology and legends of later times.

The pyramid samples also contain a mineral known as opal CT, a siliceous material. I had a debate about this with Michael S. Tite, Head of the Museum Laboratory at the British Museum. Tite was the coordinator of the Archaeometry '84 Symposium, held at the Smithsonian Institution in Washington, DC, in 1984. As coordinator, he had the advantage of prior review of my presentation. He took advantage of this and submitted a piece of a casing block exhibited at the British Museum to chemical analysis at the museum laboratory.

After my presentation titled " *Pyramids of Egypt Made of Man-Made Stone, Myth of Fact?* " [40], he arose and told the symposium, " All of the features that they [his analytical team] saw can be explained on the basis of natural origin, and there is really no need to introduce this hypothesis of reconstituted stone. " Like anyone unfamiliar with geopolymerization, Tite saw nothing unusual in the mineral composition.

Thanks to help from colleagues, especially Hisham Gaber, a geology graduate of Ain Shams University in Cairo, I obtained samples from the quarries of Tura and Mokkatam in the Arabian mountains, where it is believed that the casing blocks originated. Gaber collected more than thirty samples from various sites. We performed X-ray chemical analysis and X-ray diffraction on quarry stones and on pyramid stones. X-ray diffraction and microscopical analyses of the quarry samples indicates that they are pure calcite, sometimes containing a trace of dolomite. None of the quarry samples contains any of the unusual minerals found in the pyramid samples. If the casing stones were natural limestone, quarries different from those traditionally associated with the pyramid sites must be found, but where? This demonstrates that a complicated man-made geopolymeric system was produced in Egypt 4,700 years ago.

Thin sections made on pyramid stones of Khufu (Kheops or Cheops) and Teti show that they are light in density unlike the quarry samples which are uniformly dense. A thin section from Teti casing (Fig.17a) shows a natural nummulite imbedded in calcite surrounded with gaps in a very loose matrix. This could be agglomerated limestone. The thin sections for Tura/Mokkatam geological samples are quite different (Fig.17b). Their matrix is dense with no gap and no trapped air bubble. A problem of analysis, assuming that the Khufu (Kheops or Cheops) and Teti stones are made by agglomerating limestone using lime as a binder, is that lime hardens over a period of time and becomes recarbonated into calcium carbonate. It is impossible to distinguish a natural calcite microcrystal and a microcrystal of calcite which is the result of the recarbonation of lime. This is an obstacle involved in the detection of geopolymeric setting and new techniques must be developed to resolve it.

I met with Tite in London shortly thereafter to have a

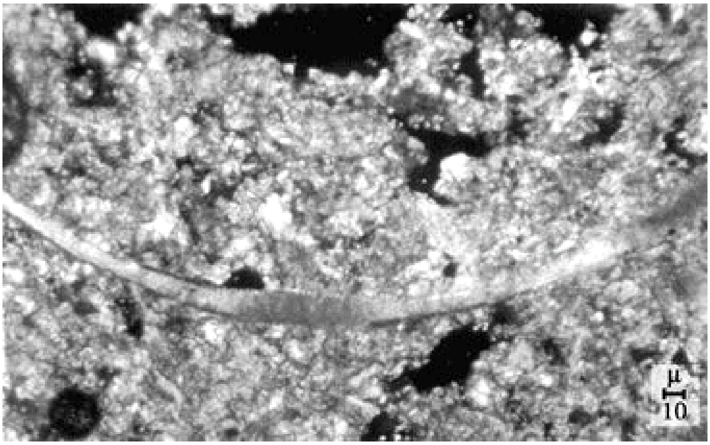


Figure 17a: Thin section of Teti casing stone with nummulite shell and calcite micrystals.

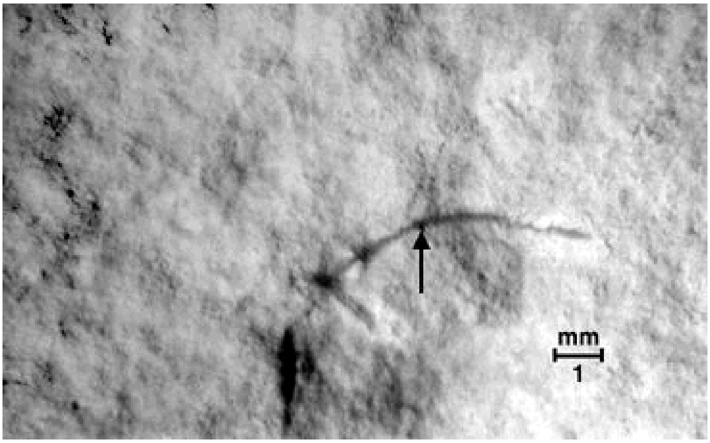


Figure 17b: Thin section of Turah limestone with quartz inclusion (arrow) in dense matrix.

closer look at his test results. His charts showed practically the same peaks as the charts produced by my analysis, indicating a comparable mineralogical makeup in our samples. I presented my official rebuttal to Tite at the Science in Egyptology Symposium, held in England at the Manchester Museum in June 1984 [41]. The title of my conference was " *X-Ray Analysis and X-Ray Diffraction of Casing Stones from the Pyramids of Egypt, and the Limestone of the Associated*

Quarries ". While a geological explanation for the presence of opal CT is valid, the presence of opal CT (detected by X-ray diffraction or microscopy) could also imply the addition of silicate materials during stone manufacture. The presence of opal CT in the pyramid stone might result from an addition of plant-ashes from bread-hearths. The burning of cereal husks, straw, and certain types of reeds yields such siliceous materials.

Although the quarry samples do not match the pyramid stone, a sample of stone I made with a very large excess of geopolymeric cement and fine limestone produced similar peaks on the X-ray charts. Researchers who previously performed chemical analysis on pyramid stone never suspected anything out of the ordinary even though their samples contain elements uncommon in natural limestone. A case in point is a project mentioned in Chapter 1, the joint research venture carried out by Ain Shams University and SRI International. G. E. Brown, a geologist at Stanford University, was unable to mineralogically classify casing-block samples devoid of classifiable fossils, which enable petrographic comparison. Consequently, he could draw only tentative conclusions about the origin of the casing blocks. I am providing another example at the end of this chapter. Because it is not easy to match blocks which appear incomparable mineralogically with the natural limestone of Egypt, one begins to see how the use of reconstituted stone settles the outstanding scientific dilemmas.

Another issue settled is the controversy raised by Klemm's geochemical study. Klemm created quite a debate with geologists at the 2nd Congress of Egyptologists, Grenoble 1979, when he compared trace elements from twenty core blocks of the Great Pyramid with those of his quarry samples and determined that the pyramid blocks had been quarried from sites all over Egypt. If Klemm's data are correct, his conclusion that the stones were quarried from all over Egypt does not necessarily follow. Not only does it make for insurmountable logistical problems, but the apparently conflicting geological and geochemical studies uphold my findings. Minerals were mined for the cement from various sites, and fossil shell limestones were gathered for the building blocks at Giza, at the very foot of the pyramids. The geological and geochemical reports contain no inaccurate data but were misinterpreted because the basic premise of pyramid construction on which most scientists rely is incorrect. Applying the standard theory ensures that the conflict will remain forever unresolved, even when the best modern equipment and well-trained scientists are used.

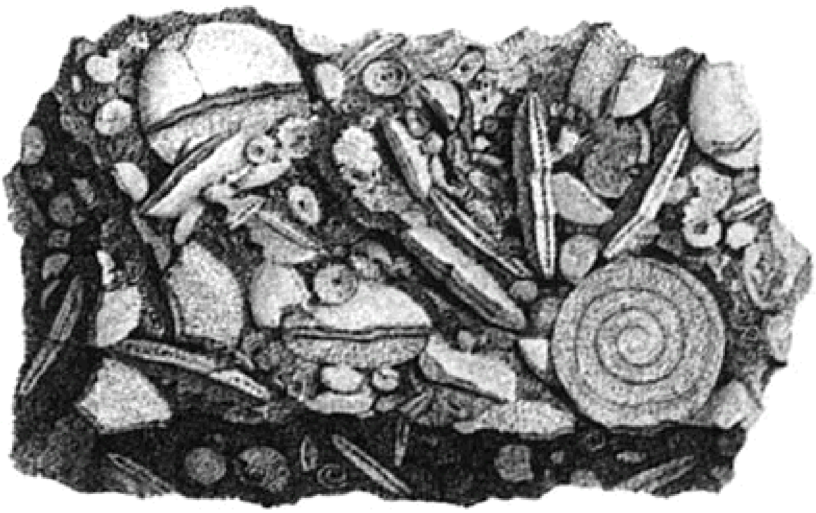


Figure 18: Drawing from Description de l'Egypte shows jumbled shells in pyramid core blocks.

Even if geopolymeric concrete is as strong and beautiful as natural stone, some telltale signs of its reconstituted nature must exist. The signs would depend on the variety of stone imitated. For instance, nummulitic limestone is comprised of the skeletal remains of foraminifers that accumulate over millions of years to form sedimentary layers of bedrock. The fossil shells lie horizontally or flat in the bedrock.

Napoleonic geologists Jomard and de Roziere, however, described the rough building blocks of the Great Pyramid as being composed of shells that are in disarray (Fig.18) [42]:

> " The main variety of limestone in the Great Pyramid is almost solely formed of an accumulation of nummulites, which are disk-like fossil shells of various sizes that seem to be arranged in all orientations. "

As in any concrete, the aggregates are for the most part jumbled, in this case devoid of sedimentary layering.

In addition to the jumbled shells and chemical makeup, the pyramid stone demonstrates other telltale physical features. Scattered through Lauer's samples are numerous air bubbles. The bubbles are not round, but oval, like those that occur during the manipulation of clay. The broken surfaces have a clay-matrix look (Fig.19). This can often be observed with the naked eye on the broken surface of casing blocks.

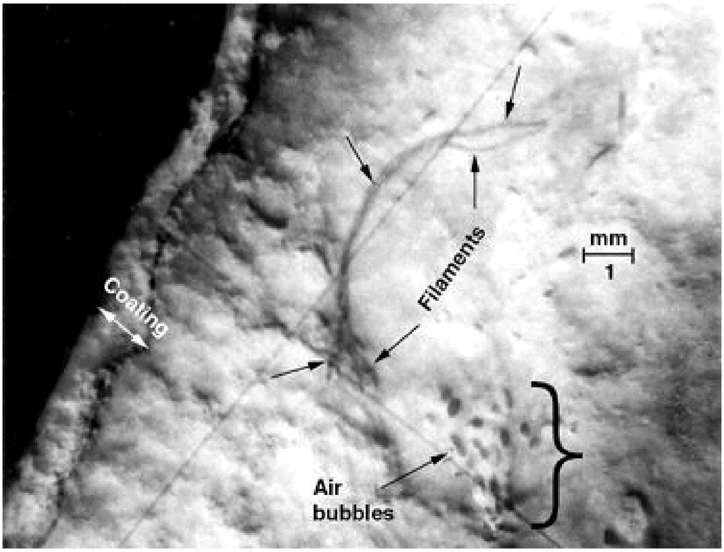


Figure 19: Organic fibers, air bubbles, and an artificial red coating are visible on a sample stone from the ascending passageway of the Great Pyramid.

I noticed a small dark streak just beneath the surface of a broken part of the sample from the Great Pyramid. The streak is visible because it is close to the surface. I contracted three different laboratories to identify this particle. All three laboratories reported that the streak could be nothing other than a small bundle of two or three organic fibers, possibly hair. The fibers are unlikely to be algal filaments occurring naturally, since algae are mainly calcite-forming and not easily preserved. The presence of organic fibers could instead result from the accidental incorporation of fragments of hair rope or the deliberate incorporation of animal remains from ritual sacrifices. The fibers are flat, like human arm hair, but they may not necessarily be of human origin. The bundle is surrounded by clusters of air bubbles. Hair has never been discovered in 50-million-year-old rocks. The limestone would have formed under the ocean 50 million years ago during the Middle Eocene geological epoch. While fur-bearing mammals on the ocean floor among the foraminifers 50 million years ago creates an impossible scenario, hair from animals or the arms of workers probably commonly fell into the stone-making slurry during pyramid construction. Organic fibers were not found in the quarry samples.

The sample from the Great Pyramid provided by Lauer is topped with a white coating overlaid with a brownish-red surface coloration. Such coloration appears also on a few remaining outer casing blocks of this pyramid and varies from brownish red to greyish black. There has been long debate about whether the coloration is a type of paint or a patina, the latter resulting gradually from desert weather conditions.

Attempting to show that the casing block coloration of the Khufu (Kheops or Cheops) and Khafra (Khefren or Chephren) pyramids is a paint, Andre Pochan, in 1934, analyzed the coloration appearing on these pyramids [43]. His tests revealed the presence of minerals highly uncommon in limestone, leading him to conclude that the coloration could not be a patina because that would require a migration of minerals from within the stone itself. He therefore proposed that some type of hard, siliceous binder was applied and painted over with a pigment of red ochre.

A. Lucas accepted the validity of Pochan's chemical analysis but disputed the presence of a deliberate coating. Lucas maintained that the coloration is a patina. Lauer and K. L. Gauri, of the Stone Conservation Laboratory of the University of Louisville, in Kentucky, also maintain that the coloration is a patina. Pochan and Lauer hotly debated the issue for twenty years. Lauer's opinion carries great weight among peers, and he had the last word on the subject because he outlived Pochan. The chemistry of geopolymerization serves to settle this issue as well.

Because Pochan had already analyzed the red coloration, I analyzed only the underlying white coating appearing on the white coating from the Great Pyramid. I submitted Lauer's sample to two different laboratories employing experts with diverse backgrounds in geology and mineralogy, Combining our expertise, I was amazed to find a tremendously complex geopolymeric chemical system in the white coating. Its principal ingredients are two calcium phosphates, brushite and crystalline hydroxyapatite, both found in bone, and a zeolite called ZK-20. The coating is pure geopolymeric cement. It is the key to the composition of the pyramid stone. This binder is infinitely more sophisticated than the simple gypsum and lime cement by which scholars have characterized Egyptian cement technology. Indeed, the binder is even more sophisticated than I had expected.

Even though Pochan did not understand the chemistry involved, he was nevertheless correct in his surmise that the red coloration is synthetic. As he knew, the minerals thought to have migrated are highly uncommon in natural limestone. In any case, the amount of minerals present in the stone is too small to form a patina. Additionally, the minerals in the red coloration, like those in the white coating, are insoluble and, therefore, could not have migrated, nor could minerals have migrated through the white coating to form a red coloration. Furthermore, the sample I analyzed exhibiting the red coloration came from the pyramid's interior where it was unaffected by weathering. Finally, using a microscope, I observed two cracks in the red coating of this sample. One crack is deep and exposes white limestone, making it much more recent than the coating. The other crack is ancient, and it is filled with the red coloration. The color was obviously painted on because it filled the crack. The coating and coloration are truly remarkable alchemical products, showing no blistering or other appreciable deterioration after about 4,500 years.

In fall of 1992, a geologist, James Harrell, University of Toledo, approached my assistant Margie Morris. She agreed that Harrell be allowed to perform additional tests on the Lauer sample. He classified the limestone as natural limestone and the coating as man-made. Harrell never gave back the sample to Mss. Morris. He told her that in his effort to prove the natural limestone case, he destroyed the Lauer sample. He never stated that my claim on the presence of organic fibers was wrong. [43b].

Geologists who have analyzed the pyramid blocks have recognized no known adhesives holding the stone together. Not realizing that the unusual minerals in the stone comprise the binder, they have not recognized the stone as reconstituted limestone. Likewise, researchers recognize no known chemical composition to justify a man-made coating and coloration on the stone. A report that typifies the reaction of geologists to this material is amusing. A geologist was commissioned by the owners of a collection of limestone artifacts from ancient Egypt to prove them to be natural stone because museum authenticators interested in the collection detected that the stone was artificial. They opined that the pieces must, therefore, be fakes. Trying to prove the natural origin of the limestone, the geologist claimed that perhaps some extraterrestrial system, far in advance of our own, might possess the technology required for producing such stone, but lacking proof of that, we of the earth must consider the stone to be of natural origin. I shall come back to this extraordinary statement in a later chapter.

There is a historical account that supports the presence of paint on the Great Pyramid, and it also mentions remarkable pyramid cement. The following remarks were made by Abd el Latif (13 century AD):

> " These pyramids are built of large stones, ten to twenty cubits [16.6 -33 feet] in length by a thickness of two to three cubits [20 - 30 inches] and a similar width. What is worthy of the greatest admiration is the extreme precision with which the stones have been dressed and laid one over the other. Their foundations are so well leveled that one cannot plunge a needle or a hair between any two stones. They are cemented by mortar which forms a layer the thickness of a sheet of paper. I do not know what this mortar is made of; it is totally unknown to me. The stones are covered with writings in ancient characters whose meaning today I do not know and nowhere in all of Egypt have I met anyone who, even by hearsay, is able to interpret them. The inscriptions are so numerous that if one were to copy on paper merely those on the surface of the two pyramids, ten thousand pages would be filled. "

Even though the paper-thin cement would afford no appreciable cohesive power for adhering one block to another, it is assumed that the builders, nevertheless, applied a thin coating of what is assumed to be ordinary lime-gypsum plaster. But Abd el-Latifs account shows that the Arabs, who were producing lime-gypsum plaster and lime mortar more than 3,000 years after the Great Pyramid was built, found the thin cement completely unfamiliar and quite impressive. Paper-thin mortar is a by-product of geopolymerization that forms when there is excess water in the slurry. The weight of aggregates squeezes watery cement to the surfaces, where it sets to form a skin. We may never learn much more about the colored hieroglyphs cited above. Abd el-Latif's report was made shortly before the earthquake of AD 1301. Cairo was destroyed, and most of the outer casing blocks were stripped to rebuild the city.

That the pyramid stone is reconstituted limestone has eluded several individuals who might have recognized it. It never occurred to Jomard and de Roziere that the pyramid stone was a concrete when they observed the jumbled shells in 1801. Only poor-quality cement was produced after the fall of the Roman Empire in AD 476. Portland cement was invented only in 1824. It was not manufactured until the 1830s.

Pochan recognized the coloration on the pyramid blocks as synthetic because it contains minerals uncommon in limestone. It follows that had he analyzed the pyramid stone as well, he would also have recognized it as the result of man-made reagglomeration, especially if he had considered the work of le Chatelier. And in 1974, the revelation eluded researchers of SRI International. Their team attempted to locate hidden chambers in the Great Pyramids of Giza. The project failed, however, because the pyramid stone contains so much moisture that the electromagnetic waves would not transmit, and were instead absorbed by the stone. This was unexpected because the natural limestone bedrock at Giza is relatively dry.

Only concrete would be full of moisture. The moisture content encountered by SRI International alone would convince any professional of the concrete industry that the pyramid stone is some kind of concrete. Today's newly built concrete structures are internally moist. The moisture in the pyramid stone is probably the result of the migration of ground water. It is common for concrete structures to absorb ground water in desert environments. Additionally, the Great Pyramids are so massive and were built so rapidly that blocks that were not exposed to air for any appreciable time never fully dried. That the pyramid stone must be a concrete never occurred to the researchers at SRI International.

Additional supporting analytical data

The basic geological knowledge set out that the stone material was extracted from quarries located at the edges of the wadi in the soft yellow marly bed. In 1993, the German geochemist Klemm published analytical data from his new study on the origin of the core stones for the three pyramids, Khufu (Kheops or Cheops), Khafra (Khefren or Chephren) and Menkure (Mykerinos) [124]. Klemm did not discuss the agglomerated stone theory in this study. His objectives were to locate the source of the limestone raw material. To do this

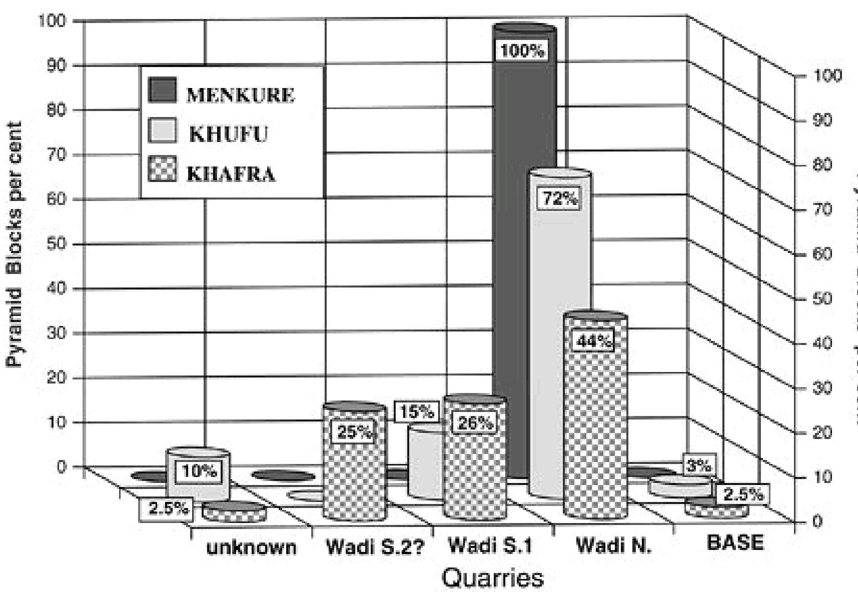


Figure 20: Origin of the core stones for Khufu, Khafra and Menkure pyramids. Adapted from Klemm [124]

he chemically analyzed pieces of fossil shells and compared the results obtained on pyramid blocks and quarry fragments. The bulk material in reagglomerated stone is made of these fossil shells or of disaggregated quarry limestone. Klemm's results relate to the origin of the fossil shells, in other words to the provenience of the limestone raw material.

The chart in Fig. 20 summarizes the results of Klemm's study performed on 72 core block samples for Khufu (Kheops or Cheops), 77 for Khafra (Khefren or Chephren) and 22 for Menkure (Mykerinos). They are statistically representative of the material representing each pyramid.

1 - Up to 100 % (100% Menkure, 72% Khufu, 44% Khafra) are attributed to the quarries located at the north edge of the wadi in the soft marly bed, some in the vicinity of Khent Kawes monument, named in the chart ***Wadi N*** .

2 - Up to 26% (0% Menkure, 15% Khufu, 26% Khafra) are attributed to a quarry located at the south edge of the wadi at the place called Hitan el Gurab and named in the chart ***Wadi S.1***.

3 - For Khafra, 25% are attributed to a quarry not recognized by Klemm; yet, from the analytical data, it could be located in the vicinity of the latter, at the south edge of the wadi, named in the chart ***Wadi S.2.***

4 - up to 10% (0% Menkure, 10% Khufu, 2.5% Khafra) are attributed to an unknown quarry, which is not located in the vicinity of the pyramids, named in the chart **unknown**.

5 - Only up to 3% (0% for Menkure, 2.5% for Khafra, 3% for Khufu) of the analyzed blocks are attributed to the hard Mokattam Formation in the direct vicinity of the pyramids, named in the chart ***Base***. It is reasonable to admit that these stones were added probably later to the site and were carved, during subsequent repair and restoration works carried out either by Ramses II or his successors.

Klemm's results confirm the basic geological statement, namely that the pyramid builders did not quarry the hard grey Mokattam limestone located nearby the basements of the pyramids, but preferred to excavate 97% to 100% of the raw material limestone in the soft marly outcrops located at the edges of the wadi (down the hill).

Some Egyptologists criticize my findings because I obtained only two small samples of pyramid stone for analysis. However, the samples analyzed by Klemm (which came from the rough core blocks), Brown, and Tite can serve further to confirm my test results. In 1984 I submitted a research proposal to the Egyptian Antiquities Organization in Cairo requesting permission to sample the core blocks of the Great Pyramid. The permission was denied. The following excerpts are from their letter to me, translated from French:

> " Cairo, December 16, 1984 Dear Sir:
> We are answering your letter from October 13, 1984, and I have the duty of informing you that the Permanent Committee of the Egyptian Antiquities Organization, during their meeting on December 6, 1984, regrets not responding favorably to your proposal concerning the authorization for analyzing the stones of the pyramids, the Sphinx, and the quarries. The decision is because your hypothesis represents only a private point of view which has no analogy with archaeological or geological facts.
> Sincerely yours, The President of the Egyptian Antiquities Organization. "

Objection to my theory

A scientific paper was published by a team from the University of North Texas, USA in the December 1993 issue of *the Journal of Archaeological Science*. The paper titled " The Pyramids - cement or stone? " by K. Ingram, K. Daugherty and J. Marshall, outlines the results of a series of tests performed in 1989 on samples of limestone from the pyramids of Khafra (Khefren or Chephren) and Menkure (Mykerinos) at Giza. Their conclusion reads: " ... We found no evidence that support his [Davidovits] ideas ...". This conclusion is wrong because the paper contains at least three data which proves the contrary. What would have upset any fair geologist seems normal to these scientists. Trained experts will decide whether the three following uncommon scientific data must be qualified as 'normal' or 'abnormal' results:

1 - To determine the chemical content of the limestone, one proceeds generally with a calcination at 900°C of a powdered sample. The calcite (calcium carbonate) decomposes and gives off carbon dioxide. In general, the calcination material loss for Egyptian limestone (and other limestones) ranges between 40-41% of its mass. In Ingram/Daugherty's paper, the material lost 60% of its mass during decarboxylation. This is an unusual result for ordinary limestone. This excessive loss should have been tentatively assigned to bounded water and therefore suggesting geopolymeric reagglomeration.

2 - The chemical analysis determined with a sophisticated tool called Inductively Coupled Plasmagraphy (ICP) provides a high amount for aluminum, 3.9 % expressed in aluminum oxide Al2O3. The authors wrote: " ... the sample appears to be normal limestone, not a geopolymeric cement blend... " This is again very unusual. We know that the limestone of the hard gray Mokattam bed does not contain more than 0.5% aluminum oxide Al2O3. On the other hand this high aluminum amount is found in the soft yellow marly limestone of the Sphinx trench and the wadi quarries and that it is not appropriate for standard constructional purpose, yet a dedicated raw material for the reagglomeration process as depicted in the previous chapter.

3 - The third mistake relates to the Infra-Red Spectroscopy investigation. The infra-Red spectrum differentiates between calcium carbonate calcite and silico-aluminate (clay constituent of geopolymeric cement). A shoulder in the spectra around 1000 cm-1 characterizes silico-aluminate. Both Khafra (Khefren or Chephren) and Menkure (Mykerinos) stones spectra display this shoulder. Yet for Ingram/Daugherty" … this is a minor variation… ". Why did they refrain from enlarging their spectra, as would have done any scientist in order to focus on this very peculiar band which pertains to routine geopolymeric characterization?

To sum up: this paper provides additional data supporting the agglomeration theory. It shows how untrained scientist, who are ignorant of the geopolymer chemistry potential, can improperly assign the analyzed samples to natural stones despite their uncommon features. K. Ingram, K. Daugherty and J. Marshall assumed that since the agglomeration stone theory is against orthodoxy, it must be incorrect; therefore, it is not worthy of serious study and hence their sloppy science and incorrect conclusion.

Chapter 8

The Proof at Giza

To further demonstrate that the pyramid stone results from a man-made reagglomeration of nummulitic limestone, I conducted several studies at Giza between 1984 and 1992. A complete survey of the geological strata of the Giza plateau has never been conducted because the site is completely filled with tombs and sand. I surveyed all of the exposed strata in the bedrock, and I made a comparative study between the exposed strata and thousands of blocks in the pyramids and those in the temples at Giza. (See also Appendix II, *The Giza Plateau Circuit*).

The variation in quality of blocks composing the Giza pyramids is striking. Certain blocks are unweathered whereas the majority has become extremely eroded by wind, rain, and the sunlight; the latter is most severe from the south and west. The effects of erosion are most obvious on a very rough layer that forms the top portion of all of the pyramid blocks. This top area, generally from twenty to 30 centimeters (7.87-8.81 inches) thick, is weaker, lighter in density, and more affected by erosion than the rest of the stone. Two explanations to this unusual feature would be as follows:

First, let us assume that limestone aggregates (with fossil shells) were poured directly into a mold that was partially filled with water and binder. As the mixture combined with the water, the heaviest materials settled to the bottom. Air bubbles and excess watery binder rose to the top, producing a lighter, weaker matrix. The top layer also exhibits the smallest number of fossil shells, which were not as crowded within the dense slurry and were therefore depositionally oriented horizontally. No mixing was required to produce the concrete, and precise measurements afforded perfectly level tiers.

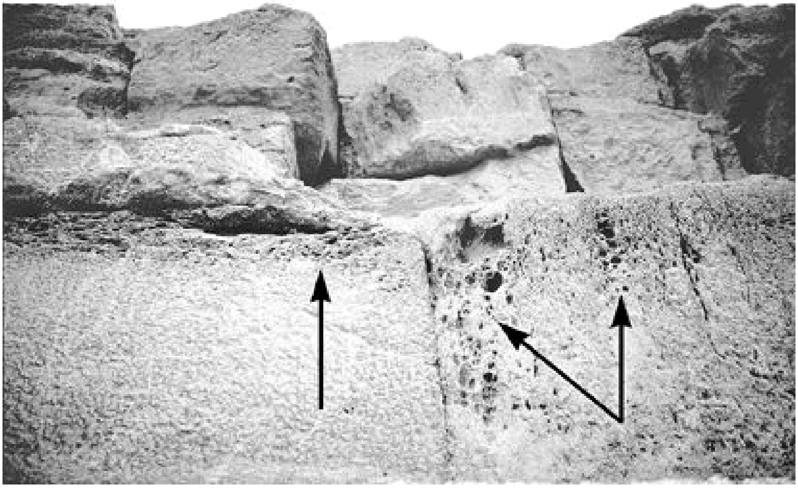


Figure 21: Blocks on the west face of Khafra's (Khefren or Chephren) Pyramid exhibit sponge-like upper portions. (1984)

In the second explanation, the limestone aggregates were rammed (instead of poured) as in the making of pisé (packed earth). The bottom of the semi-dry mixture became compacted with the pestle and was more dense than the top.

Due to the technology employed, the top layer tended to exhibit light horizontal layering (see Stage 1 in Appendix II).

Sometimes, the top layer is so rough and riddled with holes that the blocks look like sponges (Fig.21). My first impression was that they resemble geopolymeric foam, a product that I have developed. Gaber accompanied me in my survey, and his professors from the geology department of Ain Shams University commented that the numerous holes in the top portion result from fossil shells having been stripped away by erosion. I explained that although erosion caused the deterioration, it did so because the top layer is more susceptible than is the denser bottom layer.

Furthermore, I observed that blocks on the west side of Khafra's pyramid have been protected from weathering during centuries. Until about 100 years ago, the first several tiers on the west side were buried in sand (see drawings from Description de l'Egypte and Lepsius). Because erosion occurred after the sand was cleared, the blocks on the west side are relatively unweathered. However, even these unweathered blocks exhibit the light, weak top layer, which, therefore, cannot be attributed to weathering (see Stage 5 in Appendix II).

All blocks composing the pyramids at Giza, those of Khufu, Khafra, Menkure (Mycerinus in Greek), and the mile-long causeway from Menkure's pyramid to the Nile bear the weak top layer (Figures 21 to 30). In contrast, a comparison of the cast blocks and the bedrock demonstrates obvious differences.

To form a level base on the incline of the Giza plateau, five steps on the west side of the pyramid of Khafra were shaped in situ from natural bedrock (see in Appendix II, Stage 5). There are no individual blocks in these bedrock steps, and therefore, shaping them did not involve the arduous labor required to cut perfectly fitting blocks. The transition between

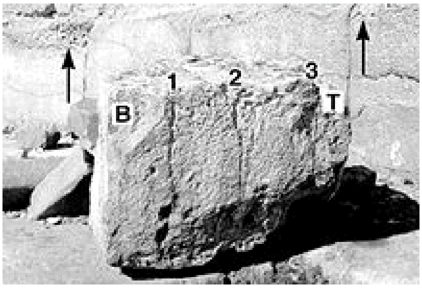


Figure 22: Block fallen from southwest corner of Khafra's pyramid has three lift lines (B-bottom; T-top); behind arrows show weak top layer (1984).

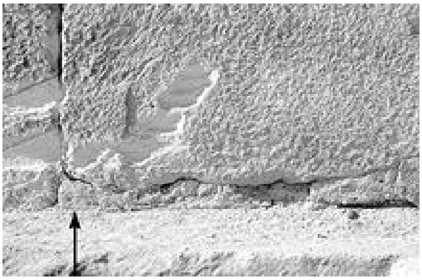


Figure 23: Arrow points out thick mortar used to seal bottom of mold for blocks on south face of Khafra's pyramid (1984).

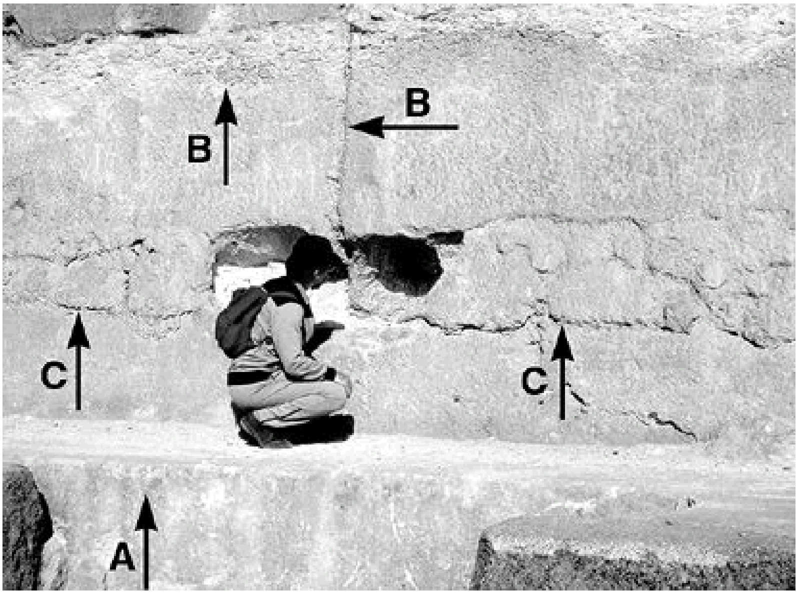


Figure 24: The author examines transition between bedrock base and pyramid blocks. (A) Fossil shells correspond to the natural sedimentary layering in the bedrock portion of the base. (B) Pyramid blocks cast on bedrock have well-fitted joints. In lighter top portion jumbled and broken fossil shells are visible. (C) Separation between bedrock and pyramid blocks (1984).

the natural bedrock steps and the man-made reconstituted limestone blocks appears near the middle of the north and south sides of the base of the pyramid (Fig. 24). Above are about 2 million individual blocks. At the base, blocks were cast directly on bedrock, which is quite homogeneous in density when cut within a given geological stratum or series thereof. The jumbled shells in the pyramid blocks reported by Jomard and de Roziere are apparent. On the opposite, the nummulites in the bedrock steps are oriented horizontally, characteristic of natural sedimentary layering.

If the pyramid blocks were natural limestone, the unnatural density pattern could be explained only if two adjacent strata of different qualities had been included in the cut, the lower of a better quality than the upper. That the pyramid blocks were cast explains why the rough top layer is always about the same size regardless of the height of a block. It would be ridiculous to suppose that quarries exhibiting this unusual feature could have been identified and used to the degree that is exhibited in the pyramids.

With few exceptions, the pyramid blocks contain no type of strata. If the blocks were quarried, it would have required that they be extracted to avoid cutting along the division between strata because the blocks are smaller than the strata in the bedrock. Incongruence with regard to strata is contrary to what is advocated by Egyptologists. They assume that the blocks were easy to cut because advantage was taken of natural divisions in the bedrock. Occasionally, a stratum (lift line) can be observed in very large pyramid blocks. When one does appear, however, it is not as high as the divisions of strata found on the Giza plateau. The divisions of strata in the bedrock near the pyramid of Khafra and in the Khent-Kawes quarry, are about 4.5 meters (5 yards) apart, three to four times greater than the heights of the pyramid blocks (Fig.25).

In the pyramids of Khufu, Khafra, and Menkure, a thick, pink gypsum mortar was used to fill cracks and level

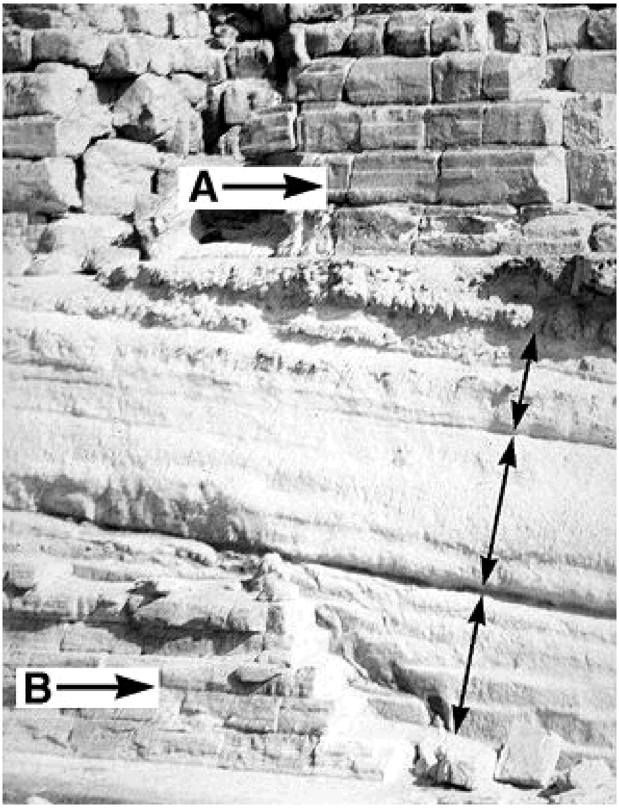


Figure 25: Exposed bedrock at Giza allows comparison between heights of pyramid blocks (A and B) and the divisions of geological strata (arrows) (1984).

imperfect blocks and also to cement a minority of rough trapezoidal-shaped core blocks to neighboring blocks. The mortar was applied to a thickness of up to 20 millimeters (0.78 inch) beneath the base of the trapezoidal blocks. These blocks are positioned with their widest area upward. The mortar was applied to be thickest at the bottom, with that thickness gradually decreasing as it neared the top of the blocks. Practically no mortar is visible at their top edges, because this area is very small. The presence of this thick mortar indicates that these particular blocks were moved into place, as opposed to having been cast in situ.

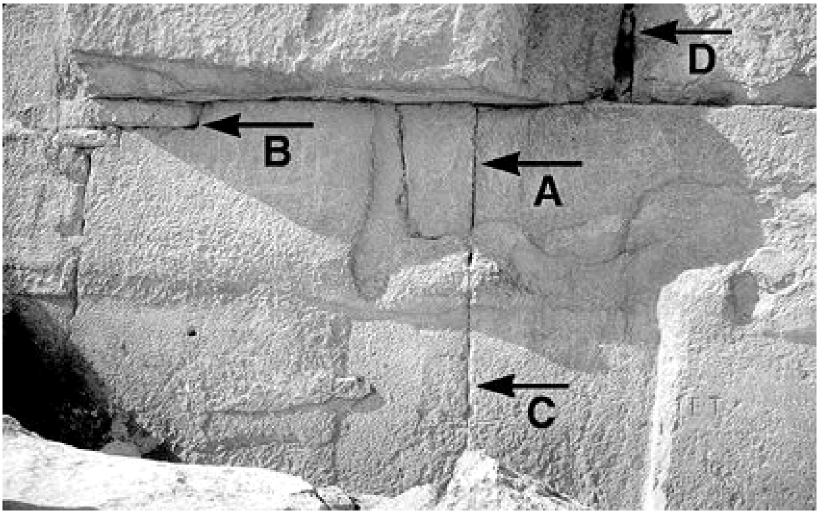


Figure 26: Second Pyramid of Giza exhibits three different types of joints. A and B are carved restoration. C is an original agglomerated stone joint. D is a joint in which thick mortar was applied during construction (1984)

That these trapezoidal blocks are bound by mortar does not invalidate the agglomerated stone theory because the blocks represent only a small minority. Instead, the blocks provide insight into the plan by which the pyramids were constructed. The blocks were probably cast near by and placed during the final construction phase to plug passageways that had remained open to provide ventilation and allow ingress and egress of materials.

I closely examined blocks in the mortuary temple, valley temple, the temple of the Sphinx in Khafra's complex, and the mortuary temple in Menkure's complex. Walls protected from weathering are smooth and light gray. Large surface areas of blocks composing walls that have been attacked by weather exhibit the same density variations as appear in the pyramid blocks. Blocks in the temples in Khafra's complex are enormous. They stand approximately 2 to 3 meters (6 to 10 feet) high and, as mentioned, weigh up to 500 tons apiece. The weathered faces of the largest of these blocks exhibit two or three wavy, irregular strata. These are smaller than the divisions of strata in the Giza plateau. The geologists I encountered from Ain Shams University opined that the strata proves that the stones are natural. They were unaware that most types of concrete can also exhibit strata, known as lift lines.

Like those exhibited in the largest pyramid blocks, these lift lines can be explained by the method used to produce the blocks (Figures 27, 28). If the large temple blocks were natural, they would have to have been quarried from close by, because their great size would make them almost impossible to move by primitive means. To cast blocks of such enormous size might require three days. After the workers quit for the day, the unfinished block hardened. As it set, a surface (lift line) formed. The process was repeated daily until the block was complete. The lift lines are visible now that weathering has destroyed the outer block. In addition, the strata in the bedrock are horizontal, whereas the wavy lift

Figure 27: Enormous blocks in the mortuary temple of Khafra exhibit lightweight, weathered top portions characteristic of concrete (1984).

lines are characteristic of material dumped into a mold.

The planed surfaces and sharp, geometrical angles of the blocks of these temple walls compare exactly with those of modern walls made of concrete blocks. It is strikingly obvious that the northern face of the valley temple in Khafra's complex is a wall of gigantic geopolymeric concrete blocks, formed of parallelepipeds with perfect right angles.

The block quality is excellent. The core blocks of the pyramids, though of better quality than the bedrock body of the Sphinx, do not compare with the fine quality of the temple blocks. The difference can be explained only by the quality of the stonemaking formula itself.

Figure 28: Blocks at Khafra's mortuary temple have wavy lift lines characteristic of construction interruptions during casting (1984).

Aside from evidence from the chemical analysis of pyramid stone, geologists supporting the agglomerated theory find the most compelling evidence for cast-in-place pyramid stones to be gross features such as the chunks of stone incorporated into the pyramid blocks (Figure 29), the wavy lift lines (Figures 27, 28), the density differences between

Figure 29: Chunk of stone incorporated into block is visible in Khafra's pyramid (1984).

the pyramid and quarry stone, and the jumbled nature of the fossil shells in the pyramid stone. The apparent absence of sedimentary stratification in the pyramid stones is also powerful geological evidence. Additionally, the quarry rocks contain cracks, ranging from microscopic to several inches in width. These cracks are filled with secondary calcite. Similar cracks were not observed in the pyramid blocks and are thought not to be present.

The pyramid of Menkure has an exceptional history. Most of its casing blocks, now disappeared, were limestone. Those appearing on the lower quarter of the pyramid are made of carved granite (see Stage 10 in Appendix II). Some of the blocks are irregularly shaped, typical of carved blocks. Menkure's pyramid probably fell victim to the New Kingdom pharaoh, Ramses II, who routinely used pyramid casing blocks to build or restore temples consecrated to his god, Amun.

The pyramid of Menkure was stripped starting at the bottom, but only one-third was denuded. A subsequent ruler restored the pyramid with carved syenite granite from Aswan, a material which was commonly carved during the New Kingdom. As opposed to supporting the traditional theory of construction, the carved blocks contribute to my theory. Their appearance clearly demonstrates the difference between carved and cast blocks because carved blocks always exhibit tool marks whereas cast blocks do not.

Edwards states in his book *The Pyramids of Egypt [123]:*

> " … Menkure (Mykerinos) must have intended to follow the example of Khafra (Khefren or Chephren) by constructing his Mortuary Temple of limestone faced with ashlars of granite…. Reiner's excavations, however have shown that this plan was never realized…. Only the foundations of the Valley Building were made of stone; the superstructure was composed almost entirely of crude brick…. In the Mortuary Temple the foundations and the inner core of some of its walls were composed of limestone blocks… but crude brick was again the material used for completing the greater part of the building… "

The blocks were overlaid with a plaster imitating granite or with a white plaster, inside and outside. The unweathered side (north) of the Menkure (Mykerinos) Mortuary Temple blocks shows visible toolmarks (Fig. 30a, 30b). These toolmarks are also observed on the blocks of other temples and have been taken as proof against the agglomerated stone theory. They are not! As mentioned above, the blocks were not bare, but recovered with a decorative coating. It is traditional in all civilizations to proceed in the same way when applying a decorative coating or plaster, or stucco, upon a smooth stone or brick surface. The stone surface must be roughened in order to achieve good mechanical adhesion between the plaster and the stone surface. In the author's mind, these toolmarks were specially worked on the agglomerated stone because Menkure's (Mykerinos) architect

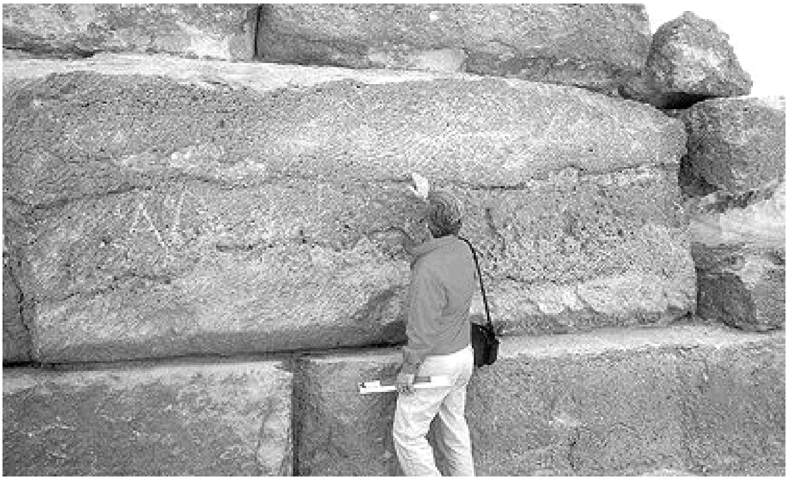


Figure 30a: Stage 11, Mortuary Temple, Menkure (Mykerinos) Pyramid, east, on the right hand when facing the valley. Blocks with tool-marks for plaster adherence and worked edge (1988).

Figure 30b: visible tool-marks (1988).

did not have the time or the budget to face the ashlars with massive granite stones. Remains of colored plaster (coating) are often visible on pyramid blocks, essentially those located on the east sides.

Ancient repairs with lime gypsum mortar caused no damage to the Sphinx body and a protective coating formed, which is in my opinion a result of geopolymerization. However, salts leaching from the modern mortar used in repairs have caused the stone to decay. This shows that ancient Egyptian gypsum mortar does not have the same chemical makeup as modern gypsum mortar. The modern material consists exclusively of hydrated calcium sulfate, whereas the ancient mortar is based on a silico-aluminate, a result of geopolymerization. I have observed well-preserved, hard lime-gypsum mortar on some ancient Egyptian monuments and lime-gypsum that is completely disaggregated on others. The disaggregated mortar is modern, and because the modern mortar has deteriorated, it is assumed that lime-gypsum mortar does not endure.

At Saqqara and Giza I found geological layers of well crystallized gypsum sandwiched between layers of limestone and aluminous clay. When a combination of these three materials is calcined and combined with natron, a geopolymeric lime-gypsum cement results, which sets rapidly and resists erosion. Such cement was used for patching and sealing in most of the pyramids. This is the thick mortar used to set the trapezoidal blocks, previously described, and it is in good condition after thousands of years. However, because it sets rapidly, it does not allow sufficient time for casting and, therefore, is unsuitable for producing limestone concrete. This explains why gypsum is not a component of the

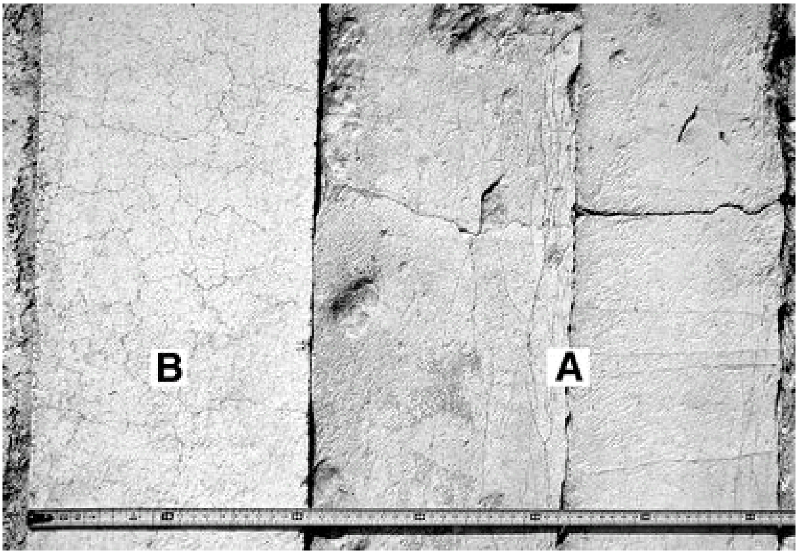


Figure 31: Restoration detail of Zoser's pyramid shows (A) original casing stones over 4,500 years old, and (B) cracked blocks made of portland cement-based concrete less than 50 years old (1984)

reconstituted limestone described previously.

Much of the restoration by Lauer on the pyramid of Zoser was made with Portland cement concrete. Those repairs of fifty years ago have cracked and, consequently, had to be replaced with carved limestone (Fig.31-32). The geopolymeric material would be ideal for a lasting restoration of monuments.

During the studies at Giza, I photographed the south

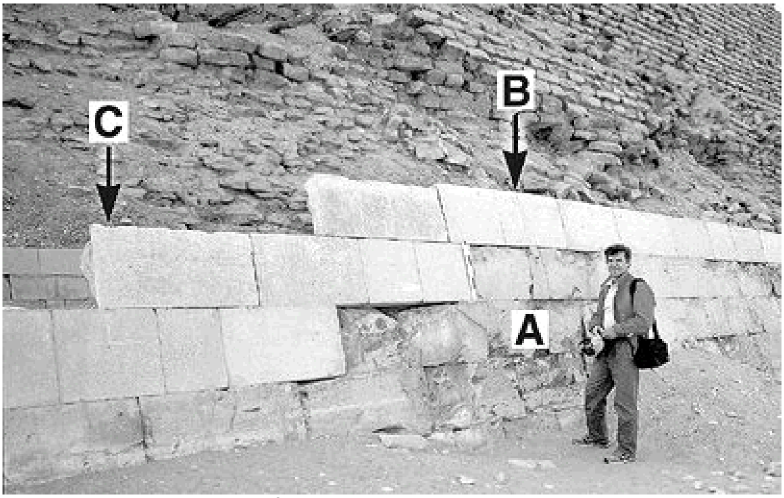


Figure 32: Restoration of Zoser's pyramid shows (A) original casing blocks, (B) Portland cement-based concrete blocks, (C) block carved from soft white limestone of Tura during recent restorations. (1984).

and west faces of the pyramid of Khafra below the top thirty levels. The uniformity of lengths of the blocks of Khafra's pyramid show that the use of agglomerated stone is the only viable system of pyramid construction. The heights of the pyramid blocks are more variable than the lengths. This would not call for more molds; the desired height could be achieved by marking the molds at a certain level and by filling them to that point. This system accounts for the dramatic fluctuations relative to the Great Pyramid that Goyon could not correctly explain.

Staggering the block heights also produces tremendous stability. This type of structural design was used in cathedrals built in northern France and Germany during the Gothic period between the twelfth and fifteenth centuries. They are capable of withstanding an impressive amount of shock. In my home town of Saint Quentin the thirteenth century basilica made this way remains standing although the city was destroyed by bombs in the battle of the Somme during World War I (1914 - 1918). Likewise, the old city hall, similarly constructed, is still standing. In Cologne, West Germany, one such cathedral stood alone above the ruins of the city in World War II. The Great Pyramid was unscathed by the earthquake of 1301 that devastated Cairo.

Figure 33: Basilica in Saint-Quentin, France, survived the old city after World War I.

One of the main purposes of my study at Giza was to determine whether the lengths of individual blocks might recur and, if so, to what degree. A high degree of uniform lengths corroborates the principle of blocks cast in molds. Almost all 2,000 blocks I photographed in Khafra's pyramid conform to ten uniform lengths. The various lengths are set in different patterns throughout the twenty-two steps. That only ten dimensions exist indicates that all twenty-two steps were produced with molds of only five sizes because some blocks were cast with their lengths perpendicular to the plane of the pyramid face.

That the longest blocks are always the same length is extremely strong evidence in favor of the use of cast stone. It shows that each block was produced according to the exact, immediate specifications of the architect during construction. Long blocks always appear directly above or beneath blocks that are short in length, making the construction plan apparent.

Any dimension required could be determined quickly by the architect because it would be relative to the length of the block in the tier directly below. It is simple to determine the length needed when blocks are all produced from molds of the same few sizes. Anyone, however, attempting to explain the preparation and use of blocks of such highly uniform dimensions based on the carving hypothesis would be unable to do so. Blocks could never have been cut, stored, and selected on the scale required.

The south and west faces of Khafra's pyramid are a mirror image of each other, indicating that the entire intricate design is three dimensional. Successive tiers are made of the same pattern, whereas others are made of different, interrelated patterns. Certain tiers have patterns that are almost the same as those of neighboring tiers. The patterns of other tiers are opposite to those surrounding them. All blocks were cast according to an uncanny master plan of patterns that eliminated the formation of vertical joints, which would cause weak points. The pyramid resembles an intricate three-dimensional puzzle that was effectively formulated to create an incredibly strong, stable superstructure. In Appendix II, the Circuit at Giza provides additional information.

Objections to my theory

Immediately upon arriving at the site in January 1990, the American geologists Folk and Campbell observed features that they interpreted to indicate that the blocks are natural. In an article published in *Journal of Geological Education* , they state:

> " Within the first minute at Kheops (Khufu) pyramid, we knew that the pyramids were built of real limestone blocks, not of concrete [agglomerated stone]… ". [128]

For a reason which is not explained in their papers, Folk and Campbell went directly to the North East corner of the Khufu (Kheops or Cheops) pyramid, and found there, natural limestone, an outcrop of the Mokattam Formation.

A major part of their preliminary geological study was carried out precisely on this location (see in Fig. 34a and the sketch in Fig. 34b). They deliberately ignored the elementary fact that the pyramid was built on a leveled plateau, which left some natural bedrock as part of the monument.

In 1983, Lehner had mentioned that this natural bedrock shows to a height of 4 meters above the base, at the North-East corner [129]. Nevertheless, Folk and Campbell based all their demonstration against the agglomerated limestone theory, on superficial investigation. They identified real stones where previous studies showed them to be located, thus proving on one hand their expertise in geology and on the other hand their scientific misconduct. They used this North-East. corner natural stone to demonstrate that

> " … they are tectonic fractures in many pyramid blocks,

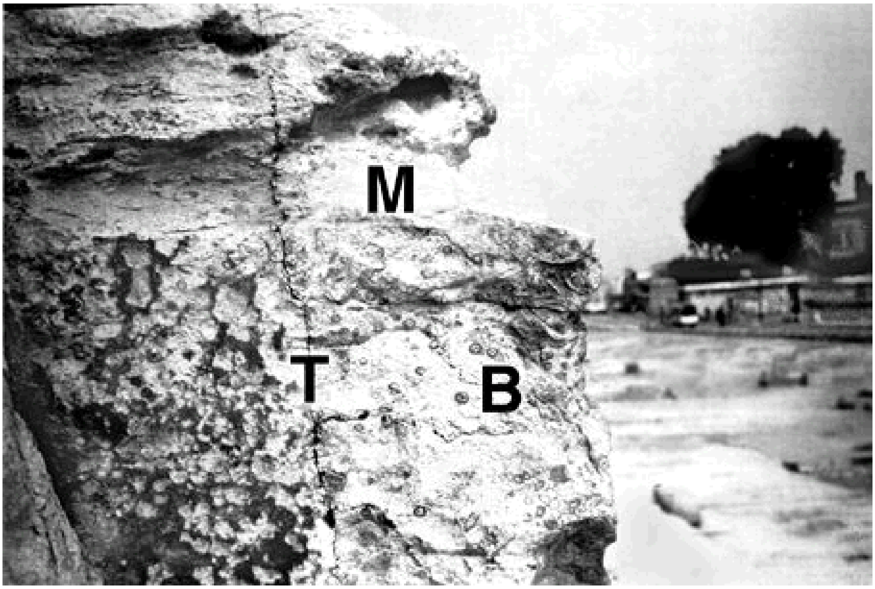


Figure 34a: Block discussed by Folk and Campbell in Ref. 92, 101, with vertical tectonic fracture T, burrow B and marly bed M. Notice the tree and the building on the right, and compare with the sketch.

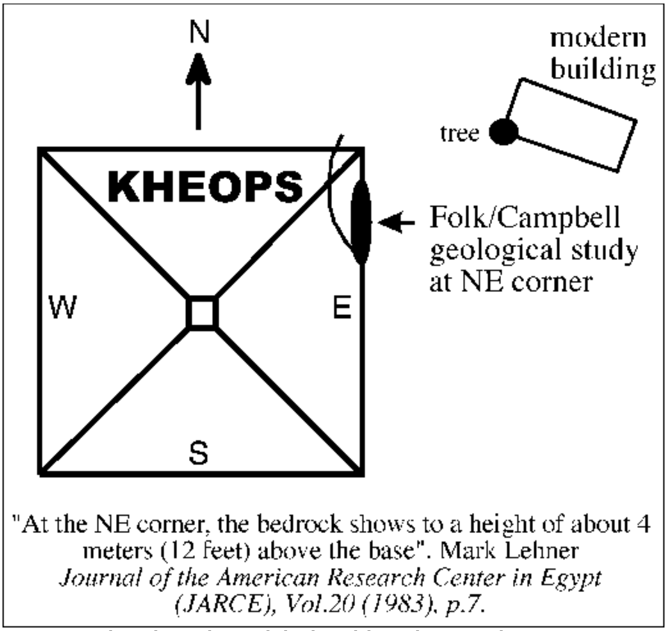


Figure 34b: Sketch published by the author in Concrete International [133] in relation with Folk/Campbell geological study.

filled with calcite [the vertical tectonic fracture T in the photo]…. These fractures generally are only about 1 mm wide, and run in a more or less straight path all across a single block….These are obvious tectonic fractures formed when the block was flexed millions of years ago, and demonstrate that the pyramid core stones were quarried blocks, not poured geopolymer… ".

They also used these natural blocks to demonstrate that specific weaker parts of pyramid blocks were caused by the presence of burrows (label B in the picture), stating that there are:

" … numerous burrows and tubes formed by animals when the sediment had a muddy consistency on the Eocene sea floor. Similar burrows are readily seen in nearby outcropping limestones. Burrowing and churning of the soft sediment by sea-floor organisms produces inhomogeneities in sediment composition, texture, and porosity, which control to a great extent the processes of hardening into rock as the pore spaces are filled with a secondary geologic cement, in this case calcite. When the rock is weathered, the inhomogeneities are strikingly brought out as generally irregular, elongated, discolored features on the rock surface. Consequently, the inhomogeneities in the rock result in its differential weathering… "

Other natural limestone blocks located on the lower two courses of the same East side were also given as proof for the explanation of density changes and lift lines presence in pyramid blocks. Taking the marly layer labeled M as example, they stated that all layers were merely geological stratification produced in the ancient Eocene seas.

In response to another of their papers also published in 1991 but in a different technical journal, *Concrete International* [132], I published in 1992 in the same journal, the sketch focusing on the N-E corner of Khufu (Kheops or Cheops) pyramid (Fig. 34b) and the obvious occurrence of natural stones [133].

I cannot refrain from citing again some excerpts from their published sloppy study:

> " … we feel it is the duty of professional geologist to expose this egregiously absurd archeological theory before it becomes part of entrenched pseudoscience….We believe that had Davidovits had any understanding of basic geologic principles and understood the implications of simple geological evidence at Giza, he would have realized that this geopolymer theory had no basis in fact….We have also shown how geologic commonsense can destroy archaeological quackery, but not, unfortunately, before it has enjoyed widespread publicity among the gullible and sensation-minded.... The geopolymer theory is defunct; we still remain in awe of the enigma of Egyptian skill and engineering… " [131].

Folk and Campbell never publicly admitted their error. Some of their 1990-1991 published papers are still used today (year 2000) by those who wants to discredit my theory. They do not know that Folk confessed his mistake in private. In March 1992, I received a letter from him dated of February 18th, 1992, that reads:

> " … I was impressed by your reasonable and interesting letter in *Concrete International*, Feb. 1992... Your argument that the lower two courses of Khufu (Kheops), on the east face, are in place bedrock is intriguing and I must admit was a new thought to me. This morning, thanks to your citation, I went over and read Lehner (1983) on Khufu (Kheops) and he does indeed show the NE corner of Khufu to be bedrock in his sketch. Our photo was of that corner. So I concede that, on the North-East corner, you are correct as the bedrock idea had not entered my head at the time we were there… "

The geologist and limestone specialist Robert L. Folk admitted that he did not have any basic geological knowledge of the Giza plateau when he made his survey and triumphally claimed: " … Within the first minute at Khufu (Kheops or Cheops) pyramid, we knew that the pyramids were built of real limestone blocks, not of concrete [agglomerated stone]… ".

Chapter 9

The Birth of Masonry

The role of the historian is to explain why events occur as they do. Many important facets of history have eluded historians as a result of lost knowledge about the alchemical stonemaking technology. Now that the old science is recovered, one is called to re-examine several issues. New light is shed on the developments that led to the construction of the first pyramid. One can recognize reasons for the rise and decline of pyramid building. These have been improperly understood as have critical periods of instability and decline in the Egyptian civilization. Then there is the question of how such an important technology could have been lost. If the old science really did exist, there must be some historical traces. An exploration of these issues sheds new light on many aspects of history. The historical remnants provide additional, powerful proof and significantly deepen our understanding.

The oldest known remains of high-quality cement are found in the ruins of Jericho in the Jordan valley. They date from 9,000 years ago. We know that white lime vessels, based on the synthesis of zeolites, were produced in Tel-Ramad, Syria, 8,000 years ago. Mortar from this era has also survived from Catal Hujuk, Turkey. The existence of these ancient products suggests that the earliest stonemaking technology migrated into Egypt.

Settlers attracted by the fertile valley arrived with various animals, plants, traditions, skills, materials, and processes. Hard stone vessels first appeared in pre-dynastic Egypt at about 3800 BC. Later, approximately 30,000 hard stone vessels were placed in the first pyramid, the Third Dynasty Step Pyramid at Saqqara. Many of the vessels were handed down from ancestry.

Stone vessels were sacred funerary objects, probably offering vessels. Stone vessels symbolized the god Khnum, the Divine Potter, also depicted with the head of a flat-horn ram. When hieroglyphic writing was invented, Khnum was represented by the stone vase symbol (sign W9 in Gardiner's list). Although unrecognized by Egyptologists, because they have been unaware of its existence, alchemical stonemaking was attributed to Khnum (Fig. 35). Egyptology classifies Khnum as a significant early god. But the profound influence of Khnum's religious tradition is vastly underrated.

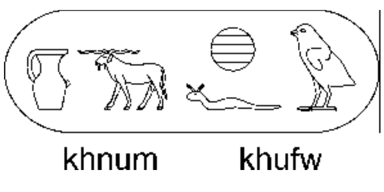


Figure 35: Name of Kufu (Kheops or Cheops) is Khnum-Khufw; the vase is the phonetic sign for khnumu and the ram indicates the god Khnum.

Khnum is one of the most ancient prehistoric Egyptian gods. Since remote times he possessed many attributes. Like all other Egyptian gods, he was identified with the Sun god, but notably he was regarded as one of the creators of the universe. As the Divine Potter, he was the ultimate technocrat. Khnum was depicted as the Nile god of the annual floods whose outstretched hands caused the waters to increase. The Nile floods were believed to originate from a sacred cavern beneath the island of Abu (first town), now known as Elephantine, the major center of Khnum worship (Fig. 36). Over the eons the annual inundation gradually converted a narrow strip of about 600 miles of coast into rich land, unparalleled for farming.

Figure 36: Detail of bas-relief from temple Khnum at Elephantine (Description de l'Egypte). God Khnum (right) welcomes Pharaoh (center).

Khnum's influence grew steadily in early epochs, but diminished after the Twelfth Dynasty and made a resurgence in the Eighteenth Dynasty. Khnum was usually depicted in human form with the head of a flat-horned ram. He was also depicted with four ram heads on a human body, which according to Egyptologist Karl H. Brugsh represented fire, air, earth, and water. The flat-horned ram was not native to Egypt, suggesting that the technology for making hard stone vessels was brought to Egypt by migratory shepherds whose national symbol was the flat-horned ram.

During antiquity it was customary to depict profession or tribal identity symbolically. In the ancient custom, men of truly great accomplishment were deified, and great principles of nature and science were attributed reverence and honor through divine personification. Other symbols of the shepherd were not personified but became part of the ceremonial vestments of the god king. Throughout pharaonic times the king's royal garb always included the crook and incense-gum collecting flail of the shepherd. The symbols were clearly associated with divine political influence.

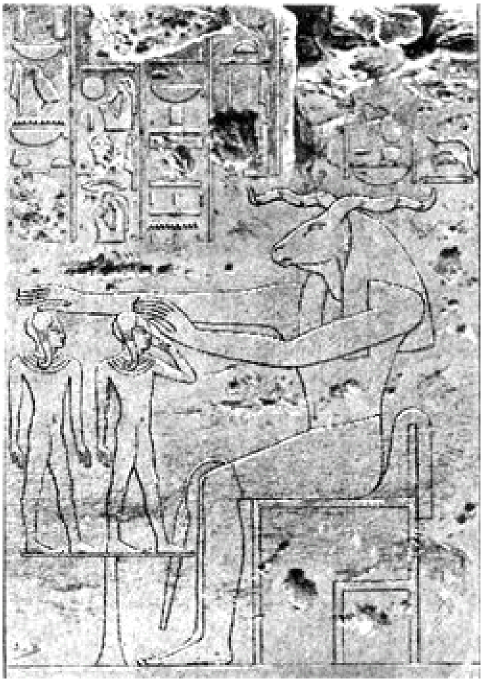


Figure 37: Khnum fashions a pharaoh and the ka (spiritual body) on his potter's wheel.

The most ancient mythology of the Old Kingdom recounts that the Divine Potter created other gods, divine kings, and mortals on his potter's plate. Khnum used different materials depending on whether the being created was divine or mortal. Divine beings were depicted with materials indicative of the eternal realm. Gods were often depicted in gold with hair of lapis lazuli. The funerary statue of the pharaoh, representing his *ka* (eternal body), was made of stone. The divine spirit was incarnated in the eternal material of stone (Fig.37).

The mortal man was made of the reddish-brown mud of the Nile River, and man was always depicted in reddish brown on bas-reliefs. The perishable mortal body was destroyed by aging and death. Only with an offering of Khnum's sacred alchemical product, the natron salt, could immortality be imparted at death. If a man was sinful, he knew that his body would be thrown into the river. The sinful would not attain immortality through the seventy-day mummification ritual using natron.

Natron never lost its sacred value. In the Talmud, natron symbolized the Torah (the Law). In Leviticus 2:13 of the Bible, natron was the salt of the covenant between God and the people:

> " And every oblation of thy meat offering shalt thou season with salt; neither shalt thou suffer the salt of the covenant of thy God to be lacking from thy meat offering: with all thine offerings thou shalt offer salt. "

The salt mentioned in this verse is not sodium chloride or potassium nitrate, but natron. Proof of this can be derived from information provided in Proverbs 25:20:

> " As he that taketh away a garment in cold weather, and as vinegar upon nitre [salt], so is he that singeth songs to an heavy heart. "

An adverse effect is implied in the verse. If one places vinegar on natron (sodium carbonate), the natron disintegrates, leaving a sodium acetate solution. If vinegar is put onto potassium nitrate or sodium chloride there is no disintegration.

The Genesis authors in the Bible described Creation within the framework of their knowledge, revered information handed down from remote ancestry. Assyriology has been studied widely in relation to the Old Testament, whereas the Egyptian influence has been mostly disregarded.

The remotely ancient tradition of Khnum is historically outstanding, for it has prevailed in some form throughout the written history of mankind. Thousands of years after the pyramids were built, Khnum was worshipped by the Gnostics, a semi-Christian sect. What is not widely recognized is that the Bible still preserves the age-old religious tradition characteristic of Khnum. A passage from an Egyptian creation legend by Khnum follows:

> " The mud of the Nile, heated to excess by the Sun, fermented and generated, without seeds, the races of men and animals. "

Passages of the Bible leave no doubt about the belief in the concept of the Divine Potter. Genesis 2:7 mentions the material used to make man, the same type of substance used by Khnum:

> " And the Lord God formed man of the dust of the ground, and breathed into his nostrils the breath of life: and man became a living soul. "

The Hebrew verb used in the verse to signify deity is *ysr*, the root of *yoser*; which means potter. Further, the tradition can be shown by Job 33:6, where Elihu reminds his elders that he is entitled to speak in their presence:

> " I am your equal as far as God is concerned; I, too, have been

> pinched off from clay ”

The tradition of the Divine Potter can be further observed in Isaiah 29:16:

> “ What perversity is this! Is the potter no better than the clay? Can something that was made say of its maker, “ He did not make me ”? Or a pot say of the potter, “ He is a fool ”? ”

and Isaiah 64:7:

> “ And yet, Yahweh, you are our Father: we the clay, you the potter, we are all the work of your hand. ”

The hard stone vessels of Khnum exhibit characteristic features of man-made reconstituted stone. To explain the vessels, Egyptologists assert that a vesselmaker spent perhaps as much as his entire life making only one vessel. But the design features of some of the vessels indicate that time was not the critical factor. Very hard stone materials, basalt, metamorphic schist, and diorite were being used to make the vessels at about the prehistoric epoch when copper was first smelted. The smooth surfaces, absence of tool marks, the vases with long, narrow necks and wide, rounded bellies and interiors and exteriors that perfectly correspond -features unexplainable by any known tooling method- are characteristic of a molded or modeled material. The methods afforded by geopolymerization, a slurry, or rock aggregates, poured into a mold or a pliable mixture fashioned on a potter's wheel, are truly the only viable means by which to explain the features of these otherwise enigmatic vases. The following are remarks made by Kurt Lange after he studied fragments of stone vessels that he found in the sand and talus near the Step Pyramid at Saqqara (Fig. 38) [44a]:

> “ This noble and translucid material is of exceptional hardness.... They are made of a perfectly homogeneous material, dense, polished, and glossy....At once robust and fragile, of unequaled finesse and elegance of shape, they are of

Figure 38: Stone vessels found in the Step Pyramid of Zoser at Saqqara by J.P. Lauer and Drioton

supreme perfection. The internal face is covered with a microscopic network of tiny grooves so regular that only an ultramodern potter's wheel of precision could have produced them. To see the grooves one needs a magnifying glass and good lighting…. Obviously, the equipment used must have been some kind of potter's wheel. But how could such a hard material be worked?… the plates on which earthenware pots were made with such regularity of form had only just been invented, and it is hard to believe that it was this tool, doubtless still extremely primitive, which was used in the fabrication of the hardest and most perfect bowls ever made. "

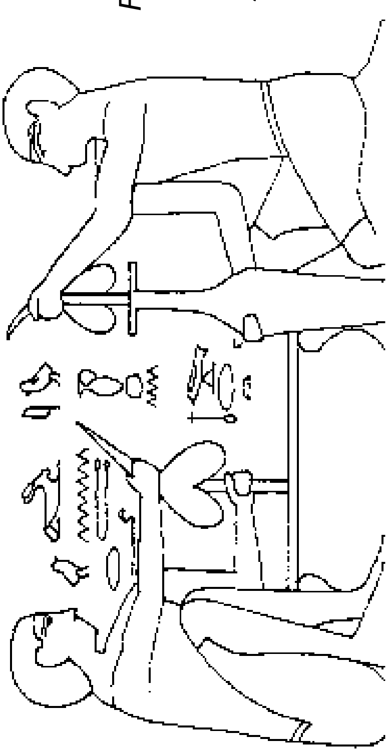
Egyptologists assume that the hard stone vessels were drilled with a type of tool often displayed in different tomb representations. This tool is a straight shaft with an inclined and tapered top handle. Two stones or bags of sand were fastened just under the handle (Fig. 39 a, b). Yet no drills of this type have ever been found. Rather, archaeological remains feature bow-drilling tools, a technology always depicted for drilling all kind of materials. According to Denys Stock [44b] the rate of drilling granite with the tool recommended by

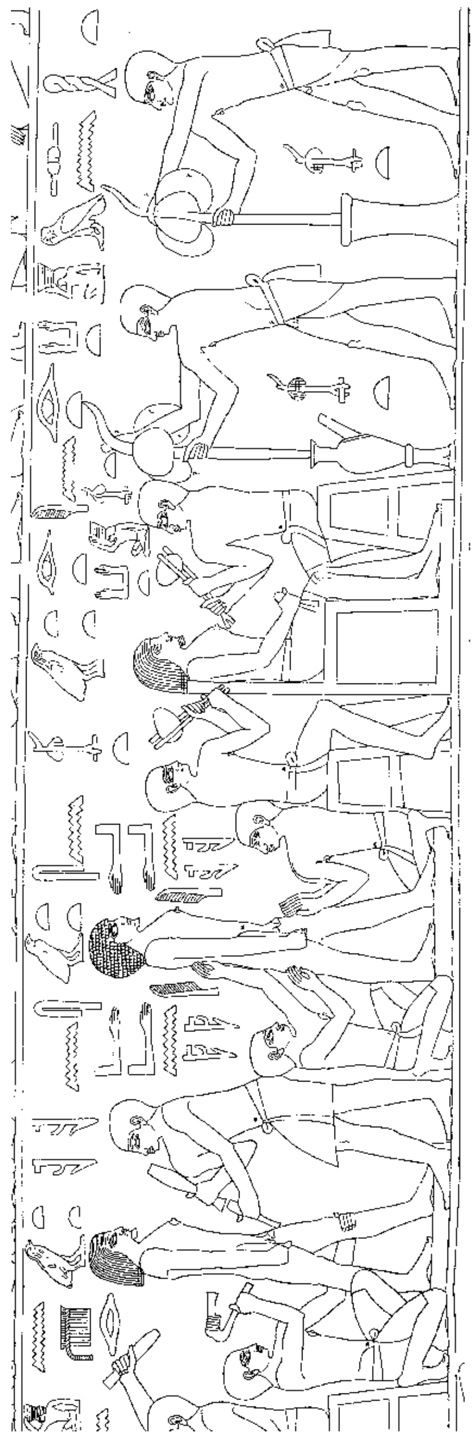
Egyptology is in the order of 60-75 times slower than drilling limestone by a copper tubular drill driven by a bow. I am therefore inclined to consider that the tool displayed in the tomb representations has a different purpose. For example, a bas-relief from the Sixth Dynasty tomb of Merah, at Saqqara, is interpreted by Egyptologists to depict workmen drilling out stone vessels (Fig. 39a). In 1982, I presented a different interpretation at the 22nd Symposium of Archaeometry, held at the University of Bradford, in Bradford, United Kingdom [45]. The vessels shown were made of Egyptian alabaster, a calcium carbonate stone. Alabaster vases made as shown were not carved or agglomerated. It is obvious the vase makers are not drilling. Rather they are squeezing a liquid, stored in a sewn animal skin or a bladder, through a tube. I suggested that they were drilling with the means of bio-tooling, that is, using an acidic liquid such as vinegar, citric or oxalic acid, or a combination of acidic liquids extracted from plants, to act upon the alabaster (calcium carbonate). It is well known that acidic plant saps dissolve calcium carbonate very easily. I have measured the efficiency of using acidic liquids of the type just mentioned on Egyptian alabaster in my laboratory. The conclusion of our scientific paper reads as follow:

> " An experiment of interest was to compare the bio-tooling technique with the shaping of a hole (in local limestone) using steel tool and the quartz sand technique recommended by archaeologists. The test was run for 15 minutes and the drilled volume was measured for each technique: for steel tool 12 ml, quartz sand 8.5 ml, bio-tooling 9.5 ml. (bio-tooling mix contains vinegar, citrus sap and oxalic sap). The hole resulting from sand abrasion has rough walls, whereas bio-tooling gives a smooth finish. "

The bio-tooling technology with acidic saps is not feasible when dealing with hard stones. It only works for calcium carbonate based stone, not for granite, basalt, hard schist

Figure 39: a) ((left) Bas-relief from the tomb of Merah. b) (down) Tomb of Ti (Fifth Dynasty) (after L. Epron and F. Daumas) showing the sculpting of wood statues (left), the finishing of a stone statue (middle) and works with vases (right).





and the like.

The relief from the Fifth Dynasty tomb of Ti provides additional clues (Fig. 39b). On the left of the relief one sees the sculpting (carving) of wood statues. The sculptors are using typical carpenter tools; over the head of each worker there is the double hieroglyphic sign *gn* (𓌩𓌩)determinative for sculptor (carver) (see T20 in Gardiner's list). In the middle of the painting, two workers are finishing a stone statue (sited men); on the right, two standing workers are at work on vases. It is generally stated by Egyptologists that these men are drilling hard stone vases. The first vessel (from the right) is an alabaster vase identical to the ones displayed in Fig. 38, whereas the second vase from the right is undoubtfully a ceramic vessel, not a stone vase. All four workers (vessel workers and finishers of the stone statue) are designated with the same hieroglyphic sign *hmt* (𓍊), which is the determinative for skilled man, craftworker. It is wrongly attributed to a stone worker's drill in Gardiner's list (U25). For a chemist, like myself, the tool represented in this relief is a hand-mixer used to mix and blend corrosive ingredients in any container (ceramic or stone vase). In addition, the hieroglyphic sentence written at the top right states: a man-made statue (*twt jrt kt*). The verb *jrt kt* (pronounced *ari-kat*) is found twice in this sentence and means: man-made, manufactured by man. It will be thoroughly discussed in Chapter 11, Fig. 50.

One can envision the production of the earliest stone vessels. The sacred alchemical products were first gathered. Natron saturated numerous lakes and was also found in large deposits in numerous desert regions. A natron lake was easily identified from other salt lakes because natron absorbs coloring from organic matter, leaving the water surface covered with a brown film. The peculiar taste of the water is also characteristic. Small white, unsoiled masses of pure natron were carefully removed from the tips of encrusted reed stalks growing above the water's surface. It is characteristic for the salt to crystallize more than an inch above the tips.

Another product was lime, CaO, acquired by calcining limestone or dolomite. Two of the earliest products of humankind are lime and bread. Yet, the lime supply for stonemaking in Egypt may have been a by-product of breadmaking. The collected wood and plant ashes may contain between 50 and 75 per cent by weight of lime CaO. The Nile valley was blessed with produce of all kinds, and some plants and trees would produce more or less lime CaO in their ashes. For bread, the main crops were winter and summer wheat and six-row barley. After agriculture was introduced in the Faiyum region during neolithic times, the lifestyle of the inhabitants of the Nile Valley gradually transformed from hunter-gatherer to farmer. Bread consumption increased over the epochs with expanded irrigation. Late records indicate that the Greeks dubbed the Egyptians *artophagoi*, the bread-eaters.

With the pharaohs involved in increasing agricultural yield, one can appreciate the precarious position of the high priests responsible for oracles and interpreting the pharaohs' dreams. The size of the pharaohs' monuments may well have depended on the predictability of the Nile. Enormous quantities of lime-ash from breadmaking in hearths, would automatically have been available and collected for stonemaking during plenteous years. Soda (natron) ritually added to bread dough to make unleavened bread during remote antiquity, would have placed all of the required elements (lime, natron, and water) in close proximity for the invention of one of the primary ingredients of stone making, caustic soda.

The Nile yielded sacred water for the process. Egyptian cosmogony asserted that the Nile water was the original abode of the gods from which sprang the forces of light and darkness. The Egyptian name for the Nile was Hapu, and the Nile god Hapu was identified with the cosmogonic gods. Hapu took the form of Khnum during the inundation, when an annual solemn, festival was celebrated to rejoice the rise of the waters.

Many types of rock aggregates, considered by the Egyptians to be withered or injured rocks, were available. Examples are flint, slate, steatite, diorite, alabaster, quartzite, limestone, dolomite, granite, basalt, and sandstone. Precious gems, such as diamond, ruby, and sapphire, were unknown. Semiprecious varieties acquired by mining or trade included lapis lazuli, amethyst, carnelian, red jasper, peridot, amazonite, garnet, quartz, serpentine, breccia, agate, calcite, chalcedony, and feldspar.

Table II. The Mafkat Minerals

Mineral	Composition	Color
malachite	copper carbonate, hydrated	bright green
azurite	copper carbonate, hydrated	light/dark blue
chalchantite	copper sulfate, hydrated	sky blue
antlerite	basic copper sulfate	light/dark green
linarite	basic sulfate of lead and copper	deep blue
olivenite	basic copper arsenate	avocado green
libethenite	copper phosphate, hydrated	olive green
turquoise	basic phosphate of aluminum and copper, hydrated	sky blue/green
chrysocolla	copper silicate, hydrated	sky blue/green
scorodite	iron arsenate, hydrated	light green/blue
lazulite	basic phosphate of iron and magnesium	bright/dull blue

In addition, the blue minerals required for geopolymerization, generically known as mafkat during the more ancient periods, are included in Table II. The first mining operations in the Sinai Peninsula were primitive. Mineral deposits were attacked with pointed flint implements. Sandstone masses were removed and crushed with harder stones to free mafkat nodules. Even though turquoise and chrysocolla look similar, the Egyptians made a distinction between the two. The following are the remarks of a miner from the time of Pharaoh Ammenemes III [46]:

> " I found that it was difficult to determine the right color when the desert is hot in the summer The hills burn... and the colors fluctuate... during the severe summer season the color is not right. "

Chrysocolla dehydrates in the hot desert sun, becoming whitish on the surface. Heating a sample with a flame would also have enabled a distinction because chrysocolla causes a flame to turn green. Nile silt was probably an ingredient of the earliest vessels. Silt was the traditional material for Khnum's mortal processes, and perhaps a union between the divine and mortal was symbolized through stonemaking.

Another substance was not vital to the chemistry but may have been added because it symbolized the highest spiritual essence. The product was gold, the metal of the Sun. During my analyses, I found flecks of gold dust in Lauer's sample from the Great Pyramid. It is possible that the gold did not occur naturally and was instead ritually added. Divine eternal qualities were attributed to gold. In addition to its beauty and association with the Sun god, gold does not rust or tarnish and can be worked indefinitely without becoming brittle or damaged. Even though gold was probably always an item of exchange, anciently its value was purely sacred. A monetary value gradually manifested. Some experts believe that the Egyptians never minted state gold coins until the Greek occupation or after 332 BC.

The practices of the first vesselmakers are lost in prehistory. A standard system of weights and measures was not adopted by 3800 BC. We can, therefore, only conjecture about a recipe for making a stone vessel of that period:

THE ETERNAL VESSEL of Khnum

1 heqat natron + 2 heqat wood ash

2 hin Nile water

2 heqat powder of mafkat + 3 heqat Nile silt + 5 heqat eternal rock particles

Ceremonial quantity of gold dust

Combine the sacred natron with ash powder collected from the hearth and blend them in a ceramic bowl with blessed water to form the caustic substance. Obtain mafkat which turns white on the surface during summer and which produces a green color of fire when you burn it. Powder the mafkat by crushing it with hard rocks and add it to the caustic substance. When the *mafkat* has been consumed, add fine silt such as Khnum uses to make perishable creatures. Recite prayers every day until the liquid has the consistency of honey, then add the injured, eternal aggregates (the limbs of Neter [God]), and the golden particles (the spirit of Neter), to incarnate His Divine Presence.

Protect your hands with oil and knead the material. Then fashion the vessel on your turning plates. Tear strips of linen and coat them with bitumen. Wind the strips around the outside of the vessel. Line the inside and carefully pack it. Allow the vessel to remain overnight. It will gain strength. When the vessel is strong, unwind the linen. Cover the vessel loosely with a linen cloth so that it can breathe. Remove the cloth when the vessel attains eternal life. Rejoice that Khnum's living vessel may endure forever!

Although the ritual is speculative, the chemistry is based on reactions that work very well in our laboratory. An analysis of stone pottery may prove that the early binders were far more sophisticated. A process involving turquoise and allowing objects to harden in air-tight molds was introduced at about 3000 BC and is described in Appendix 1. Methods used to make vases with narrow necks and rounded bellies were innovated for making glass vases in the Eighteenth Dynasty at about 1350 BC.

From primitive beginnings, Khnum's alchemical stonemaking technology advanced beyond pottery to produce the world's most impressive architecture. The earliest burial places were pits, where funerary gifts were placed for use in the afterlife. Buried bodies were naturally preserved in the warm, dry sand of the desert necropolises. Mastabas represent the next phase of tomb construction. These are rectangular mud-brick structures, named mastabas from the Arabic word for bench used to describe their shape.

Stone material began to appear in the mastabas erected at Abydos and Saqqara during the Archaic period. These tombs have been badly plundered and only enough material remains to establish a tenuous history of this period. The remains suggest a constant evolution of mastaba design and an increased magnificence of furnishings. The early royal mastabas of the First Dynasty consisted of a large covered underground chamber surrounded at ground level by a wall. As the dynasty progressed, the tombs acquired additional storerooms and an access stairway. Large wooden beams and linings were incorporated into the tombs of the pharaohs. Sealed in the tombs were funerary offerings of food, precious articles of copper and gold, and various commemorative items. The tombs also included a vast array of alchemically made vessels in various beautiful shapes and hard stone materials.

An artifact from a First Dynasty cenotaph indicates that the precious mafkat deposits were jealously guarded. An ivory label of Den, the fifth king of the First Dynasty, depicts him symbolically smiting a bedouin in the Sinai.

A dramatic architectural advance appeared by the end of the Second Dynasty. Adjacent to the mastabas the king built a large enclosure. The well preserved Palace of Eternity erected by Khasekhemwy, the last king of the Second Dynasty in Abydos, consists of imposing crude brick walls, 10-12 meters high and more than 700 meters periphery (Fig. 40).

Figure 40: Khasekhemwy's enclosure made of crude bricks, Abydos.

Until recently, local tradition assimilated this construction to the grain storehouses of the biblical patriarch Joseph, or to military fortifications. In fact, Khasekhemwy's Palace of Eternity was a replica of the enclosure wall of his secular palace. The enormous walls are crenellated, composed of alternating projections and recesses. A great number of their crude silt bricks are in excellent conditions, with little or no sign of erosion, after 5000 years. The crude bricks were overlaid with a decorative coating of white gesso, or white plaster. Khasekhemwy is the first of the great builders in Egyptian history.

The next major technological innovation, based on Khasekhemwy's superstructure, would revolutionize mortuary construction and have dramatic impact on the course of history,

Chapter 10

The Invention of Stone Buildings

Khasekhemwy left no male heir to the throne, and the Third Dynasty pharaoh first to rule was Zanakht. He was followed by Neterikhet (Zoser). Pharaoh Zoser's architect, Imhotep, was responsible for the construction of the first pyramid. Before discussing this accomplishment, we will review what little relevant information has survived about this intriguing historical personality. Imhotep left an unforgettable legacy. Historically, the lives of few men are celebrated for 3,000 years, but Imhotep was renowned from the height of his achievements, at about 2700 BC, into the Greco-Roman period. Imhotep was so highly honored as a physician and sage that he came to be counted among the gods. He was deified in Egypt 2,000 years after his death, when he was appropriated by the Greeks, who called him Imuthes and identified him with the god Asclepius, son of Apollo, their great sage and legendary discoverer of medicine.

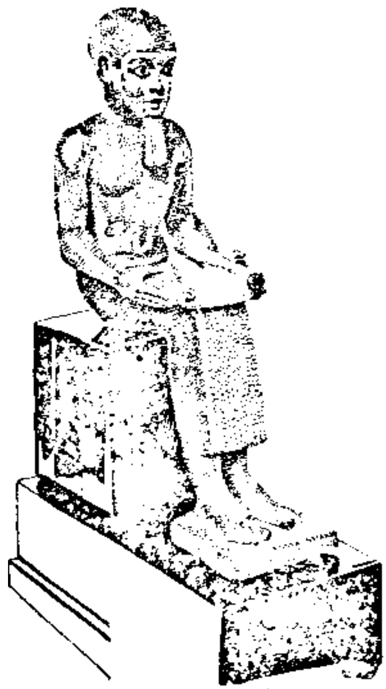


Figure 41: Statue of Imhotep.

Imhotep wrote the earliest " wisdom literature ", venerated maxim, which regrettably has not survived, and Egypt considered him as the greatest of scribes. This presiding genius of King Zoser's reign was the first great national hero of Egypt. During King Zoser's reign, Imhotep was the second most eminent man in Egypt, and this is registered in stone (Fig. 41). On the base of a statue of King Zoser, excavated at the Step Pyramid, the name and titles of Imhotep are listed in an equal place of honor as those of the king. Imhotep had many titles, Chancellor of the King of Lower Egypt, the First after the King of Upper Egypt, Administrator of the Great Palace, Physician, Hereditary Noble, High Priest of Anu (On or Heliopolis), Chief Architect for Pharaoh Zoser, and, interestingly, Sculptor, and Maker of Stone Vessels.

The titles confirm the records of the Greco-Egyptian historian Manetho on Imhotep, written in Greek 2,400 years later, during the early Ptolemaic era, in the third century BC [47]. Manetho was one of the last high priests of Heliopolis. Part of his text (reported by Sextus Julius Africanus) was translated in AD 340 by the ecclesiastic historian Eusebius to read, " the inventor of the art of building with hewn stone " . In fact, Eusebius's translation is incorrect. The Greek words Manetho used, *xeston lithon*, do not mean hewn stone: they mean polished stone or scraped stone. The words describe stone with a smooth surface, a feature characteristic of fine, agglomerated stone [see the discussion in note 48]. These words were also used in the Greek texts of Herodotus (see the discussion in Chapter 12). It is impossible for translators accurately to translate texts while lacking vital technical knowledge. Similar errors of translation have been made throughout history, and more examples will be provided. For Manetho, Imhotep was " the inventor of the art of building with agglomerated stone ". This refers to the construction of the first pyramid (Fig. 42).

Figure 42: Step pyramid of Zoser was the world's first building made entirely of stone.

Imhotep was regarded as the son of a woman named Khradu'ankh and the god Ptah of Memphis. The title Hereditary Noble indicates aristocratic parentage. His career would have begun when he was a boy trained by a master scribe. With his parents among the elite, lessons would have begun around the age of twelve. Because priests were among the literate of Egypt, he may have received scribal training by entering the priesthood. His title, High Priest of Heliopolis, was traditionally attained on two conditions. A man either succeeded his father in the priesthood, or he was personally appointed to office by the king because of some great deed. The position of high priest was attained after extensive training in the arts and sciences-reading, writing, engineering, arithmetic, geometry, the measurement of space, the calculation of time by rising and setting stars, and astronomy. The Heliopolitan priests became guardians of the sacred knowledge, and their reputation for being the wise men of the country sustained even into the Late Period.

Their religious ideologies and sciences were heavily applied to the construction of tombs and other sacred architecture. A magnificent solar temple oriented by the heavenly bodies was erected during the reign of Zoser to mark the most sacred place in Heliopolis. The city was the holy sanctuary of Egypt, the ground itself religiously symbolic. The site for Heliopolis had been chosen at a location in the apex of the Delta where the inundating Nile waters first began to recede. There the earth, fertilized by the arrival of silt and nurtured by the Sun, received the first renewed life of the agricultural year. This ground represented rebirth and Creation.

Located about twenty miles north of Memphis, the town is estimated to have measured 1,200 x 800 meters (3/4 mile x 1/4 mile). It became the capital of the thirteenth Lower Egyptian nome or district. No precise archaeological history of the city has been established. So it is unknown when ground was first broken for construction. The city is considered to have been founded during prehistory, and it had a very impressive life span. It flourished in the Pyramid Age and still remained an important center when Herodotus visited Egypt in the fifth century BC. Today, all of the temples and buildings of Heliopolis have vanished and the abandoned site has been incorporated into a suburb of eastern Cairo. Only a single standing obelisk, erected for a jubilee of Pharaoh Sesostris 1 (1971-1926 BC), remains amid empty fields.

When King Zoser was enthroned, he no doubt expected to be buried in a mud-brick mastaba with a superb Palace of Eternity similar to that of his predecessor Khasekhemwy. The site for his tomb was selected at Saqqara, south of Memphis. Design plans and calculations for orienting the monuments were being made. At this point, the subsequent history of the construction of all pyramids must be revised on the basis of my discoveries.

Khasekhemwy's Palace of Eternity provides a key architectural design, which has been ignored by the archaeological community. Because the massive walls were

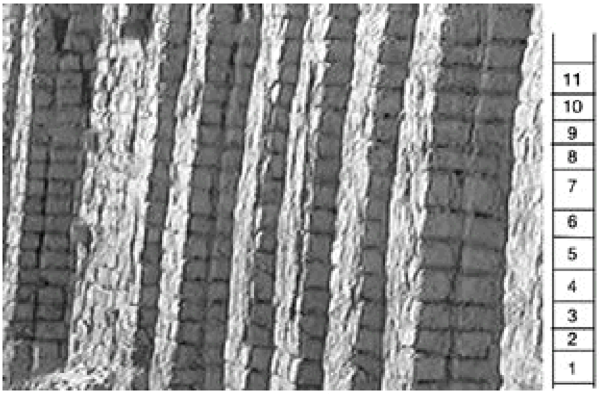


Figure 43a: Enclosure of Khasekhemwy Palace of Eternity is made of crude bricks of different sizes.

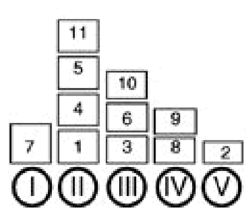


Figure 43b: Five sizes for crude bricks in Khasekhemwy's enclosure.

made of crude bricks, formed in molds, it has always been stated that the brick sizes would be uniform from one layer to the other. The picture of Khasekhemwy's enclosure wall and the sketch focusing on the bricks heights, reveal that this statement is entirely wrong (Fig. 43a,b).

Khasekhemwy's enclosure displays five different brick sizes. By measuring the height of 11 successive layers, I found that layer no.7 contains large crude bricks of size (I), layers no. 1, 4, 5, 11, medium high bricks of size (II), layers no. 3, 6, 10 medium bricks of size (III), layers no. 8, 9, medium bricks of size (IV) and layer no.2, the smallest size (V). In other words, the architect deliberately prepared 5 different molds for the manufacture of the crude clay bricks. In the previous Chapter 8 on the Proofs at Giza, I mentioned how the staggering block heights produce tremendous stability. This key architectural knowledge was continuously used in the construction of every major building erected since that time. It explains the height variations measured for Khufu Pyramid layers, displayed in Fig. 5.

Minerals were being excavated to produce stone and blue ceramics for lining interior walls and floors. King Zoser's workmen inscribed a stele in the sandstone cliffs of the mines of Wadi Maghara in the Sinai to commemorate the construction of the monument. Some time before actual construction got under way, Imhotep made an important discovery. Certain titles of this Chief Architect, Sculptor, and Maker of Stone Vessels profile prerequisite skills for building a monument with alchemically made stone. He would have applied himself to producing a mastaba which would last forever. Like the pride in a great nation, the pride intrinsic to a monument would be its longevity.

Khnum's clergy apparently amalgamated its alchemical science with that of the Heliopolitan priests when stone was first made for use in architecture. Imhotep perhaps specialized in materials processing or alchemy. His aim may have been to strengthen the sun-dried Nile silt bricks used for mastabas and enclosures. Any attempts made by Imhotep or others to fire bricks made of silt from the Nil River would have been futile. The Nile silt contains the refractory element aluminum oxide, not the silico-aluminates, the components required for producing good, fired bricks at temperatures that they were capable of achieving. They would not even come close to the required temperatures of 1,300 to 1,500°C (2.400 to 2,700°F). Ordinary clay had been fired for pottery since pre-dynastic times by using fluxes to lower firing temperature, but this fired material was impractical for construction purposes.

Let us suppose that Imhotep discovered the properties of the yellow limestones located at Saqqara: a lime-sandstone and a clay-limestone (marl). These materials contain a minimum of 10%, sometimes up to 60% of aluminous clay, which is released in water, yielding a muddy limestone [49] (see Appendix I, *The Fifth Alchemical Invention*). Water eases disaggregation, making the limestones ideal for stone making, and the aluminous clay itself produces a dramatic result in combination with caustic soda and lime. Using aluminous clay instead of the required amount of mafkat, the material of the process most difficult to obtain was indeed eliminated for building the pyramid. Mafkat was required only for stones of high quality, such as stone vases. By eliminating the mafkat, Imhotep's simple innovation enabled the enormous leap from small-scale funerary applications to the massive scale of the pyramids.

Small mud-brick molds with different sizes were filled, as they had been for Khasekhemwy to produce the pharaoh's Palace of Eternity. But for the first time, the mud-brick molds were being filled with muddy limestone concrete and, as for the making of pisé, the material was rammed with a pestle. When, two decades ago, I started this study, I introduced the notion of " cast-stone ". Several magazine writers exaggerated this description and their headlines went far beyond by emphasizing on " … pouring a Pyramid " (see in note [40]). Casting a fluid or pouring blocks or bricks require sophisticated molds like those implemented for the making of stone vases (poured) or statues. I am presently introducing a slightly different and more feasible technology. It is connected to the packed-earth (rammed earth) or pisé technique. This more practical method is developed in several following chapters.

The new stone bricks, produced in five or six different sizes, were dried in the shade to avoid premature cracking, demolded, and transported to the construction site. The alchemically made stone bricks were used to produce a huge Enclosure and a square mastaba with its sides oriented to cardinal points. The Enclosure comprises limestone bricks of six different heights (Fig. 44). The burial chamber was underground. The mastaba was covered with small casing bricks of smooth limestone, and the sacred monument was considered to be complete.

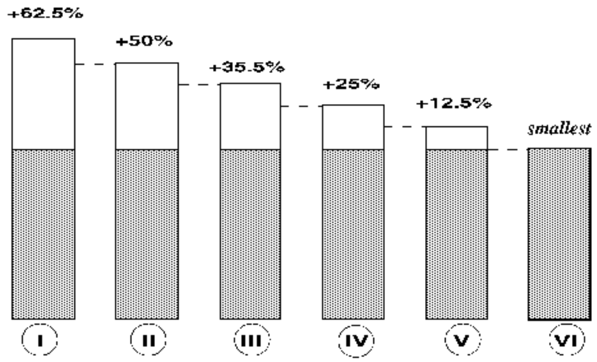


Figure 44: Six heights of limestone bricks measured in Zoser's pyramid Enclosure at Saqqarah; increase of height in per cent compared to brick nr. VI.

Some time passed, and the stone bricks showed no sign of cracking. The pharaoh no doubt soon desired to make

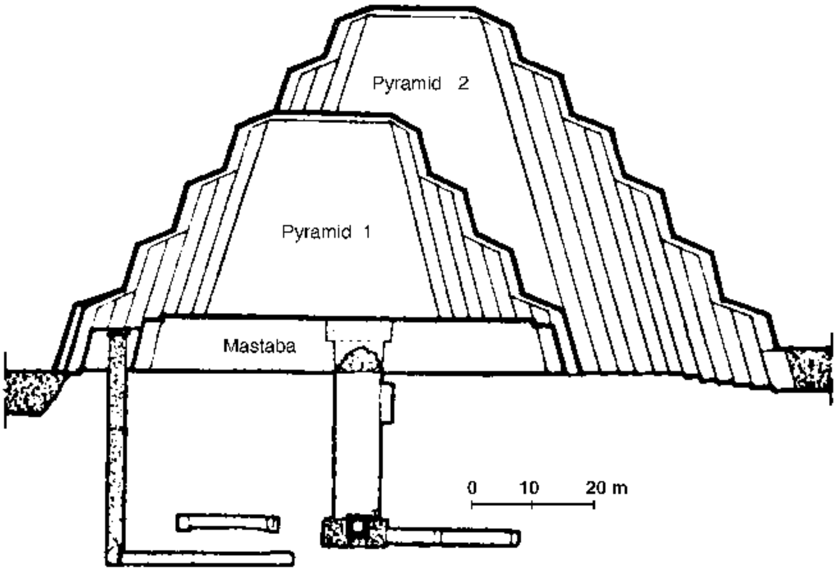


Figure 45: Successive stages of construction of Zoser's pyramid are the Mastaba (M) and elaboration on the design (P1 and P2, after J.P. Lauer).

additional use of the new building material. Imhotep drew up plans to enlarge the mastaba. First, ten feet of agglomerated limestone were applied on each of its sides. Then, a more elaborate plan was devised. A twenty-five foot extension on its eastern face transformed the square mastaba into a rectangular shape, and the project was again brought to a close (Fig. 45).

A later inspection would show that the stone under the weight of the mass showed no sign of cracking. King Zoser and Imhotep conferred again, and a plan was devised to heighten the structure to two tiers. Additional subterranean chambers, a shaft, and corridors were also dug.

As the size of the structure increased, the size of the bricks increased, maintaining, however, the five-six size distribution of the height within the construction (Fig.46). We are witnesses to dramatic design alterations inevitable with all revolutionary technological breakthroughs.

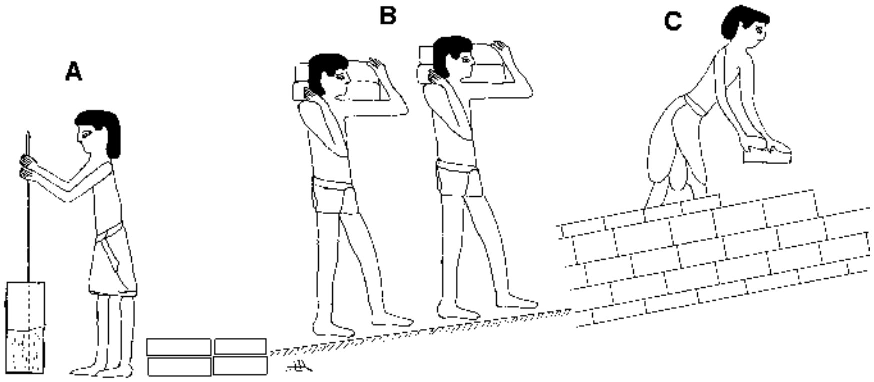


Figure 46: To construct Third Dynasty pyramids, worker (a) rammed limestone bricks in different wooden molds, (b) transported the bricks to the construction site, and (c) built the pyramids in inclined layers made of different brick sizes.

The more extraordinary their architectural wonder became, the more they built upon it. The amount of agglomerated stone that could be made would have appeared endless. A transformation into a four-tiered structure was followed by another construction phase in which the final form of a six-tiered pyramid, sixty meters (196 feet) high emerged. Its design included internal walls and inclined stone

Figure 47: Limestone bricks of Zoser's pyramid are rounded like molded bricks.

layers to provide great stability. With great skill and ingenuity, Imhotep incorporated all of the engineering and artistic methods the nation had derived from countless decades of building with wood, bundles of reeds and stalks, and sun-dried silt brick.

The final outcome was an extraordinary funerary complex. The Heliopolitan religious doctrine profoundly influenced its architectural form and the symbolism of its motifs. The design theme incorporated mythology which preserved and amalgamated Egypt's most ancient and cherished cosmological beliefs. Heliopolitan theology taught that in the beginning, a primordial megalith, known as the Ben Ben (benben), arose out of the waters of Chaos. The benben represented the hill or mound upon which Creation began. The benben has been interpreted to symbolize dense, primeval physical substance or matter.

The Creator appeared on the benben in human form, as Atum, the personification of the Sun, or in the form of Bennu, the phoenix of light. Out of elemental chaos the Creator separated the darkness from the waters. The Creator formed a trinity after having created himself and Shu, the god of air, and Tefnut, the goddess of moisture. Tefnut and Shu procreated Geb, the earth, and Nut, the heavens. Four other deities were created, and all of the gods together made up the Heliopolitan Enneade. In later times, the Greek philosopher Empedocles (c. 495 - 435 BC) recognized in the primordial Egyptian gods personifications of air, water, earth, and fire. Empedocles, and alchemists of later eras, held that these were the indestructible elements that composed all matter.

James Henry Breasted (1886 - 1935), founder of the Oriental Institute at the University of Chicago, first recognized that the pyramids themselves are representations of the benben. After the first Heliopolitan temple was built, Egypt had adopted the ideology that the benben, or stone symbolic of the Sun god, was located beneath the temple.

The theogonic theme appears in subterranean chambers of King Zoser's pyramid. Special chambers are lined with blue ceramic tiles in patterns depicting the primeval reed marsh from which vegetable life first emerged. Blue was the color symbolic of the Creator, and the blue glaze on the tiles imitated chrysocolla, the mafkat mineral indicative of Creation. With the exception of this monumental first pyramid, the artistic theme depicting the events of Creation was preserved only in the holy of holies of the great Sun temples.

In a specially designed room a life-size stone statue of Zoser seated upon his throne represented his eternally reigning spirit or ka. When this statue was found by archaeologists, it was intact except for damage to the eyes and surrounding facial area. The eyes were probably made of semiprecious gems, which would most likely have been pillaged when the tomb was plundered. Certain stone statues of the Old Kingdom now in the Louvre and the Cairo Museum are greatly admired for their inlaid eyes, a technique offering extraordinary realism and easily afforded by using alchemically made stone. Other rooms held the 30,000 stone vessels of Khnum, agglomerated using aggregates of schist, breccia, granite, diorite, and various other stones .

Surrounding the pyramid, a wall with clean architectural lines, originally more than thirty feet high, encloses more than a square-mile area. A characteristic of the smooth stone, encasing the wall and now mostly removed, is that it appears to be polished. The wall protects an elegant entrance colonnade, great courts, large buildings, a mortuary temple, and ceremonial altars and shrines. The enclosed area is virtually an entire town. The design character of the enclosure wall resembles contemporary architecture, and did, in fact, influence a style of twentieth century architecture. European architects visiting Saqqara earlier in the century found the enclosure wall a refreshing, appealing diversion from ornate

Victorian architecture. They left with the inspiration for a style of architecture that we now consider modern and take for granted.

It was the pride of Egypt. Zoser's funerary complex, with its towering pyramid and exquisite artistry, was unprecedented in the history of the world. Throughout Egyptian history the time of Imhotep was looked on as an age of great wisdom. Like the First Time event of Creation, as it was called, and the founding or amalgamation of the Egyptian nation by the first pharaoh, King Menes, the construction of the Step Pyramid was viewed as another first time event of great importance.

Chapter 11a

It Is Written in Hieroglyphs

Written texts of pyramid construction must have existed. The legacy of and events surrounding these monuments were far too important to have gone unrecorded. Surviving documents from the Old Kingdom (c. 27O5 - 225O BC) are limited in number and extent, and Egyptologists have long claimed that no ancient Egyptian record from any period describes how the pyramids were built. Their error is that they seek records of stone cutting, hauling, and hoisting. They do not have the pertinent texts that would be required for making their historical deductions about pyramid construction.

Unaware of the technology used, Egyptologists have misunderstood the meaning of Egyptian writings that document pyramid construction-writings that concur with my findings. A pertinent document was inscribed on a rock, called the Famine Stele, discovered on the island of Sehel, near

Elephantine, by Charles Wilbour in 1889. Egyptologists are divided on its authenticity, but insist the document is a copy of Old Kingdom texts made by priests of Khnum in about 200 BC. The texts date to the reign of the pharaoh Zoser, 2,500 years earlier.

During 200 BC, foreign kings ruled Egypt. In 332 BC, the king of Macedon, Alexander the Great, led an allied Greek army into Egypt. Having endured centuries of oppressive foreign domination, Egypt welcomed Alexander as the deliverer. Egypt had been ruled by Libya, Sudan, Assyria, Nubia, and Persia, and only managed to regain a brief re-establishment of native power when the Greek army advanced. Alexander sacrificed to Egyptian gods and ceremoniously received the double crown of the pharaohs, acquiring the title " Son of the Sun ".

In the winter of 332-31 BC, Alexander founded the capital city of Alexandria in northern Egypt along the Mediterranean Sea at the western edge of the Nile delta. After his death, Egypt was ruled by his subordinates, who laid the basis for the Ptolemaic dynasty. Under Ptolemaic kings, Alexandria rapidly became the main religious and intellectual center of Jewish and Hellenistic culture. Even though Greek interests dominated, there was no desire to eradicate Egyptian culture. The Macedonian people held the utmost regard for the Egyptians. They admiringly traced their own architectural heritage and religion to Egypt. Numerous Egyptian deities were identified with Greek gods.

Under Hellenistic cultural dominion Egyptian cities became known by Greek names. The holy city of the Sun cult, Anu, became known as Heliopolis, the city of the Sun. A town called Khmun (the City of Eight) became known as Hermopolis, the city of the Greek god Hermes. The Greeks identified the Egyptian god Djehuti, or Thoth as he was called in Greek, with Hermes. The town of Khmun acquired its name from the Ogdoad, four pairs of primeval gods that presided in the waters of Chaos, namely, Darkness, Invisibility, Secret, and Eternity. By historic times, Thoth had absorbed and replaced these gods. Thoth became the personification of divine wisdom, the scribe of the gods who protected learning and literature. Egyptian texts called him Lord of Divine Books, Scribe of the Company of Gods, and Lord of Divine Speech.

Alexandria possessed two celebrated royal libraries, and Hermopolis also maintained a great library containing treasured literature preserved by the virtues of Thoth. It was this library that preserved a document from the time of King Zoser that recorded Imhotep's revelation.

The Famine Stele was produced during the reign of King Ptolemy V Epiphanes (205 - 182 BC). This king was enthroned at the age of five, and his reign was characterized by the loss of foreign territory, revolts in the Nile delta, and general civil and political upheavals. His decree inscribed on the famous Rosetta stone, produced in 196 BC, indicates that in this political setting native Egyptians were gaining more control over their domestic affairs. Taxes and debts were remitted and temples received benefactions.

The political climate was appropriate for the clergy of Khnum to resolve a matter of growing concern to them: Greek troops stationed in the region near the first cataract paid great tribute to the goddess Isis. Greeks at all levels, soldiers, commanders, and the king himself especially venerated this goddess. The king's father, Ptolemy IV was so devoted to Isis that he made the title Beloved of Isis part of his royal name. An old temple of Isis at Philea, built during the Saite period (664 - 525 BC), was torn down by Ptolemy II (285 - 246 BC) and replaced with an extravagant, costly temple. Territories of Nubia, south of the border, were dedicated to Isis, and additional elaborate offerings made her cult the wealthiest in southern Egypt.

The region Isis occupied was the primary seat of Khnum worship since remotely ancient times. It encompassed the entire cataract region, including the island of Elephantine, Philea, Sehel, Esna, and Aswan. Elephantine, the sanctuary of Khnum, is located in the middle of the river, and the island represented the official southernmost border throughout most of the nation's history. Elephantine served as a garrison because of its location directly below the first cataract, a natural defensive barrier, and also as an entrepot for imports entering Egypt by ship from the south.

The importance of the island of the southern frontier varied after the Middle Kingdom (2035 - 1668 BC), depending on what territory Egypt controlled. Khnum's influence was vastly diminished before the Ptolemaic period, long after the pyramids were built. Khnum's temples suffered a great deal of damage over the centuries at the hands of invaders entering from the south. And Khnum's dilapidated temples sorely contrasted with the exquisite new temple of Isis. This, coupled with the loss of Nubian territory to Isis, meant that Khnum's cult was rapidly being displaced by that of Isis.

An opportunity apparently presented itself for Khnum's clergy to confront the king with the matter. The Rosetta stone informs us that in the eighth year of the reign of Ptolemy V the Nile produced an extraordinary inundation of all of the plains. This created famine by diminishing the productive farmland temporarily. Khnum symbolized the Nile, and his clergy administered matters concerning its aberrant flooding. A nilometer leading from the bank to the low water level, with calibrated steps to measure the rise of floodwater, still remains on Elephantine.

The priests visited the Hermopolitan library probably around 190 BC. There they referenced old texts to demonstrate how Nile aberrations had been remedied in the past. Even though there were many famines in Egyptian history they sought records dating to the time of Pharaoh Zoser and Imhotep. These records showed generous offerings to Khnum for ending a famine, and the priests were able to demonstrate to the king that their cult had more than 2,500 years of experience in effectively dealing with abnormalities of the Nile.

Figure 48: Famine Stele on Sehel, near Elephantine.

The accounts they referenced had been preserved for 2,500 years despite episodes of civil war and invasion. They produced from the records a dramatic historical story, animating Khnum, as was customary with Egyptian gods, in an episode with King Zoser. For this they used a written message sent to Elephantine by King Zoser, identifying his pleas for an eight-year famine to end. They sought to show that the territory given to Isis had been dedicated to Khnum by King Zoser himself. Not only did the priests have the data to produce a stele serving as a territorial marker, but they could demonstrate the prosperity provided for Egypt by their cult's careful management of the Nile over the ages. Their records also served to remind the Greek administration of the great legacy that Khnum's alchemical technology had given Egypt.

They reproduced inscriptions on a rock, now called the Famine Stele, which stands on the large island of Sehel, 3 kilometers (1.8 miles) south of Elephantine (Fig. 48). Sehel, treasured for its mineral deposits, was the traditional abode of the goddess Anunkis, Khnum's daughter. When the stele was viewed by the king and his ministers, its authenticity and authority were honored. The Greeks revered Zoser as an exceptionally great king, who, along with Imhotep, was considered to be one of the founders of Egyptian culture. An earlier king, Ptolemy II, had established the worship of Imhotep as a deity in the upper level of the temple of Deir el-Bahari, located on the West Bank almost directly opposite Karnak. Still standing are remains of a temple dedicated to Imhotep on the island of Sehel built by Ptolemy V at about 186 BC.

It appears that the priests had advised the king well with regard to the Nile. The wise management of the destructive flood turned it into a blessing. The Rosetta stone relates that King Ptolemy V spared no expense in erecting a dam to direct an overflow of the Nile to proper channels. In doing this, he created an abundant crop yield and earned the title Savior of Egypt. The king also drew up a new decree to provide benefactions for Khnum's temples. Khnum was given all rights of sovereignty up to a distance of twenty miles of Elephantine, which included lost portions of Nubia. All who fished or hunted within this territory were required to pay a fee. The quarries of Sehel and Aswan could be exploited only by consent of Khnum's priests. Boats would pay duty on imports, such as metals or wood entering Egypt along the Nile from the south.

Egyptologists believe that the relevant inscriptions on

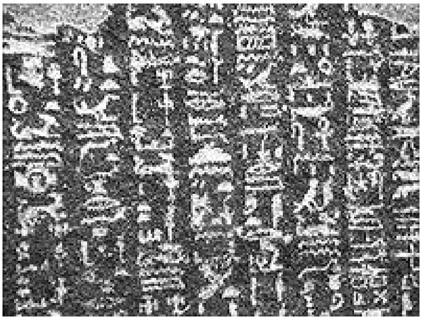


Figure 49a, b: a) Head of the Stele. b) Medium portion of columns 8 to 15 (read from right to left) on the Famine Stele.

the Famine Stele were derived from authentic documents dating from Pharaoh Zoser's reign (2630 - 2611 BC), that were enhanced by Khnum's priests during the Ptolemaic period. The Famine Stele consists of five chapters, made up of thirty-two columns of hieroglyphs written from right to left: columns 1 to 4, The Description of the Famine; Columns 4 to 6, The Visit to the Library of Hermopolis; Columns 8 to 18, The Revelations of Imhotep; Columns 18 to 22, The Dream of Pharaoh Zoser; Columns 22 to 32, The Royal Decree.

The Famine Stele contains other major elements having nothing to do with territorial rights or famine. Actually, the stele might be better named Khnum's Alchemical Stele, for it holds the key to the method of manufacturing man-made stone. Of about 2,600 hieroglyphs making up the inscriptions, about 650 or approximately one-forth pertain to rocks and mineral ores and their processing (Fig.49).This disclosure occurs in columns 10 to 22 and I am focussing on this passage. I use the English version of Lichtheim [51] as a guide because it is the English version available today. I have underlined the words (keywords) I studied so far:

The revelations of Imhotep

(Col. 11) There is a mountain massif in its eastern region,
with <u>precious stones</u>
and <u>quarry stones</u> of all kinds, all

(Col. 12) the things sought for building temples in Egypt, South and North, and stalls for sacred animals, and palaces for kings, all statues too that stand in temples and in shrines. Their gathered products are set before the face of Khnum and around him.

(Col.13)… there is in the midst of the river a place of relaxation for every man who works the stone on its two sides.

(Col. 15) Learn the names of the stones that are there lying in the borderland: … bhn, mt3y, mhtbtb, r'gs, wtsy, prdn, tsy.

(Col. 16) Learn the names of the precious stones of the quarries that are in the upper region: …gold, copper, iron, lapis lazuli, turquoise, thnt, red jasper, k', mnw, emerald, tm-ikr, nsmt, t3-mhy, hm3gt,

(Col. 17) ibht, bks-'nh, green eye-paint, black eye-paint, carnelian, shrt, mm, and ochre,…

The dream of Zoser

(Col. 18) I found the god standing before me…, he said, I am Khnum, your maker! My arms are around you, to steady your body,

(Col. 19) to safeguard your limbs. I bestow on you stones upon stones (that were not found before) of which no work was made for building temples, rebuilding ruins, on laying statues' eyes. For I am the master who makes, I am he who made himself exalted Nun, who first came forth, Happy who

(Col. 20) hurries at will; fashioner of everybody, guide of each man.

In column 12, Lichtheim changes the meaning of the hieroglyphic sign for pyramid into palaces, which is not the same (see in Fig. 51). In columns 11 to 17, Imhotep describes the rocks and minerals of the Elephantine region to Zoser. Columns 18 to 20 describe a dream of Pharaoh Zoser, in which Khnum gives the minerals to Zoser to build his sacred monument. Limestone (transliterated *ainr hedj*), the predominant variety of stone found in the pyramids, is not found on the list. Sandstone (*ainr rwdt*), the primary material

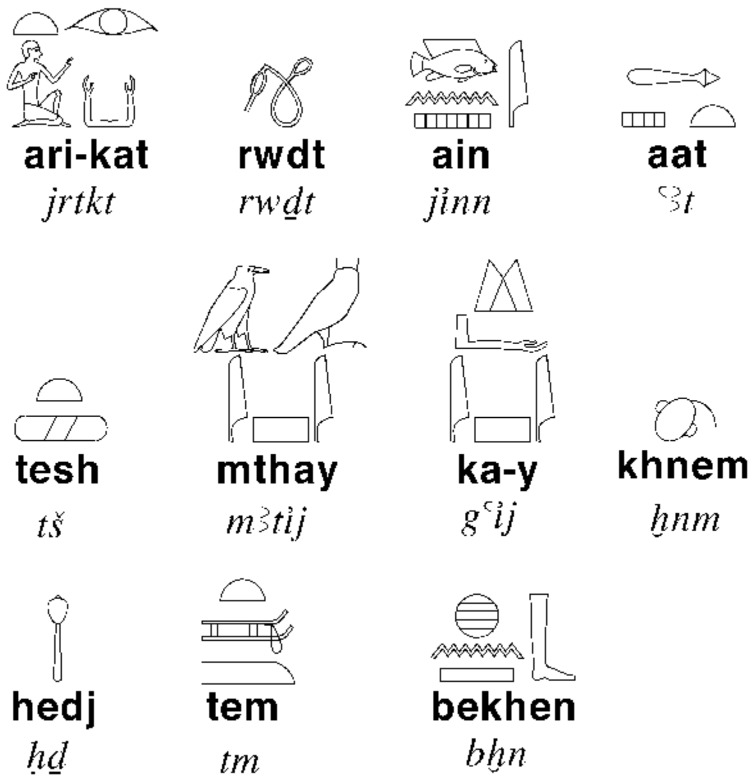


Figure 50: Key words in Famine Stele

used to build temples between 1500 BC and Roman times, is not listed, nor is Aswan granite (*maat*), the preferred building material of the Ptolemaic period, especially at Alexandria. A pyramid cannot be built with mineral ores unless one uses the minerals to produce a binder for agglomerating stone.

The hieroglyphic names of several minerals on the list have never been translated. Other words are of dubious translation. Their correct translation is vital to the meaning of the stele. I refer to the latter as key words, and they are related to rocks and minerals or their synthesis. Based on my own archaeological discoveries and knowledge of mineralogy and chemistry I have started an in-depth study to decipher as many of the untranslated and mistranslated terms as possible.

In 1988, I produced a new translation of the stele at the Fifth International Conference of Egyptologists, Cairo, Egypt, presented here [50]. It combines my research with the standard translations made by Egyptologists Karl Brugsch (1891), W Pleyte (1891), Jacques Morgan (1894), Kurt Sethe (1905), Paul Barguet (1953) and Lichtheim (1973) [51]. Barguet's translation reflects the most up-to-date knowledge of Egyptology. The only fairly recent study of the stele was made by S. Aufere in 1984. The only improvement the latter may provide is a possible translation of one semiprecious variety of stone. The key words I studied follow (Fig. 50):

Ari-Kat

The first word is an adjective which is transliterated into English as *ari-kat*. *Ari*, when associated with minerals, is a verb that means to work with, fashion, create, form, or beget. The second part of the word, *kat*, means man. *Ari-kat* means the work done by man. In other words, *ari-kat* means man-made, processed, or synthetic. A general example of its use is the designation of imitation lapis lazuli. The word appears in columns 13, 19, and 20. In columns 13 and 19, it describes the process of mineral ores for pyramid building. In column 20 it refers to Khnum creating mankind.

Rwdt

Another key word appears in column 11 and is transliterated *rwdt*. Barguet translated this word to mean hard stone. J. R. Harris, in Lexicographical Studies in Ancient Egyptian Minerals, discussed *rwdt* in some detail and stated [52]: " In any event, there can be little doubt that *rwdt* is a term indicating hard stone in general, though which stone would fall into the category it is difficult to say, especially in view of the reference to alabaster as *rwdt*. "

Alabaster is a very soft stone. *Rwdt*, however, generally refers to the monumental sandstone of southern Egypt. This is the soft stone discussed in Chapter 3 used to build the temples of Karnak, Luxor, Edfu, Dendera, and Abu-Simbel, the stone material so soft that it can be scratched with one's fingernails. This type of stone is eight times as soft as Aswan granite, and *rwdt* therefore could not indicate hard stone.

Rwdt, however, also means to germinate or grow. A causative verb form, *s-rwdt*, means to make solid or tie strongly; *rwdt* also describes aggregates or pebbles of sandstone, quartzite, and granite. These varieties of stone result from the natural solidification of aggregates. Sand, for instance, reconstitutes into sandstone in nature. *Rwdt* could therefore indicate aggregates that can be naturally or otherwise cemented into stone and could be the determinative for agglomerated stone.

Ain

The word transliterated *ainr* simply means natural, solid stone. Most types of stone used for construction are referred to as *ainr*. When the " r " is omitted from *ainr* to produce *ain*, the word has a slightly different meaning. *Ain* is a generic word for stone, simply used to set it apart from other materials such as wood or metal. The generic word *ain* appears in column 15 to describe the various rocks and mineral varieties, whereas *ainr* or solid stone block, such as *ainr hdj* (limestone) and *ainr rwdt* (sandstone) do not appear in the Famine Stele at all.

Tesh

The composite word, *rwdt uteshui*, appears at the end of column 11. Barguet translates the word to mean « hard stone from the quarries ». He notes, however, that his translation may be doubtful because of the peculiar way in which the word is written. I have shown that *rwdt* could not mean hard stone.

The root word *tesh* also appears in two stone materials listed in column 15. Barguet transliterates this root as *sheti*. *Tesh* has the general meaning of crush, separate, or split. The word *hetesh* indicates the action of dissolving or disaggregation. *Tesh*, therefore, describes a stone that has been crushed, disaggregated, or split, meaning an aggregate such as would be required for making synthetic stone. The compound word *rwdt uteshui* could refer to the raw material, crushed, disaggregated, or naturally weathered natural stone. If this assumption is correct, the stony materials (*ain*) listed in column 15 were in a loose form or easy to disaggregate. In column 15 two names contain the root *tesh*, whereas four names do not. As discussed later, however, the two stones (*mthay* and *bekhen*) belong to the category of disaggregated materials.

Mthay

Mthay appears to contain the word *mat*, which means granite. Harris agrees with Barguet when he notes that it is strange that granite is not otherwise mentioned in the Famine Stele. They expected to find stone suitable for construction. Furthermore, granite and sandstone are the most common stone varieties found in the Aswan region.

It is likely that this remarkable form of writing alters the word *mat* (granite). Except for the peculiar hieroglyphic orthography that occurs in the Famine Stele, granite is always written in a standard way, namely, a sickle, which indicates the sound “ me ”, accompanied by various adjectives.

Instead of the sickle, in columns 15 a denuded bird appears, devoid of feathers or wings. This way of writing “ me ” also appears in the word *mut*, meaning to kill oneself. A similar word, *meth*, means to die. And *mat* or granite is often written with the ideogram for heart of life, suggesting the notion of living granite. Assuming that the scribe wanted to indicate that the desirable granite chosen must be weathered, loosely bound, or disaggregated, he would have emphasized the idea of dying or withered granite.

Bekhen

The stone called *bekhen* has also been named in inscriptions at Wadi el-Hammamat, located in the desert southwest of Aswan. *Bekhen* is considered to be one of several possibilities, black basalt, diorite, sandy schist, porphyry, graywacke, or psammite. The inscriptions at Wadi el-Hammamat indicate that quarrying *bekhen* was carried out in a primitive fashion [53]. The boulders chosen were pushed off a cliff and thereby split into numerous chunks. This would indicate that this hard stone was, after all, separated in smaller aggregates, as would be required for agglomeration.

Aat

Aat appears in columns 11, 16 and 19. *Aat* designates for Bruggsh *Steinen* (stones), for Sethe *kostbare Mineralien* (precious minerals), for Barguet *pierres précieuses* (precious stones), for Lichtheim *precious stones.* Harris [52] discusses the meaning of *aat* and concludes:

> “ Now it is evident that *aat* does in fact cover a very wide range of materials, largely minerals… If then *aat* is to be regarded as a word for mineral, with perhaps certain implications of value and rarity, the distinction between *aat* and *inr* becomes clear, since the latter refers principally to stones which were quarried in large quantities… it is possible to arrive to some significant conclusions regarding the ancient Egyptian attitude to raw materials as a whole and to mineral substances in particular… In general there seems to have been a fairly clear distinction drawn between those natural resources which were minerals, and those which were of

vegetable or animal origin, the former being referred to as *aat*, the latter as *shmw*,… "

According to Harris *aat* means a mineral brought from the mountains and probably therefore mined, generally in small lumps as opposed to the larger blocks of constructional stone; *aat* would then refer to mineral ores. Column 16 starts with " learn the names of the rare *aat* " and the list provides the hieroglyphic names for mineral substances including metals, semi-precious stones (mafkat), mineral ores (red ochre) and other untranslated substances. More restricted terms for the different classes of mineral substances are almost entirely lacking, and it is quite evident that there was little or no differentiation between the metals and the mineral ores. In historical times most metals were obtained by smelting ores suggesting that *aat* also refers to mineral ores which had to be processed. Although Egyptologists often associate *aat* with hard stone vessels, many of the minerals listed in Columns 16-17 are friable and even powdery. In column 19, one really appreciates the exceptional value of this text. It speaks of the actual processing of mineral substances, which were being used for the very first time for building a pyramid and temples. Verse 19, quoting Khnum, reads, " I give you *aat* after *aat*… never before has anyone processed them [to make stone] in order to build the temples of the gods… "

Khnem, Khem (a bladder with liquid) (sign Aa3 in Gardiner's list)**.**

This hieroglyph opens several areas of discussion. None of the aforementioned translators have offered a phonetic value for the hieroglyphic symbol or ideogram depicted. The symbol signifies odor, but not a pleasant scent such as that of perfume. Instead, it depicts substances that give off an odor, efflux, or emanation which is not offensive; the word, therefore, does not imply stench. At times the symbol is found in combination with the symbol for pleasure or pride.

Brugsch suggests that the ideogram signifies an unguent, whereas neither Barguet nor Lichtheim attempt to translate it. Instead, Barguet remained cautious and stated that it indicated, " products connected with those cited in column 11 ", that is, mineral substances.

The ideogram for *Khnem* (the bladder with a liquid) is the key for deciphering certain minerals found on the stele. I suggest that the symbol could depict a bladder containing urine, which would give off an odor as opposed to the pleasant scent of perfume. My assumption is that the symbol signifies chemical odors specifically. Most chemical products have a particular odor with which chemists are familiar. According to columns 11 and 12, the odorous products are the mineral substances used for building the pyramid and temples.

Nobody has ever considered that the ancient Egyptians could have used some of the same methods we use today for classifying and determining the chemical composition of minerals. We know that since prehistoric times the Egyptians heated minerals for enamel production. Today, the blowpipe is used to detect various phenomena that occur during heating. Some minerals melt and give the flame a color, such as violet for potassium and yellow for sodium. Some types of minerals break up, whereas others shed flakes, and still others swell and emit bubbles. Some, such as arsenic minerals and sulfides produce irritating fumes. My examination of the Famine Stele reveals that then, just as today, the names of certain minerals were derived from their chemical composition. When mineral ores are to be deciphered, it is when odor, color, taste, and other chemical determinatives are considered that we comply with their means of classification.

The English words for stones, derived from Greek and

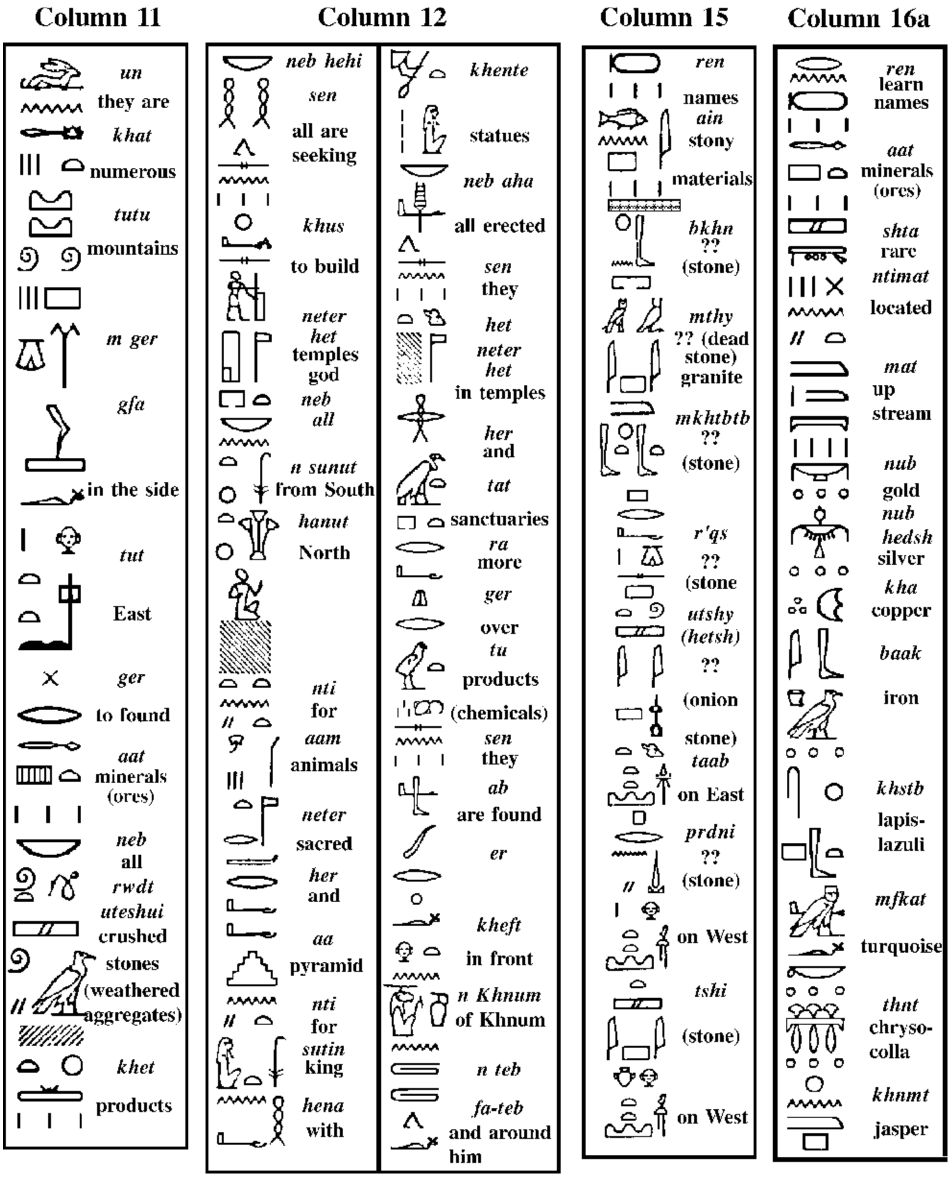
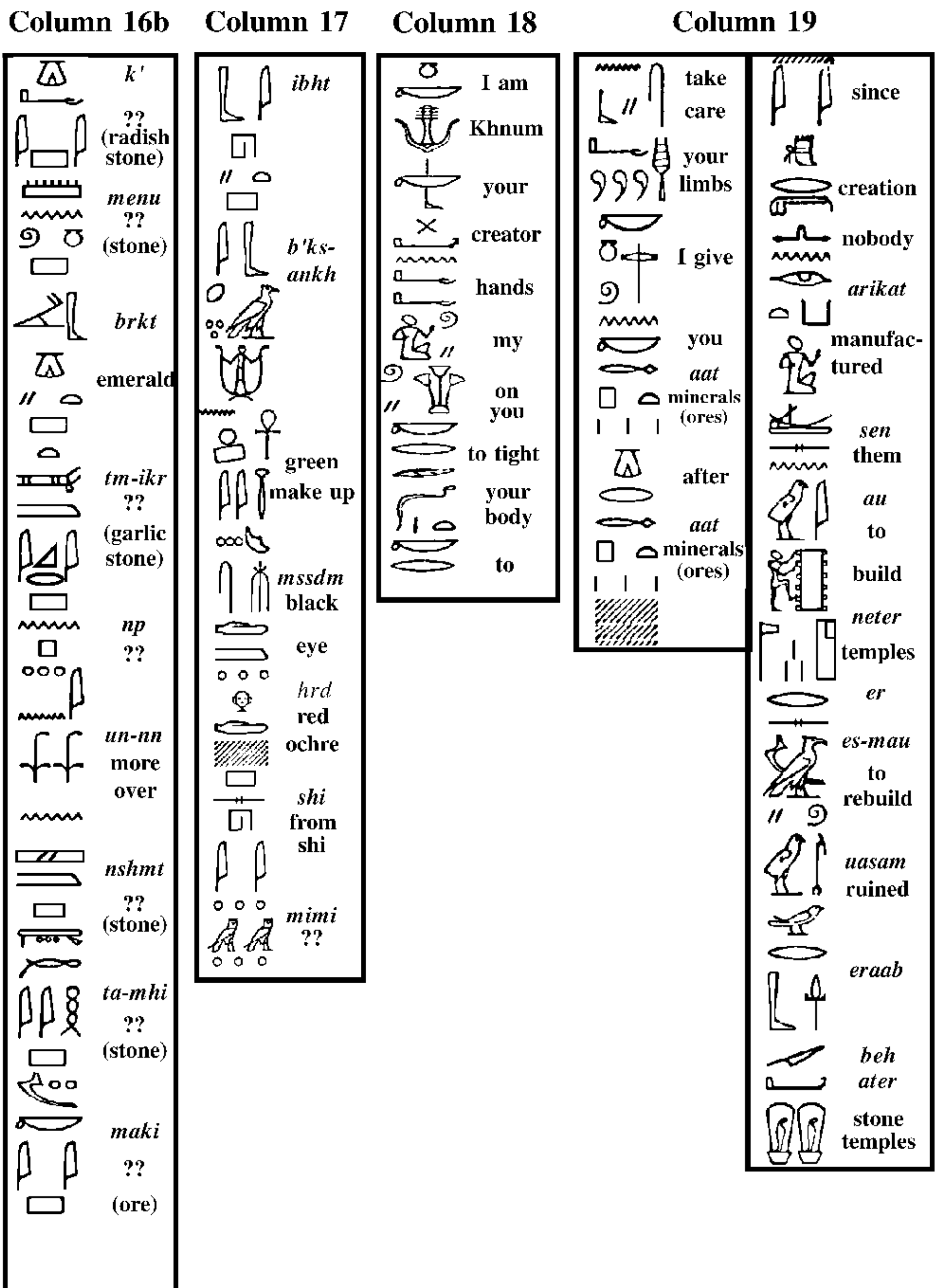


Figure 51: The Famine Stele. Davidovits translation of columns 11, 12, 15, 16, 17, 18, and 19.


Column 16b
k'
?? (radish stone)
menu
?? (stone)
brkt
emerald
tm-ikr
?? (garlic stone)
np
??
un-nn
more over
nshmt
?? (stone)
ta-mhi
?? (stone)
maki
??
(ore)
Column 17
ibht
b'ks-ankh
green
make up
mssdm
black
eye
hrd
red
ochre
shi
from
shi
mimi
??
Column 18
I am
Khnum
your
creator
hands
my
on you
to tight
your body
to
Column 19
take care
your limbs
I give
you
aat
minerals (ores)
after
aat
minerals (ores)
since
creation
nobody
arikat
manufac-tured
sen
them
au
to
build
neter
temples
er
es-mau
to
rebuild
uasam
ruined
eraab
beh
ater
stone
temples

Latin, can usually be traced to the root word for their color or general appearance. For instance, ruby comes from the Latin word rebeus, which is akin to the Latin word *ruber*, meaning red. But this was not the main criterion for naming rocks and minerals in ancient Egypt. Barguet, for example, was unsuccessful in deciphering the hieroglyphic names of rocks and minerals on the Famine Stele by comparing them with the hieroglyphic words for colors. Because the Egyptians generally did not classify rocks and minerals by color, the majority of their hieroglyphic names have no contemporary equivalent.

One area of discussion this ideogram raises is etymological. It may seem incredible to find that our modern word for chemistry was derived from a root word associated with Khnum. Certain hieroglyphic words variously transliterated as *khnem*, *shemm*, and *shnem*, include this ideogram. This would indicate that the word is associated with or is one of Khnum's odorous products.

Some etymologists hold that the word " alchemy " originated from the ancient name for Egypt, Kemit, which means black earth. Others maintain that the root is the Hebrew word for Sun, Chemesch. I propose that the original root of the word " alchemy " is *khem* or Khnum, written *shnem* during the Old Kingdom [54]. The corruption in Greek could have produced khemy or chemy; indeed, the name of the pharaoh for whom the Great Pyramid was built, Khnum-Khufu, was altered in Greek to Cheops and also Chemis. I suggest that the base *khnem* or *khem* became alchemy through language corruption, for example: Greek, chymeia; Arabic, alkimiya; Middle Latin, alchemia; Old French, alchimie; English: alchemy, chemistry.

Determinative mineralogy was never before applied to deciphering the Famine Stele. Perhaps the main reason for this is that the large-scale chemical uses of minerals were unknown. Even today, Egypt's primary mafkat mineral, chrysocolla, has no major industrial use; another mafkat, turquoise, has only an ornamental value. The arsenic minerals, olivenite (arsenate of copper) and scorodite (arsenate of iron), are listed in guides to rocks and minerals as being of interest only to mineralogists and collectors. In ancient Egypt these minerals, blended with copper ores, were used to produce the well-known copper with high arsenic content. Olivenite and scorodite could also have been used to produce rapid setting, needed for stone artefacts. Although arsenates are not similarly used in modern geopolymers, arsenic chemical wastes act as a catalyst when combined with geopolymers, environmentally safe containment of chemical wastes being one of the applications of geopolymers.

Scorodite is an arsenic mineral that when heated gives off a strong odor of onion or garlic, and there is historical testimony indicating the use of arsenic minerals in pyramid construction. In his book titled Euterpe, the Greek historian, Herodotus (c. 485-425 BC), reported what Egyptian guides told him about the method of constructing the Great Pyramid. Egyptologists use Herodotus's account to support the standard theory of pyramid construction, and his full account will be more fully examined in the next chapter. One passage reads:

> " On the pyramid is shown an inscription in Egyptian characters of how much was spent on radishes, onions, and garlic for the workmen. The person interpreting the inscriptions, as I remember well, told me this amounted to 1,600 talents of silver. "

Today, 1600 talents of silver represents approximately $100 million in U.S. currency, a colossal sum for feeding radish, onion, and garlic to workers. Herodotus was surprised by the large sum for such a limited variety of food. In the light of

Khnum's chemistry, the legendary implication becomes clear: The sum of $100 million represents the cost of mining arsenic minerals for constructing the Great Pyramid.

The Famine Stele also supports the fact that the ancient Egyptians used arsenic minerals for pyramid construction. The stele lists garlic, onion, and radish stones.

Hedsh

For the mineral ore that smells like onions when heated, the word is hedsh (also *uteshi*). Barguet provides no translation. Harris says the meaning remains inconclusive. Brugsch thinks the word means white. According to E. A. Wallis Budge's hieroglyphic dictionary *hedsh* means onion. But the translation of onion for a stone has puzzled Egyptologists and they have, therefore, avoided translation. The *hedsh* stone could be a mineral ore that gives off white fumes which smell like onion when heated.

Tem

Similarly, the words *tutem* and *taam*, containing the root *tem*, are thought to mean garlic. An ore listed in column 16, *tem-ikr*, could indicate a mineral that gives off the odor of garlic. The last two letters, " kr ", mean weak. This, therefore, could qualify the word to mean the mineral that gives off a weak smell of garlic.

Kau

Kau (also *ka-t*) means radish. An ore in column 16, *ka-y*, could indicate an ore that smells like radishes when heated.

Based on the key words discussed, the following is my translation of the relevant passages of the Famine Stele. The English transliterations are provided for rocks and minerals which remain untranslated. Small parts of the stele are missing because they contain no relevant information. Those portions are here filled in with ellipses, and on the hieroglyphic chart with diagonal lines. The new translation clearly depicts mineral processing for fabricating pyramid stone (Fig. 51). The words which differ from the traditional interpretation (Lichtheim) are underlined.

The Revelation of Imhotep

(Column 11) On the east side (of Elephantine) are numerous mountains containing all of the minerals (ores), all of the loose (disaggregated, weathered or crushed) stones (aggregates) suitable for agglomeration, all of the products (Column 12) people are seeking for building the temples of the gods of the North and South, the stables for the sacred animals, the pyramid of the king, and the statues to be erected in the temples and the sanctuaries. Moreover, all of these chemical products are in front of Khnum and surrounding him… (Column 13)… in the middle of the river is a wonderful place where on both sides people are processing the minerals for the stone… (Column 14)… learn the names of the gods which are in the temple of Khnum…. (Column 15) Learn the names of the stony materials which are to be found eastward, upstream of Elephantine: *bekhen, mtay* (dead or weathered granite), *mhtbtb, regs, uteshi hedsh* (disaggregated onion stone),… *prdn,… teshi* (disaggregated stone)… (Column 16) Learn the names of the rare minerals (ores) located in the quarries upstream: gold, silver, copper, iron, lapis lazuli, turquoise, chrysocolla, red jasper, *ka-y* (radish stone), esmerald, *tem-ikr* (garlic stone), and also *neshemnet, ta-mehy, heaget* (Column 17), *ibehet, bekes-ankh,* green makup (malachite), black antimony, and red ochre….

The Dream of Pharaoh Zoser

(Column 18) I found the god standing. He spoke to me, saying, " I am Khnum, your creator I am putting my hands upon you in order to strengthen your body, to (Column 19) take care of your limbs. I give you mineral (ore) after mineral (ore)…. Since creation (never before) has anyone manufactured them (to make stone) in order to build the temples of the gods or to rebuild the ruined temples… “

Building inscriptions relating to the Colossi of Memnon also contain language similar to that found in the Famine Stele. One inscription refers to the mortuary temple which stood behind the Colossi and reads,“ Behold, the heart of his majesty was satisfied with making a very great monument such as never happened since the beginning ”. This will be discussed in another chapter.

The hieroglyphic writings for the notion “ to build ”

The notion of building monuments is represented by two distinct verbs, namely *khusi* and *kedj*.

The sign for the verb *kedj* is found in the middle of Column 19. It represents a man building a wall or an enclosure made of crude silt bricks (see in Gardiner’s list the sign A35). In addition, this sign is often found as the determinative for the notion of: to fashion, mold, model, form, construct (a body or a statue?) (Fig. 52).

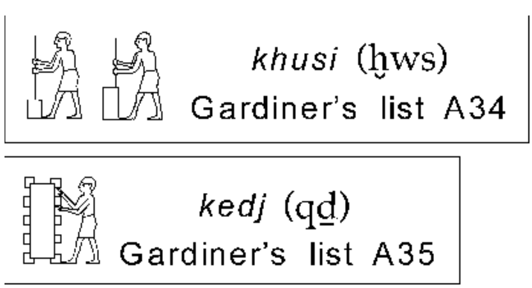


Figure 52

The verb *khusi* is found at the beginning of Column 12. It is also spelled *khuas*, *khesi*. It is always written with the determinative sign showing either a man pounding in a mortar or packing material in a mold (see in Gardiner’s list the sign A34). For Egyptologists to whom I talked,- for example the hieroglyphs expert A. Loprieno from UCLA, University of California at Los Angeles -, this verb was probably derived from the word that originally designated the technique used in building walls with rammed earth (pisé). Instead of describing the packing of malleable wet earth, this hieroglyphic sign may well describe the packing of wet nummulitic limestone paste, to make pyramid stones, as well as the packing of other stony materials for temple stones. This technique is still in use today in the Mediterranean countries and in Africa.

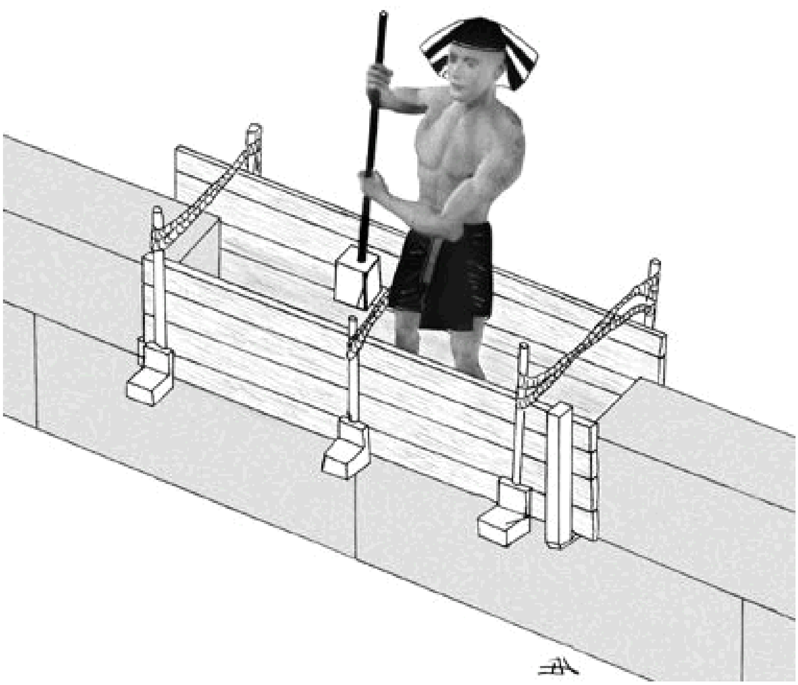


Figure 53: the pisé technique used today in Africa for rammed earth building.

Fig. 53 outlines today's making of a wall with the pisé technique. The worker stands barefoot inside the mold made of short planks of wood held together with ropes and is pounding the wet material with a wooden pestle. The block is packed against a bare neighboring block producing a close fit. Sometimes hairs fall from his arms or his legs and are pounded into the stony material. Air is also becoming trapped during packing. Owing to the pressure applied during pounding, the resulting trapped air bubbles, instead of being spherical, are ovaloid in their shape. This would explain the characteristic features of the analyzed pyramid sample in

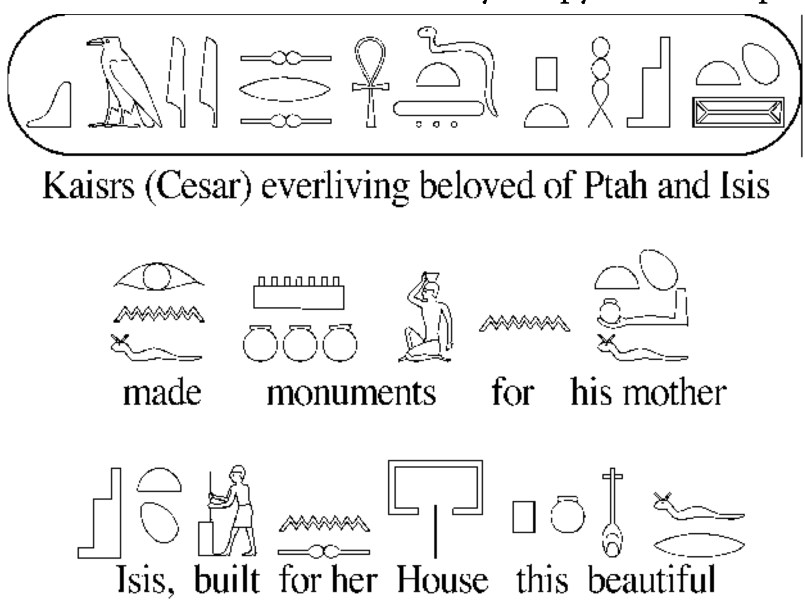


Figure 54: the hieroglyphic sign khusi, to build with the pisé technique, used for building with hewn stone.

Chapter 7 and Figure 19.

When hieroglyphic writing was invented in Egypt, the verbs *khusi* and *kedj* were associated with the handling of clay or earth. In the early dynasties, hundreds of years before the erection of the Pyramids, the notion of building mastabas with crude mud brick was well expressed with the notion of packing or pounding Nile silt, that is *khusi*. When Imhotep substituted packed limestone for packed mud brick in the construction of Zoser's pyramid, he reproduced in stone the architectural forms of the bricks and maintained the hieroglyphic writing. Later on, when carved stones replaced agglomerated (packed) stones, the notion *khusi* and its hieroglyphic sign depicting a man packing agglomerated stone, remained associated with the building of temples with carved stone. Even 2,500 years after Zoser's time, the Roman Emperor August engraved an inscription in the Temple of Kalabsha (Talmis), south of Aswan, that reads as follows (Fig. 54): " The Lord of Egypt, the Emperor son of the sun God ... Caesar ... has erected monuments in honor to his mother Isis and has built (founded) (*khusi*) for her this beautiful temple " [55].

During the entire Egyptian civilization, 3000 years long, the hieroglyph sign for " to build " (*khusi*) has not changed at all.

Chapter 11b

It is written in hieroglyphs The Irtysen Stele

Recently, we found a second hieroglyphic stele considerably outdating the *Famine Stele.* This stele can be contemplated by every tourist visiting the Louvre Museum in Paris. It is called the *Stele of Irtysen* and is practically 4.000 years old (Fig. 55).

The Stele (C14 in the Louvre nomenclature) is the autobiography of the scribe and sculptor Irtysen who lived around 2000 B.C., under one of the Mentuhotep Pharaohs, 11th. Dynasty. A brief description of the stele is given on a note placed on the bottom of it. It reads as follows:
In French:

> “ Stele du chef des artisans, scribe et sculpteur Irtysen, règne de Nebhepetrê Montouhotep, 2033-1982 av. J.C., XI° dynastie, calcaire. Je connais les techniques de la coulée (?) Je sais fabriquer des matières (d'incrustation ?, des faïences ?) que le feu

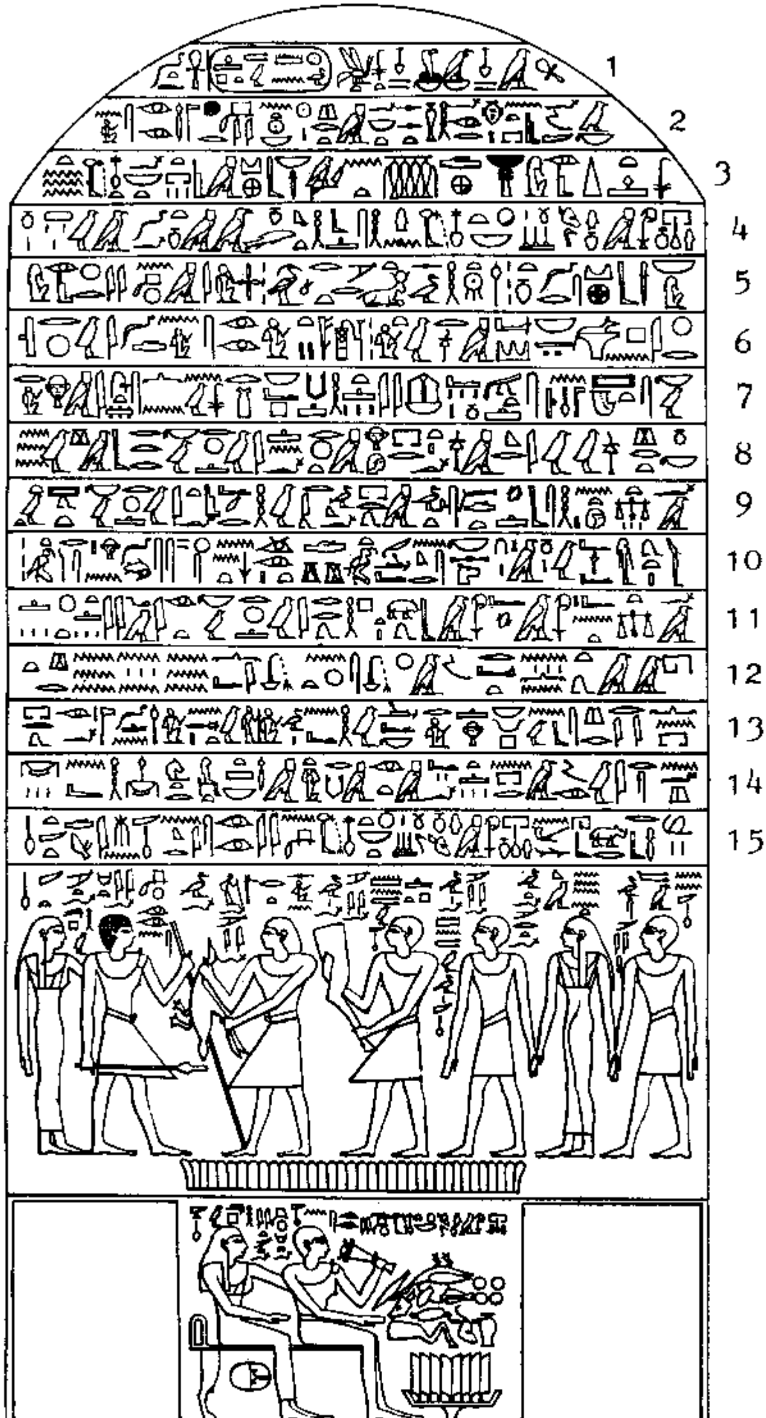


Figure 55: The C14 Louvre Stele or Irtysen Stele, 2000 B.C.

ne peut consommer ni l'eau dissoudre. Je n'en revèlerai le procédé à personne, si ce n'est mon fils ainé.. "

English translation:

" Stele of the overseer of the craftsmen, the scribe and sculptor Irtysen, reign of Nebhepetrê Montouhotep, 2033 - 1982 B.C., 11th dynasty, limestone. I know the techniques of the cast (?) … I know how to manufacture objects (for inlays? faience?) that fire cannot consume, nor water dilute either… I will not reveal this process to anybody, except my eldest son… "

The Stele comprises four parts:

1) The usual dedication, social titles and the call for offerings (lines 1 to 5).
2) The main body of the stele (lines 6 to 15), subdivided into five paragraphs, each conveying a certain kind of information. There is a first paragraph which introduces Irtysen as a scribe, conducting the offering-ritual and proficient in magic, as well as a successful craftsman. Each of the three following paragraphs begins with the leitmotiv " I know… " and deals successively with craft (sculpture), style (design) and technique (cast objects). The final paragraph contains a eulogy of the eldest son Senusert.
3) The presentation of Irtysen's family, his wife on the left, and his three sons, daughter and son in law .
4) The bottom scene of the offering-ritual.

The stele C14 of the Louvre has been often studied. Yet many of its expressions pertain to the domain of technology and have been tentatively translated with terms differing so widely that obviously the translators were not able to understand the described technology.

I have selected five out of fourteen translations issued since 1877, which I believe are representative of all the others.

The fourteen authors are: G. Maspero, (1877); Fl. Petrie (1895); E. Naville (1907); H. Madsen (1909); H. Sottas (1914); M.A. Murray (1925); M. Baud (1938); W.St. Smith (1946); J.A. Wilson (1947); H.E. Winlock (1947); W. Wolf (1957); A. Badawy (1961); W. Schenkel (1965) and W. Barta (1970) [56-69].

The translation by A. Badawy seems probably the most adequate to date, and is used as a guide for our discussion of the main body (lines 6 to 15) of the stele.

(General Introduction)

(**line 6**).....I know (**line 7**) the secret of the hieroglyph; the conducting of the offering-ritual; every magic I mastered it: none thereof passing me by. (**line 8**) Moreover I am a craftsman excellent in his craft, pre-eminent on account of what he has known.

(Craft)

I know the parts of *bagw;* (**line 9**) the weighings of the norm; bringing forth (or) letting in as it comes out (projects) (or) goes in (recedes), so that a member come in its place.

(Style)

I know the going of (**line 10**) a male figure (statue?), the coming of a woman; the positions of an instant (?); the cringing of the solitary captive; the glance of the eye at its sister; frightening the face of the guarded foreigners; (**line 11**) the balance (lifting) of the arm of the one who throws down the hippopotamus; the tread of the runner.

(Technique)

I know how to make baked (objects), things (**line 12**) cast without letting the fire burn them, nor that they be washed by water, either.

(Eulogy of eldest son)

(**line 13**) It was not revealed about it to anyone except (to) me alone and my eldest son of my body

; (for) the god (Pharaoh) had commanded that he does a revelation (**line 14**) for him about it. I saw the achievements of his two hands when acting as overseer of works in every costly material beginning with silver and gold (**line 15**) even to ivory and ebony.

According to A. Badawy's interpretation, Irtysen was a sculptor who worked relief sculpture, not round statue. I shall demonstrate that Irtysen's secret knowledge pertained to the making of statues, not carved, but cast (agglomerated stone) like plaster cast.

Let us examine more carefully the various technical terms of this text and the way they were translated in the five selected interpretations (I am not discussing the chapters *General Introduction*, *Style* and *Eulogy of eldest* son, which do not contain difficult special technical terms). The selected translations are those of Maspero, Baud, Wilson, Badawy and Barta.

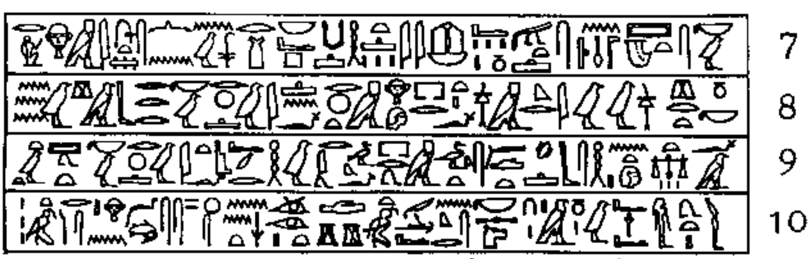


Figure 56: Lines 7-10 of Irtysen Stele

All authors share the same view on the importance of Irtysen's exceptional knowledge set forth in Lines 8-9, (*Craft*) (Fig. 56). However their translations differ widely and remain obscure,

G. Maspero: " … I know what belongs to it, the sinking waters, (9) the weighings done for the reckoning of accounts, how to produce the form of issuing forth and coming in, so that a member go to its place… "

M. Baud: (translated from French) " … I know how to mix the cements, (9) to weigh the parts according to the rules, to dig out the bottom, go in and dig in so that the member (the flesh) (remains or) goes to its place " [in French : " Je savais malaxer (gacher) les ciments, doser suivant les regles, creuser les fonds, introduire sans que cela dépasse ou creuse de facon que le membre (la chair) (reste ou) vienne a sa place "].

J.A. Wilson: " … I know (how to reckon) the levels of the flood, (9) how to weigh according to rule, how to withdraw or introduce when it goes out or comes in, in order that a body may come in its place. "

A. Badawy: " … I know the parts of *baagw;* (9) the weighings of the norm; bringing forth (or) letting in as it comes out (projects) (or) goes in (recedes), so that a member come in its place. "

W. Barta: (translated from German) " … I know the parts of transformation, (9) how to determine the right calculation… ". [in German: " Ich kenne die Teile der Umwandelbarkeit und die Abschätzungen der richtige Berechnung… "]

The important technical keyword *baagw* comes just after the claim " I know… " (Fig. 57). It is written with three " n " signs for water. This explains why a great number of translators connect it with the measurement of the Nile water level, a skill hard to explain for a sculptor. Badawy does not translate it and Barta ignores the water signs (i.e. the meaning of fluidity) by simplifying the meaning to a simple graphical skill. Baud brings an interesting clue. She translates the word *baagw* into " cement " in connotation with another verb *baag* " to become thick ".

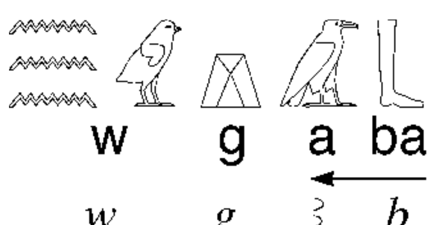


Figure 57: keyword baagw

Badawy compares this word with a Semitic root, *megwn* in Arabic " putty, paste ".

The action of casting a fluid stone paste into a mold to make a statue fits exactly with Irtysen's skill; one takes a fluid (the water signs *nw*) that becomes thick (it hardens or sets, the verb *baag*). The different reactive components must be weighed (*faat*) according to the exact receipt (*hesb*). Molding and demolding require multiple mold parts that must be introduced inside the mold (*shdjt saqt*) (during casting and hardening) and withdrawn (*prj aqt.f*) before demolding " … so that a member come in its place… ".

In the section (*Technique)*, lines 11-12, Irtysen characterizes the technology.

G. Maspero: " ... I know the making of amulets, that we may go without any fire giving its flame, or without our being washed away by water ".

M. Baud: (translated from French) " … I know the making of embellishments (literally pretty items) that are inlaid, not melted by fire, and not washed away by water… " [in French: " Je savais faire des enjolivures (exactement de jolis objets) qui s'incrustent, qui ne sont pas fondues au feu, et qui ne sont pas delavables non plus à l'eau "].

J.A. Wilson: " I know how to make (things of paste and inlaid things), without letting the fire melt them, nor do they wash off in water either ".

A. Badawy: " I know how to make baked (objects), things cast without letting the fire burn them, nor that they be washed by water, either ".

W. Barta: (translated from German) " I know the making of the outward appearance (literally: the things that belong to it), without letting a fire melting them; they also cannot be washed out by water ". [in German: " Ich kenne die Herstellung des Äusseren und der Bestanteile (wörtlich: der Dinge, die dazu

> hineingehen), ohne zuzulassen, dass ein Feuer sie verbrennen könnte; sie können auch nicht vom Wasser fortgewaschen werden ”].

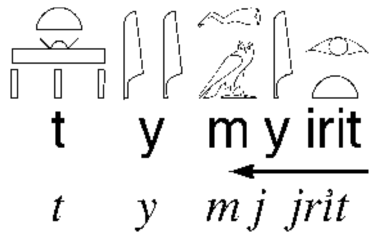


Figure 58: irit ymyt

One important technical keyword *irit ymyt* comes just after the claim “ I know ” (Fig. 58). It comprises the verb *irit* (to make) and the complement *ymyt*, translated as amulets (Maspero), embellishments (Baud), things of paste (Wilson), baked object (Badawy) and outward appearance (Barta).

The hieroglyphic writing of the plural name *ymyt* comprises the sign F23 in Gardiner’s list, foreleg of ox, also found in *khepesh*, blacksmith’s forge, foundry, a place with fire. Only Badawy acknowledges this sign by translating *imit* with baked objects. Yet, a foundry is also a place where metallic items, or clay like objects (*ammit*) are cast in molds. Irtysen uses casting molds to manufacture items and to replicate them in several exemplars (the cast things for Badawy). The word (*haawt-n*) (Fig. 59) is very close to the word *hawt*, descendant, progeny. With one mold, Irtysen could produce several replications (*haawt-n*) (descendants) in a material that cannot be burned out by fire and yet remained stable to water.

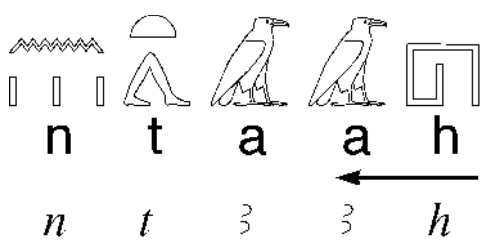


Figure 59: haawt-n

It is noteworthy that Irtysen did not use wax or other natural resins to replicate the statues. Although these items are generally stable to water, they will burn. Irtysen’s reproductions are made in a material that will not be destroyed by fire, unlike wax or resins. It is on the one hand mineral based (fire resistant), and on the other hand water resistant. Irtysen's material might relate to the geopolymeric reactions described in this book.

The final paragraph (*Eulogy of eldest son*), line 18, is extremely interesting since it explains how Irtysen's post in the arts and crafts was transmitted. As a rule the revelation of the professional secrets was to be authorized by Pharaoh Mentuhotep himself. Irtysen's eldest son was the eligible heir to the secrets of his father's craft, provided that he shows sufficient abilities in this field. The technique is also highly secret and part of the religious belief (the making of the *ka* statue, the double in stone, according to god Khnum's technology).

The Louvre stele C14 outlines the secret and religious technique of making statues with agglomerated stone (cast stone, man-made stone). I had long discussions with Egyptologist and linguist A. Loprieno from University of California, Los Angeles. He could not find anything against my proposed translation of the key-words. My interpretation of Irtysen's knowledge is the following:

(General Introduction)

(**line 6**)… I know (**line 7**) the secret of the hieroglyph; the conducting of the offering-ritual; every magic I mastered it: none thereof passing me by. (**line 8**) Moreover I am a craftsman excellent in his craft, pre-eminent on account of what he has known.

(Craft)

I know the parts belonging to the technique of molding (with castable) fluid (stone), namely: (**line 9**) the weighing (of the ingredients) according to the exact recipe; the (making) of mold parts that must be introduced inside (during casting and hardening) and withdrawn before demolding so that a member come in its place.

> *(Style)*
>
> I know the going of (**line 10**) a male figure (statue?), the coming of a woman; (how to capture) the instant of a realistic posture; the cringing of the solitary captive; the glance of the eye at its sister; frightening the face of the guarded foreigners; (**line 11**) the balance (lifting) of the arm of the one who throws down the hippopotamus; the tread of the runner.
>
> *(Technique)*
>
> I know the making of (foundry) molds to make reproductions (**line 12**) cast in a material that will not be consumed by fire, nor be washed by water, either.
>
> *(Eulogy of eldest son)*
>
> (**line 13**) This (secret) knowledge was not revealed to anyone except (to) me alone and my eldest son of my body; the god (Pharaoh) had commanded that he stands (**line 14**) before him, and took the revelation about it. I saw the achievements of his two hands when acting as overseer of works in every costly material beginning with silver and gold (**line 15**) even to ivory and ebony.

Other remarkable hieroglyphic words bring additional clues. They comply with the made-stone scenario and are discussed in the notes 70 to 72.

Chapter 12

It Is Written in Greek

Not to be overlooked is the classical historical account of pyramid construction, the well-known account of Herodotus. His account reflects beliefs popular in Egypt during the fifth century BC, which Egyptologists assume have no significant bearing on the actual method of pyramid construction. In any case, they agree that it complies fully with the standard carving and hoisting theory. But does it?

Herodotus was a remarkable and reliable historian, a unique figure of antiquity. He is called the Father of History for producing the first comprehensive attempt at historical narrative based on scientific inquiry. His work marks the beginning of the Western approach to historical reporting. His writing shows superb analytical skills; it is anecdotal, charming and entertaining.

Born in Asia Minor around 485 BC, he began seventeen years of extensive travel in the ancient world while in his twenties. The journey for which he is most well known is a four-month stay in Egypt, which he recounts in his entire second book of The History. One summer, sometime after 460 BC, Herodotus arrived in the western Delta at the town of Canapé, Egypt. He visited several renowned sites and encountered many people until his departure from Pelusuim in the eastern Delta before the following winter.

He was captivated by Egypt's wondrous monuments and geography. He reported what he learned of these and of history, arts, folklore, customs, and beliefs. During his visit to Memphis, he discussed the construction of the Great Pyramids with local guides. Herodotus's work has been translated several times since AD 1450 from the old Ionic Greek, with each translator attempting to improve on the precise meaning of the text. The relevant portion of his report of their account is presented below. I have emphasized certain words and phrases vital to the true method of pyramid construction. The account begins [73]:

> " Now they told me, that to the death of Rhampsinitus there was a perfect distribution of justice, and that all of Egypt was in a high state of prosperity. But that Cheops (Khufu), the next king to reign, brought the people absolute misery. First he shut all the temples, and forbade the offering of sacrifice. Then he ordered all of the Egyptians to work for him. Some were appointed *to drag stone from the quarries* in the Arabian mountains to the Nile. Others he ordered to *receive the stones* which were transported in boats across the river, and *drag them* to the hills called the Libyan. "

The group of emphasized words refers to the transportation of stone. Instead of stone blocks, this description could just as well relate to the hauling of stone rubble. The limestone material used for the casing blocks was most likely hauled from quarries in the Arabian mountains. The quote continues:

> “ And they worked in gangs of 100,000 men, each gang working for three months. For ten years the people were afflicted with toil in order to make the road for the *conveyance of stone*. This work, in my opinion, was not much less than that of the pyramid itself; for the road is five stades [3,021 feet] in length, and its width ten orgyae [60 feet], and its height, where it is the highest, eight orgyae [48 feet]; and it is built of *polished stone* and is covered with engravings of animals. ”

Again, a reference to hauling stone may just as well relate to the hauling of rubble. Above, and again in the next portion provided below, the word polished appears to describe smooth stone bearing no tool marks. This is the same word, *xeston*, used about 200 years later by Manetho to describe Imhotep's invention. As discussed in Chapter 10, this word does not mean hewn. Herodotus’s account never states that the pyramid blocks were carved.

Another word above is translated engraved. Engraving is assumed by Herodotus, who does not understand the construction method. Just the same, inscriptions or impressions do not require carving. Assuming agglomeration, hieroglyphic figures were impressed in objects such as the Colossi of Memnon and monolithic sarcophagi by the mold. Herodotus continues:

> “ As I said, ten years went into the making of this road, including the underground chambers on the mound upon which the pyramid stands. These the king made as a burial place for himself. These last were built on a sort of island made by *introducing water by canals from the Nile*. Twenty years were spent erecting the pyramid itself. It is a square, each face is eight plethra [820 feet], and the height is the same; it is built entirely of *polished stones*, and jointed with the greatest exactness; none of the stones are less than thirty feet. ”

Again, we see a reference to the *xeston* polished or scraped stones, actually the casing of Khafra's pyramid. Herodotus could not describe the pyramid made of stairs and tiers, the way one sees it in modern times. His visit to Giza took palace 1800 years before the inhabitants of Cairo started dismantling the casing of all pyramids. There is also mention of canals extending from the Nile to the site. As mentioned in Chapter 6, on-site canals would be necessary for introducing water onto the Giza plateau for disaggregating the limestone and for the production of enormous quantities of cement. Mythology also supports the existence of on-site canals. According to mythology the pyramids would be connected to the Nile so that the spirit of the pharaoh could travel in his boat each night to the underworld.

Residues of cement production have long since vanished. There is, however, another historical account that implies that the river was let in through a canal to disaggregate limestone and natron, as would be necessary for cement production. This comes from *Historical Library*, by Diodorus Sicilus a later Greek historian visiting the pyramids [74]:

> “ And the most remarkable part of the account is that, though the surrounding land consists of nothing but sand, not a trace remains either of ramps or the dressing of stones, so that they do not appear to have been made by the slow hand of man but instead look like a sudden creation, as though they had been made by a god and set down bodily in the sand. Some Egyptians make a marvel out of these matters, saying that in as much as heaps were made with salt and natron, when the river was let it dissolved them and completely effaced them without the intervention of man’s hand. ”

Herodotus continues…

> “ This pyramid was built thus: in the form of steps, which some call *krosae*, and others call *bomides*. After preparing the foundation, they raised stones by using *machines made of short*

> *planks of wood*, which raised the stones from the ground to the first range of courses. On this course there was another *machine* which received the stone upon arrival. Another *machine* advanced the stone on the second course. Either there were as many machines as courses, or there was really only one, and portable, to reach each course in succession whenever they wished to raise the stone higher. I am telling both possibilities because both were mentioned. ”

When researchers introduce designs for wooden machines, which they propose might have been used for hoisting pyramid blocks, their concepts do not comply with the archaeological record. No evidence of any such wooden machinery from the Pyramid Age has ever been found by archaeologists. There was certainly no focus during the late Stone Age on the invention of machinery as we think of it-structures consisting of a framework and fixed and moving parts.

Herodotus' firsthand reporting nevertheless led to speculation about the existence of tripods and pulleys during the Old Kingdom, but archaeologists are satisfied that these implements were not introduced in Egypt until Roman times, after 30 BC. This contradiction between the firsthand report and the archaeological record produces a dilemma.

The wooden machines cited could be wooden molds or, better, wooden containers. The quote reads in the following manner when the word “ machine ” is changed to read “ mold ” or “ container ”.

> “ This pyramid was built thus: in the form of steps [like a step pyramid], which some call *krosae*, and others call *bomides*. After preparing the foundation, they raised the other stones by using *containers (or molds) made of short planks of wood*, which raised the stones from the ground to the first range of courses. On this course there was another *container (mold)* which received the stone [rubble] upon arrival. Another *container*

> *(mold)* advanced the stone on the second course. Either there were as many *containers (molds)* as courses, or there was really only one, and portable, to reach each step in succession whenever they wished to raise the stone higher. I am telling both possibilities because both were mentioned. "

This machine (*mechane*) may be similar to the *pisé* technique described in Chapter 11, Fig. 53. It is a box made of short planks of wood held together with ropes, therefore versatile, and easily portable. Workers used it either as a container to temporarily store the " wet stone ", and as a mold to pound the wet material giving it the final shape. The slight language distortion that converted *machines* to *containers (molds)* shows how difficult it can be to interpret even very simple technical words when knowledge has been lost. A container or mold can be considered as an apparatus or device. The Greek word, *mechane*, used by Herodotus, is a general term indicating something contrived, invented, or fabricated. Because the word is nonspecific, a gross generalization, what is left to the imagination produces a conceptual distortion, and unfamiliarity with the actual construction method affects the way translators interpreted and therefore translated the text.

Not only does Herodotus's account not support stone cutting, it also does not imply that blocks were hoisted up the pyramid. What exists is a description complying with piling a pyramid tier by tier. The account never states that blocks were raised via ramps or from the ground by machine directly to great heights. The account continues:

> " The highest parts of it, therefore, were first finished, and afterwards they completed the parts next following. Last of all they finished the parts on the ground, and those that were the lowest. On the pyramid is shown an inscription in Egyptian characters of how much was spent on radishes, onions, and

> garlic for the workmen. The person interpreting the inscription, as I well remember, told me this amounted to 1,600 talents of silver. And if this be true, how much more was probably expended in iron tools, in bread, and in clothing for the workers, since they took the time that I have mentioned to build this edifice without even counting, in my opinion, the time for quarrying the stones, their transportation, and the construction of subterranean chambers, which were without doubt considerable ".

Herodotus, who liked to calculate problems, had trouble believing that the pyramid had been built in twenty years. But more interestingly, without appropriate scientific insight, the reference to onion and garlic is absolutely absurd. It appeared, for instance, so ridiculous to the noted Egyptologists Budge and Gaston Maspero, that they thought Herodotus was deceived by the interpreter. Budge commented in *The Mummy* that the inscriptions were pure invention. We now know, however, that chemical odors, such as those resembling garlic, comply with Khnum's alchemical processes as described in the earlier chapter 11 " *It is written in Hieroglyphs* ". Knowing this, we recognize that this passage is something truly precious. It is a piece of genuine news preserved from the time of the completion of the Great Pyramid.

Herodotus's comments about other costs clearly indicate that he did not understand the chemical sense of the inscriptions. Nor does it seem that he was made to appreciate why this relevant information was provided. It was certainly considered to be a primary part of the guides' explanation, lending a clue that they may have understood something about the construction method. If they did not understand, they certainly knew that the inscriptions were relevant.

It is not difficult to understand why the guides would be ineffective in communicating the construction method to

Herodotus if they understood it. There seems to have been no suitable Greek word to describe such stone, the closest word being polished or scraped (*xeston*). Communicating the notion of man-made stone and stone otherwise prepared or reconstituted by man could easily be misunderstood, especially when conversing with a traveler unfamiliar with the technology through an interpreter.

Different possibilities emerge regarding Herodotus's quote. One is that the guides thought they were adequately communicating the method of pyramid construction. The interpreter may have distorted the account in translation. More probably, the guides related only distorted legendary information. Whatever the case, modern translators have inadvertently obscured the text by misinterpreting some key words. Preconceived ideas about pyramid construction played a significant role in the translations of the text into modem languages.

Although the account contains some misinformation, we also find that, paragraph by paragraph, it is riddled with clues of the actual construction method, relevant clues that could not be present otherwise. The amount and relevance of the clues can be no accident, nor can these clues be ignored. This leads to the standard interpretation of the account coming into serious question. When stripped of distortion, a clearer account emerges. Instead of supporting the standard theory, this account must be taken as historical documentation supporting my findings.

Chapter 13

It Is Written in Latin

When did the last vestiges of the technology disappear and why? The answer to these questions remains elusive. Existing alchemical knowledge can still be pinpointed to a time shortly after the death of Jesus Christ. A description is found in the ancient science encyclopedia written by Pliny the Elder (AD 23 - 79), the Roman naturalist. Pliny's account is not legendary or written esoterically; it clearly describes the salient features of the technology.

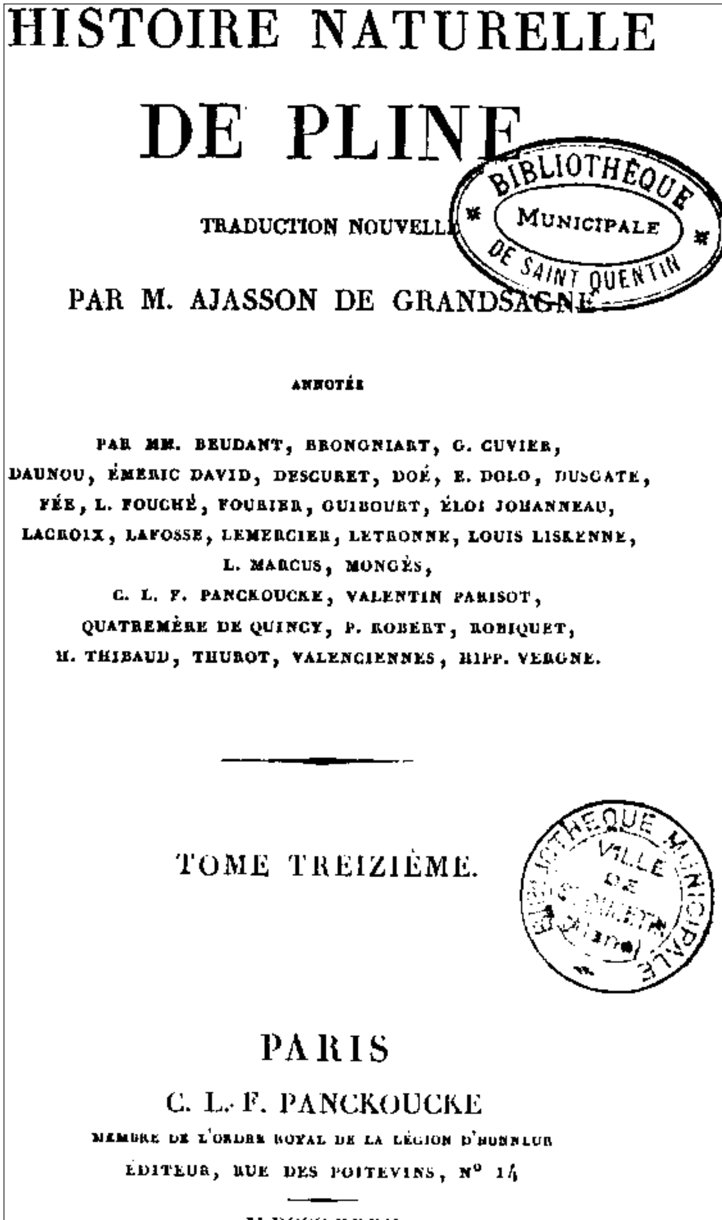
Pliny became one of the authorities on science and its history for the Middle Ages, making a profound impact on the intellectual development of Western Europe. He had established a new type of scientific literature - the encyclopedia. He was the first to collect old, diversified material of science and pseudoscience and methodically and expertly assemble it. The resulting encyclopedia of *Natural History*, consisting of thirty-seven books, is impressive in its scope. It covers botany, zoology, geography, anthropology, cosmology, astronomy, and mineralogy. During the Middle Ages, lessons in his work often substituted for a general education, and Pliny's authority remained undiminished for over 1,500 years.

It was not until 1492 that Pliny's authority was first challenged in *Concerning the Errors of Pliny*, by the noted physician and philologist Niccolo Leoniceno. Although Pliny's encyclopedia is today appreciated as one of the monumental literary works of classical antiquity, some scholars still declare the work useless as science. Be that as it may, if our aim is to understand, appreciate, and indeed attempt to recover the best of the sciences of antiquity, Pliny's encyclopedia is a jewel of science.

To date, the passages related to alchemical stonemaking confuse scholars, resulting in gross errors of translation in Pliny's work. Worse, the salient principles and characteristics of the ancient science being unknown, the translators dismissed Pliny's account as erroneous. De Roziere commented on the problems of translation [75]:

> " M. Grosse, author of a German translation of Pliny, highly esteemed by learned people, points out that in the whole of this description the Roman naturalist seems to have done his best to make himself obscure." Despite my familiarity ", he said, " both with Pliny's style and with the meaning he gives to terms, it has been difficult, sometimes even impossible, to translate the passages clearly and exactly ". The reason was certainly that he was simply unfamiliar with the substance that Pliny was describing."

One can appreciate the difficulty of literally translating technical material after technical knowledge has been lost, especially for a strictly literary scholar. Except for my translation, all attempts to translate the relevant passages have been futile.



HISTOIRE NATURELLE

DE PLINE

TRADUCTION NOUVELLE

PAR M. AJASSON DE GRANDSAGNE

ANNOTÉE

PAR MM. BEUDANT, BRONGNIART, G. CUVIER, DAUNOU, ÉMERIC DAVID, DESCURET, DOÉ, E. DOLO, DUSGATE, FÉE, L. FOUCHÉ, FOURIER, GUIBOURT, ÉLOI JOHANNEAU, LACROIX, LAFOSSE, LEMERCIER, LETRONNE, LOUIS LISKENNE, L. MARCUS, MONGÈS, C. L. F. PANCKOUCKE, VALENTIN PARISOT, QUATREMÈRE DE QUINCY, P. ROBERT, ROBIQUET, H. THIBAUD, THUROT, VALENCIENNES, HIPP. VERGNE.

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MEMBRE DE L'ORDRE ROYAL DE LA LÉGION D'HONNEUR

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Figure 60:Annoted French translation of Pliny's Natural History, 1832-33

In 1832-1833, the French Academy of Sciences, in order to compare ancient scientific knowledge with that of its day, produced and annotated a French translation of Pliny's encyclopedia (Fig. 60). The first half of the nineteenth century produced several important developments. Jean-François Champollion deciphered Egyptian hieroglyphs, and Georg Friedrich Grotefend deciphered Persian cuneiform. Portland cement was first manufactured, and a complete mineral classification was established. The latter allowed for a comprehensive critique of Pliny's writings on mineralogy by the French Academy of Sciences.

A passage from Book 31 of Pliny's encyclopedia made no sense to the French scholars. But the passage is compelling in its support of the existence of alchemical stonemaking. The passage appears in Latin as follows:

> " Nitrariae Aegypri circa Naucratim et Memphim tanturn solebant esse, circa Memphim deteriores. Nam et lapidescit ibi in acervis: multique sunt cumuli ca de causa saxei. Faciunt ex his vasa... "

Translated into English this passage reads:

> " In previous times, Egypt had no outcrops of natron except for those near Naucratis and Memphis, the products of Memphis being reputedly inferior. It is a fact that in accumulations of materials it (natron) petrifies [minerals]. In this way occurs a multitude of heaps [of minerals] which become transformed into real rocks. The Egyptians make vases of it.... "

This particular passage is simple and straightforward, so there is no error of translation - the Egyptians made real rocks according to Pliny. And the last sentence suggests that Khnum's technology was again being used to produce stone vases. Pliny provides a more detailed description of the manufacture of artificial stone in a segment about vase production. The vases are called murrhine vases. The following is a standard translation of Pliny's description found in Book 37:

> " Date of the introduction of the murrhine vases and what they commemorated:
>
> **VII.** With this same victory came the introduction to Rome of

the murrhine vases. Pompey was the first to dedicate murrhine cups and bowls to Jupiter in the Capitol. These vessels soon passed into daily use, and they were in demand for display and tableware. Lavish expenditure on these items increased daily: an ex-consul drank from a murrhine vessel for which he paid 70 talents [about 1 million $US in 1988] although it held just three pints. He was so taken with the vessel that he gnawed its edges. The damage actually caused its value to increase, and today no murrhine vessel has a higher price upon it. The same man squandered vast sums to acquire other articles of this substance, which can be determined by their number, so high that when Nero robbed them from his children for display they filled the private theater in his gardens beyond the Tiber, a theater large enough to satisfy even Nero's urge to sing before a full house as he rehearsed for his appearance at Pompey's theater.

It was at this event that I counted the pieces of a single broken vessel included in the exhibition. It was decided that the pieces, like the remains of Alexander the Great, should be preserved in an urn for display, presumably as a token of the sorrows and misfortune of the age. Before dying, the consul Titus Petronius, in order to spite Nero, had a murrhine bowl, valued at 30 talents [$400,000 U.S.], broken in order to deprive the Emperor's dining table of it. But Nero, as befitted an emperor, surpassed everyone else by paying 100 talents [$1.5 million U.S.] for a single vessel. It is a memorable fact that an emperor, head of the fatherland, should drink at such a high price."

The passage indicates that the precious stone vases were dedicated to Jupiter, the supreme god in Roman mythology. This could reflect a carry-over in religious tradition. It is probable that more anciently alchemically made stone vessels were dedicated to the Sun god of Egypt, Ra in the form of Khnum Ra. After the Roman conquest, Jupiter was worshipped in Egypt in the form of Jupiter-Amun, Amun being the supreme deity identified with the Sun during the late era. It could be that the word murrhine was derived from the name of Khnum.

The Latin spelling is *murrhinum*. Excluding the " m ", the succession of consonants in Latin is: *.rrh.n.m*, which could be a Latin way of writing *.kh.n.m*: The letter " kh " are pronounced the same as are " ch " in German and the letter " J " (jota) in Spanish, the sound heard in the name Juan. This pronunciation has a guttural sound " rrh ". This type of pronunciation or sound would transform the word to *mukhinum*, which is close to the name Khnum.

These vases were truly precious items, either because of sacred tradition or simple technological developments. Adding certain raw materials and heating under certain conditions produces extraordinarily beautiful optical qualities, such as those described next. Clearly the material described has features that do not comply with those of natural stone. In the relevant passages, emphasis is added.

> " **VIII.** The murrhine vases come to us from the East. They are found there in various little-known places, especially in the kingdom of Parthia. The finest come from Carmania. They are said to be made of a liquid to which heat gives consistence when covered with earth. Their dimensions never exceed those of a small display stand. Rarely, their thickness is no more than that of a drinking vessel such as mentioned. They are not very brilliant. They glisten rather than shine. What makes them fetch a high price is the varieties of shades, the veins, as they revolve, vary repeatedly from pink to white, or a combination of the two, the pink becoming firey or the milk-white becoming red as the new shade merges through the vein. Some connoisseurs especially admire the edges of a piece, where the colors are reflected as in the inner part of a rainbow. Others favor thick veins. Any transparency or fading is a flaw. Also there are the grains and the blisters which, like warts on human bodies, are just beneath the surface. The stone is also appreciated for its odor."

According to Pliny these vases were made from a liquid that hardened when heated, a description indicating that the vases could not have been produced by carving natural stone. The mention of blisters and odor could refer only to an artificially produced material. A puzzled committee of scientists from the French Academy of Sciences responded as follows:

> " The matter of the murrhine vases was discussed for a long time. According to Scaliger, Mariette, Lagrange, et al., it was porcelain that, in Roman times, was only made at the extremities of the known world (China, Japan, and Formosa), and which, transported at great cost overland through the hands of twenty different people, must indeed have fetched an enormous price. But porcelain is artificial, and the variety of colors, the play of light on the murrhine surface, the stripes, and the wavy stains of which Pliny speaks, are not traits of porcelain. Moreover, -… *humorem sub terra calore densari*…- a liquid to which heat gives consistency when covered with earth, i.e., hardens when it is heated in clay, can hardly mean a man-made process analogous to that which transforms kaolin into porcelain. But from his description, the only natural substance with all the features described by Pliny is fluorite. "

Despite Pliny's description of a material that could only be manmade, the French scholars decided that the vases had to be made of fluorite, a stone material, with white and pink veins, which must be carved. Their comments continue:

> " To identify fluorite in the midst of so many heterogeneous substances would have been difficult; to extract it, i.e., to isolate it and purify it, impossible. It was thus necessary to find native pieces of heterogeneous material with as little filler as possible. This was rare. Rarer still were pink crystallized samples, for pink is last in the order of abundance: greenish gray, white, yellow, violet, blue, honey yellow, and pink. It should be remembered that, even today, fine specimens of fluorite are

used to make beautiful vases. Recently, fluorite was used to give a matte finish to porcelain statues which had become vitrified during firing."

In this last statement, the scholars were referring to the fact that fluorite is used to produce hydrofluoric acid, vital to ceramic production. Fluorite is dissolved in sulfuric acid to make hydrofluoric acid for attacking glass. An interpretation of Pliny's text by the French Academy of Sciences follows:

" ...For which he paid 70 talents: Such incredible sums (70 talents) are almost beyond belief. Seventy talents equals almost 35,000 sovereigns [1 million $US] in our money; and we shall be referring to a sum more than four times as great as this a little later-and all this for a vessel meant for the least auspicious applications.

Any transparency or fading are flaws: Semitransparency: this is confirmed below.

The stone is also appreciated for its odor: This is one of the reasons to believe that the murrhine was artificial.

Made of a liquid to which heat gives consistence: it is difficult to understand that heat can cause solidification. Normal experience is that when a solid is heated it melts. Thus, we must consider the possible meanings of the expression, viz.: (1) evaporation followed by condensation, binding together of a magma, and still more likely, crystallization, (2) kinds of stalactites or stalagmites (remembering that there does exist a compact variety composed of small lumps bound together)."

In the 1830s, the members of the French Academy of Sciences did not know that a liquid could become hard when heated. With organic chemistry not yet developed, the phenomenon was unknown. In keeping with developments in inorganic chemistry in their day, the transformations of the different states of matter as produced by heat could only occur in an immutable manner. When heated, solids become liquids. Liquids become gases. Then, upon cooling, gases become liquids as they condense, and liquids become solids as they crystallize. This fundamental, uniform behavior of all matter constituted immutable natural laws for the members of the distinguished French Academy of Sciences.

Therefore, Pliny's description was nonsense in their opinion. It defied natural laws. Their consensus was, " Beware of Pliny and his fantastical descriptions! " Modern chemistry, of course, has substantiated Pliny's claim that liquids can become solid when heated. Thermosetting plastics harden upon heating. And the chemistry of geopolymerization demonstrates that a colloidal solution of minerals hardens when heated.

However, Pliny's authority in this regard has still not been vindicated. Despite the description that could only indicate the production of artificial stone, fluorite, a natural stone, remains in the translations of Pliny's text.

Every Egyptian hieroglyphic and cuneiform text deciphered during the early 1800s reflects the limitations of the scientific knowledge of that time. For 150 years, the translations of most ancient texts have not been updated to reflect modern knowledge. This means that ancient texts that may contain descriptions of alchemical stonemaking remain grossly inaccurate.

Pliny is appreciated for his ability to tie together bits of information from scattered sources and arrive at conclusions that often prove to be accurate. He criticized the pharaohs for building such elaborate pyramid tombs but probably gave little thought to the pyramid construction method. Like Pochan and the researchers at SRI International, Pliny also overlooked the construction method. He knew that the murrhine vases were artificial stone, and he knew that, using natron, the Egyptians made " real rock ", yet, though he wondered how the Egyptians raised the heavy blocks in the Great Pyramid so high, he never applied his knowledge to pyramid construction.

Chapter 14

The Rise of Pyramids

Pyramid construction methods pose great questions. The work that would be involved using the accepted method is staggering, even with modern machinery; and with the construction method eluding historians, reasons for the rise and decline of pyramid building are misunderstood.

In general, Egyptologists advocate that early pyramid building put an intolerable burden on manpower and the economy, causing the decline. This explanation fails to address the reason why pyramid building was not at least attempted during certain later wealthy dynasties possessing additional territory, masses of slaves, better tools, and executing prolific building projects.

The reasons for the rise and decline of pyramid construction crystallize when one considers the developments associated with the use of agglomerated stone. The developments in construction parallel those of the modern concrete industry after the introduction of Portland cement; specifically, the first pyramid blocks weighed only a few pounds. Their size gradually increased over the pyramid-building era to include enormous blocks and support beams weighing up to hundreds of tons apiece. If the pyramids were built of carved blocks, the observed evolution of pyramid construction would be highly unlikely. An overview clarifies these points.

Figure61: Sphinx and the Great Pyramid

The Great Pyramid is one of the earliest pyramids (Fig. 61). More than seventy pyramids are known, and others may be concealed beneath the desert sands. Any still buried would not be great pyramids, but small, ruined structures. All known pyramids are situated in groups located at several different geographical areas of the necropolis on the West Bank (Fig. 62).

The pyramid of Pharaoh Zoser served as a prototype for following Third Dynasty pyramids. Because Third Dynasty history is obscure, with the number and order of reigns still debated, the identification of the pyramids immediately

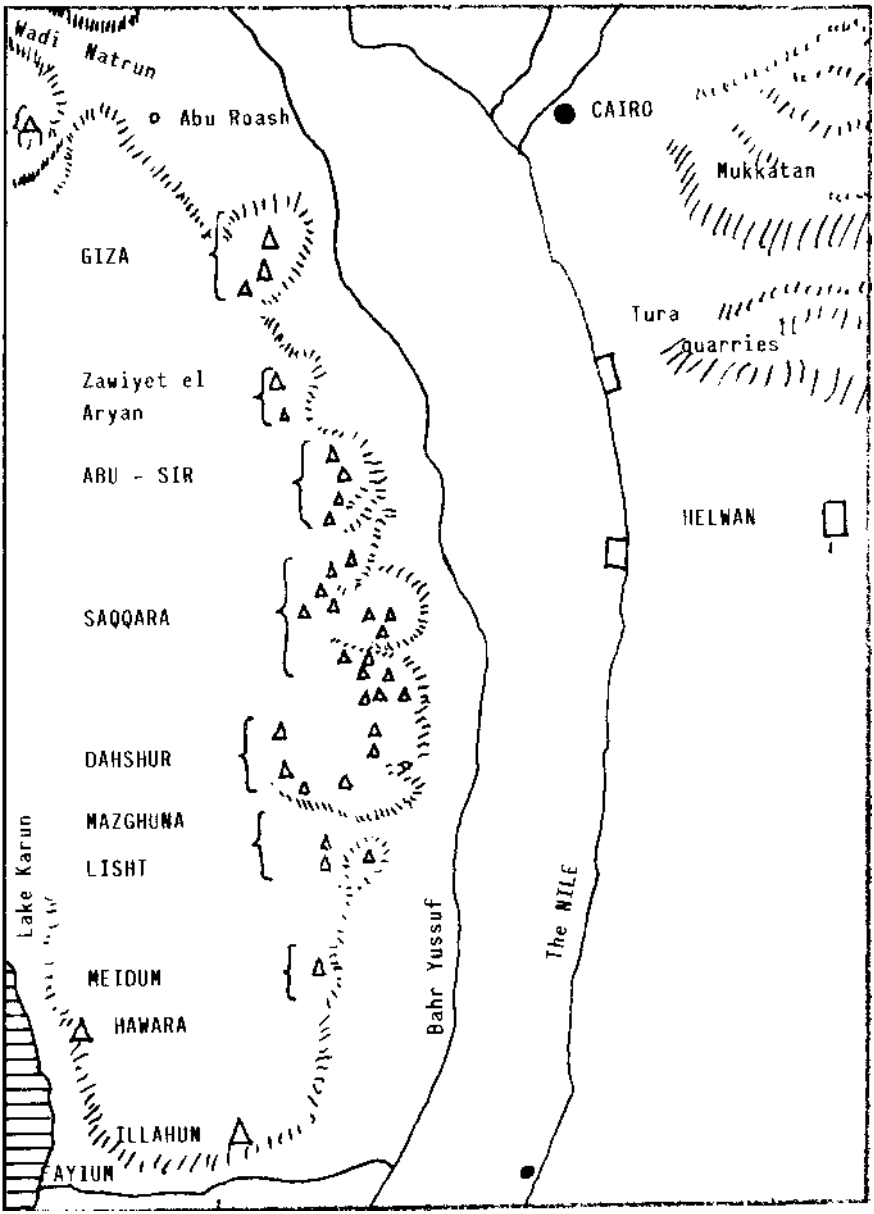


Figure 62: The pyramids are situated in the necropolis on the West Bank of the Nile.

following Zoser's is tenuous. Tentatively among Zoser's Third Dynasty pyramid-building successors were pharaohs Sekhemkhet, Neb-ka, and Kha-ba. None of these kings reigned long enough to complete his monument.

The pyramid considered second in chronology is attributed to Zoser's successor, Sekhemkhet, who is believed to have reigned from six to eight years. This complex is located at Saqqara near the original pyramid and was planned along a similar design. The intent to build a larger monument is apparent from a larger enclosure. This unfinished monument is in ruins. Only two tiers remain.

One distinctive architectural feature found inside is a door framed by an arch. If this pyramid were correctly dated to the Third Dynasty, the arch would most likely be the earliest ever constructed. Nearby, several Ptolemaic mummies were discovered in the sand. Also discovered were objects dating from the Twenty-sixth Dynasty and later During the Twenty-sixth Dynasty old traditions were revived. A chamber inside the pyramid, which was first entered during excavation in the 1950s, showed signs of previous entry even though almost 1,000 items of gold jewelry had not been removed from the adjoining passageway.

Construction ramps were found in situ. These ramps do not provide evidence for the hoisting of enormous blocks for the Great Pyramids because the blocks of this structure are small. If this pyramid is correctly dated to the era when stone was agglomerated, the blocks were manufactured near the site in numerous small wooden molds of different sizes. The blocks were then carried up the ramps and placed to construct the pyramid. It would have been cumbersome and unnecessary to cast these small blocks in place.

Relief drawings on the sandstone cliffs near the Sinai mines show Sekhemkhet smiting the local desert people in order to protect mineral deposits. Rothenberg's expedition examined tool marks and graffiti on cavern walls, enabling a distinction between early and late mining operations. Whereas Middle and New Kingdom dynasties used pointed metal tools, in earlier times mine shafts were produced with pointed flint tools. Rothenberg observed that the mines were most heavily exploited by the end of the Fourth Dynasty. In other words, the mines were heavily exploited by the time the major pyramids were built [76].

Sandstone masses were removed from the mines by producing a series of holes. This stone was then crushed into sand with harder rocks to free the mafkat nodules. The mafkat itself was most likely transported back to Egypt to be crushed for the cement.

A pyramid located at Zawiet el-Aryan, not far from Giza, is known as the Layer Pyramid and belongs to the first phases of Egyptian architecture. It has not been attributed adequately. Pharaoh Kha-ba's name is found in the nearby cemetery, making him the most likely builder (Fig. 63). The Layer Pyramid was poorly constructed and is in a state of ruin. The use of small limestone blocks here still prevails, but they have become somewhat larger. The block quality is inferior and is believed to originate from a quarry to the south. This quarry may well be the origin of the aggregates used to produce blocks for the pyramid. No chemical analysis

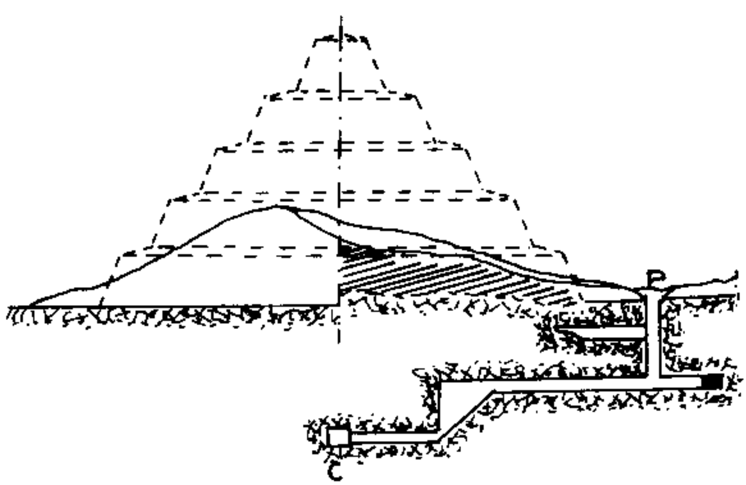


Figure 63: Depiction of projected outline of Kha-ba's pyramid, which was never completed, rises over ruins (J.P. Lauer).

has been made of these blocks, but their inferior quality could be the result of several factors.

A mining or general work slowdown or the use of inferior minerals are possibilities. If the king was elderly when crowned or in poor health, mining, a difficult and very time-consuming operation, might have been cut back and the construction work completed as well as possible with the least amount of cement before his death. If the cement were used sparingly, the resulting blocks would not be well adhered. If these were poor agricultural years, vegetable products (plant ashes) for the cement might have been less abundant. Another possibility is that the noncarbonate parts of the limestone did not react. This occurs if the clay in the limestone is of a type called illite by geologists.

It is also possible that the cement used did nor harden fast enough to produce good quality blocks beyond a certain size. The blocks did not crack to pieces as the larger size present in this pyramid, and they perhaps seemed adequate during construction. Close observation may have revealed tiny cracks or a poor finish, prompting the Heliopolitan specialists to continue experimenting with the formula.

The objective for Third Dynasty builders was to achieve more rapid setting, yielding larger blocks of better quality. Building with larger units has definite advantages. The architects no doubt realized that large blocks, being difficult to move, provided more protection for the burial chambers. Large units are less likely to be exploited at a later date, and transporting stones is a lot of work that can be eliminated provided the blocks can be cast directly in place. In other words, the larger the building units, the less work involved.

Three other structures built far from Memphis are tentatively grouped into the Third Dynasty. Generally, these show no architectural advance over Pharaoh Zoser's pyramid. These pyramids are small and far inferior except for larger blocks. Third Dynasty pyramids were designed as stepped structures with subterranean tombs. Structural designs varied in the different pyramids as architects experimented with engineering possibilities.

The last Third Dynasty king was Huni, also the last to build a step pyramid (Fig. 64). His structure is usually discussed in connection with Fourth Dynasty pyramids because of its controversial history. It seems that Sneferu, the first king of the Fourth Dynasty performed an experiment on Huni's pyramid. Huni's large step pyramid had been beautifully constructed at Meidum, forty miles south of Memphis. It originally had seven tiers and stood ninety-two meters (304 feet) high. Some of its blocks weigh about 0.25 tons x (550 pounds).

Figure 64: Huni's pyramid at Meidum (1988).

When Sneferu was enthroned, he ordered his workmen to increase its height and add additional casing blocks from the base to the summit of Huni's pyramid. This produced the first exquisite, geometrical pyramid. The design was hailed as a great innovation, the inspiration for subsequent pyramids. The newly transformed pyramid, with its smooth finish of casing blocks, reflected brilliant streams of gleaming sunlight and won Sneferu the reputation of solar innovator. Sneferu ushered in the era we call the Pyramid Age.

At some point in history Huni's elegant superstructure or Sneferu's mystical architectural form underwent a sudden, cataclysmic demise. Much of its outer masonry crashed to the ground in one tumultuous earth-shaking moment. A huge mound of stone debris resulted. It still surrounds the monument. The site attracts a great deal of attention, with the causes of the incident becoming one of the puzzles of Egyptology.

The generally held theory is that, at an unknown date, key support blocks shifted out of place or were removed. If the latter, the most likely culprit would have been Ramses II, who was notorious for pillaging blocks from pyramids for his own monuments. Other theories accounting for the cataclysm are that the pyramid was disturbed by an earthquake or that there were incompatibilities between the original and the radical new design. Any of these possibilities might have caused a chain reaction, setting off the enormous avalanche that tore away most of the outer masonry [77]. Now, when viewed from afar, the remains have the surreal appearance of a fabulous high tower rising from the midst of an enormous mound.

Sneferu was the most industrious builder in Egyptian history. On the Libyan plateau, six miles south of Saqqara, at

Figures 65: Sneferu's Bent Pyramid and Red Pyramid (1988).

Dashur, he constructed two gigantic pyramids. They dominate the skyline even today. He appropriately named the first the Southern Shining Pyramid, and the second, to the north, the Shining Pyramid. Today they are known as the Bent Pyramid (also Rhomboidal, Blunted, and False Pyramid) and the Red Pyramid, respectively (Fig. 65). Together they incorporate more stone than the Great Pyramid. Sneferu's workmen produced the monuments during the king's twenty-four year reign, and we have already considered the logistical problems that this creates for engineers.

In addition, the Palermo Stone records that Sneferu built temples throughout Egypt. He is also believed to have constructed the first Valley temples and causeways, as well as the small, subsidiary pyramids found south of parent structures. These types of masonry works adorned his own cons-

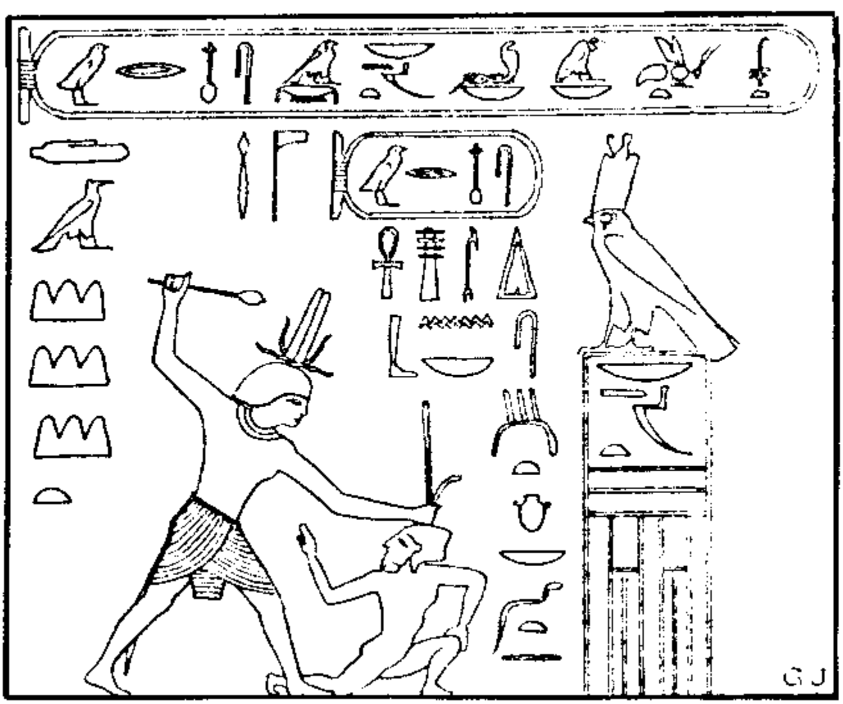


Figure 66: A stele of Sneferu was engraved on a cliff face in the Sinai.

truction and were also believed to have been added by him to Huni's complex. Sneferu far exceeded other prolific builders of Egyptian history.

The Palermo Stone records that he sent to Lebanon for cedar. He launched a fleet of forty large ships to retrieve enormous beams of cedar at the Lebanon coast, the same sort of mission carried out since early times. We have already considered how this historical event connects with the preparation of molds and containers for pyramid construction. Also relevant is that Sneferu's name is found in the Sinai in large reliefs in the cliffs. As would be expected, he exploited the mines on an enormous scale. The Sinai mines exploited by him were known as Sneferu's mines for 1,000 years (Fig. 66).

Sneferu's Bent Pyramid was the first of the truly colossal superstructures. It is well preserved with a tip that is still pointed, and a great many of its casing blocks remain intact. Some of the casing blocks on the lower part of the pyramid are reported to be five feet high, a sure sign of casting on the spot, whereas some of the smaller masonry fits together fairly roughly, suggesting the use of precast stone bricks. The heights of blocks range from small to large, providing for stability

The modern name of Bent Pyramid was inspired by the angle of its slope, which suddenly diminishes on the upper half of the pyramid. Its shape makes it unique among pyramids. It is assumed that the architect radically altered the angle in an attempt to reduce the tremendous amount of stress on the corbeled walls of inner chambers, which, it is believed were already beginning to crack during construction. Yet, there could be another explanation.

For an unknown reason Sneferu went on to build the even larger Red Pyramid, so called because of the pink tint of its stones. Here the blocks are big, with each one cast directly in place. Cumulative alchemical and engineering developments afforded superior strength and design over all previous pyramids. The burial chamber, traditionally underground, was incorporated into the pyramid itself. The heights of the blocks vary from 0.5 meters (1.64 feet) to 1.4 meters (4.6 feet). The Red Pyramid stands 103.36 meters (113 yards) high, and has a square base of 220 x 220 meters (240 x 240 yards). Its dimensions approach those of the Great Pyramid to follow. Both pyramids were until 1995 in a restricted military entry zone, so I have not examined them personally.

Painted limestone statutes of Prince Rahotep and his wife Nofret, the former a son of Sneferu, were found in the cemetery around Huni's pyramid at Meidum (Fig. 67). The paint used is a fine alchemical product that maintains its fresh

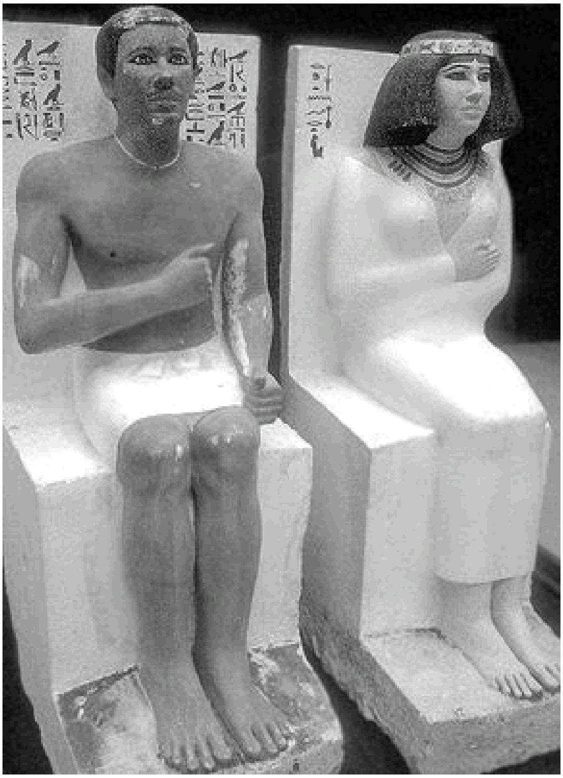


Figure 67: Prince Rahotep and his wife Nefret. Fourth Dynasty. Cairo Museum (1988).

color today. The inlaid eyes are truly exquisite, as would be expected of agglomerated stone. Eyelids are made of copper, the whites of the eye are quartz, and the corneas are rock crystal. The material composing the irises is of uncertain composition, thought perhaps to be a type of resin. The Fourth Dynasty produced the most remarkable statuary.

Another son of Sneferu was Khnum-Khufu (Kheops or Cheops), who built the Great Pyramid (Fig. 68). His full name shows his reverence for Khnum. Although today it is called the Great Pyramid, Khufu named his monument *The Pyramid which is the Place of the Sunrise and Sunset*. The name, inspired by Heliopolitan mythology depicted the pyramid as the throne of the Sun god Ra during his daily course across the heavens.

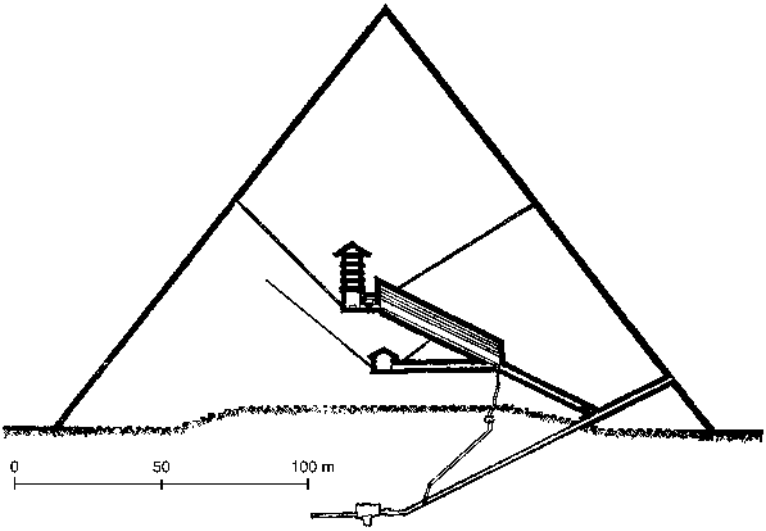


Figure 68: Cross section of the Great Pyramid.

Khufu and his pyramid were richly endowed with a royal estate, which had been maintained for thousands of years. During those years a line of priests assigned to Khufu faithfully maintained temples and property and ritually prepared offerings for the deceased god-king. Altars were covered over with offerings of flowers, incense, and food. Monuments that make reference to these priests date to several historical periods spanning thousands of years. They indicate that the tradition was not broken until Ptolemaic times.

This same tradition was upheld by priests of Khufu's father, Sneferu, and also those of his son, Khafra (Khefren or Chephren). Like his father, Khufu sponsored numerous building projects. His name appears on monuments throughout Egypt. He excavated for minerals in the Arabian Desert, Nubia, and the Sinai, where he was depicted on the cliffs protecting the mines.

Much of the complex belonging to the Great Pyramid has been destroyed. Only the foundations of the enclosure walls and the mortuary temple remain. The great causeway that Herodotus remarked almost equaled the pyramid in size was practically intact until 100 years ago. Today many large blocks remain to provide an idea of its original size and solidity. Other portions of the complex, such as the Valley Temple, are yet to be excavated. The cemetery surrounding the Great Pyramid is the most extensive, with large, impressive mastabas.

The seventh or eighth in chronology, the Great Pyramid is the largest and represents the peak in engineering design. Never again would Egypt build on this scale. Because of its masterful construction, this monument is the most celebrated of all time. It is little wonder that modern engineers wince at the thought of duplicating this monument, even with the best equipment. The base is 232 meters (253.7 yards) per side and the area of the base is 5.30 hectares (13 acres). Through careful observation of the stars, the Great Pyramid was oriented more accurately than any other; it is off only one-tenth of a degree of present-day true north. Its original height is estimated to have soared to 147 meters (481 feet). Today it is about 138 meters (450 feet) high with its capstone and some tiers missing. Its volume is 2,562,576 cubic meters (90,496,027 cubic feet). It contains approximately 2.6 million building blocks and has an overall weight of approximately 6.5 million tons.

It is difficult to appreciate the enormous size of the Great Pyramid by reading statistics. Perhaps a better illustration is this: if all of its blocks were cut into pieces one-foot square and laid end to end, they would reach two-thirds of the way around the world at the equator. Notwithstanding all of the problems of pyramid construction already raised, if the blocks of the Great Pyramid were carved and their carving waste taken into account, the total weight of the stone used would have been close to 15 million tons-placing an enormous burden on the accepted theory.

The carving and hoisting theory indeed raises questions that have been insufficiently answered. In October 1991, during the shooting of the TV production “ This Old Pyramid ” by NOVA with M. Lehner, aired on the American PBS network, I witnessed the weaknesses of the traditional theories. The pictures I took there (Fig. 69-74) illustrate the difficulty of the task. Using stone and copper tools, how did workers manage to make the pyramid faces absolutely flat?

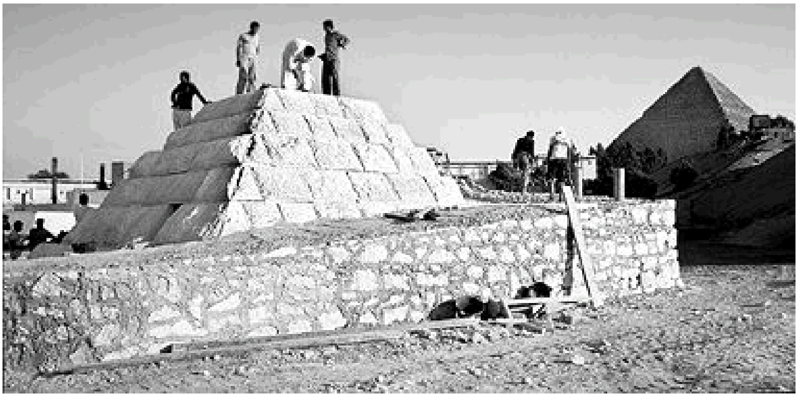


Figure 69: NOVA's mini pyramid (1991); Khufu's (Kheops or Cheops) pyramid in background.

Figure 70 (above): NOVA's craftsmen used modern steel tools (left and right), not the Old Kingdom stone tool imitation (center).

Figure 71 (right): Even with modern steel tools, dressed casing blocks did not provide close fit rather a gap up to 0.5 cm (0.2 inches) wide, and chipped corners.

How did they make the faces meet at a perfect point at the summit? How did they make the tiers so level? How could the required amount of workers maneuver on the building site? How did they make the blocks so uniform? How were some of the heaviest blocks in the pyramid placed at great heights? How were twenty-two acres of casing blocks all made to fit to a hair's breadth and closer? How was all of the work done in about twenty years? Experts can only guess. And no

Figure 72: NOVA pulling of stone on rollers was only feasible on a flat hard surface, like modern road. It did not work on sand.

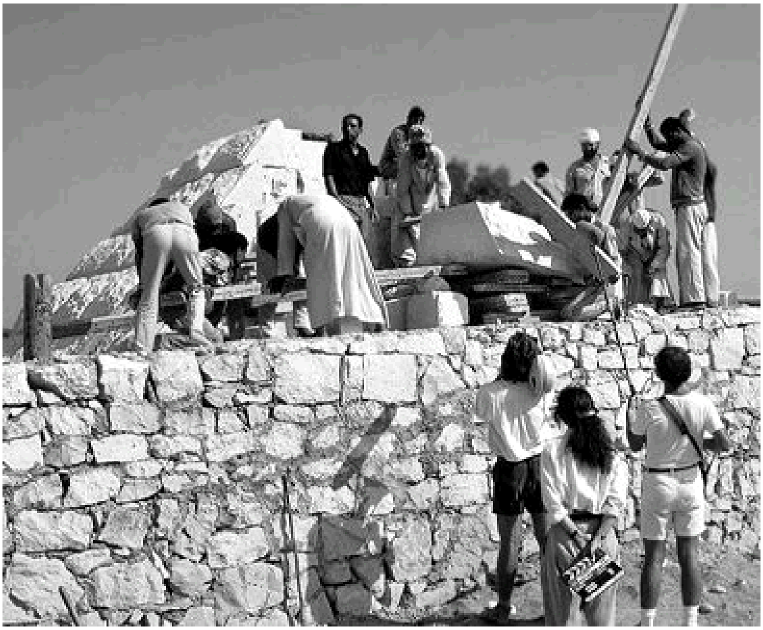


Figure 73: NOVA crew (foreground) filming the desperate efforts of lifting one stone block with wooden levers. It took 5 hours to lift the stone from ramp level to top level.

Figure 74: NOVA mini-pyramid and its gigantic wraparound ramp demonstrate the difficulty of the ramp scenario with its enormous amount of material (1991).

Egyptologist can claim that the problems have been resolved.

Theories of construction are many and continue to be invented. All are based on carving and hoisting natural stone, and none solves the irreconcilable problems. Only the agglomerated stone theory instantly solves all of the logistical and other problems.

What direct evidence of molding is to be found in the Great Pyramid? The casing blocks are clearly the product of stone casting. As mentioned, most were stripped for construction in medieval Cairo after an earthquake destroyed the city in AD 1301. Those that survive are at ground level, buried beneath the sand in 1301. Joints between the casing blocks are barely detectable, fitting as closely as 0.002 inch according to Petrie's measurements. The casing blocks are smooth and of such fine quality that they have frequently been mistaken for light-gray granite. The English scholar John Greaves (1602-1652) thought, at first sight, that they were marble.

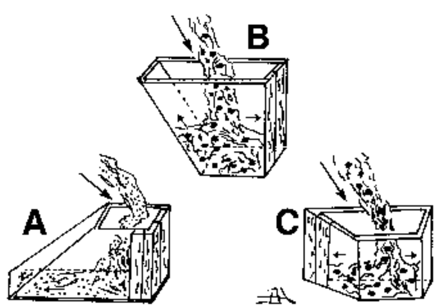


Figure 75: Three possible positions for casting casing stones.

The casing blocks were angled to produce the slope of the pyramid. Because of their shape, casting them was more complicated than casting rectangular blocks. In Fig. 75, A, B, and C show three casting methods: casting from the top, casting upside down, and side casting. B and C are feasible when making fluid or semi-dry concrete. Filling a mold using method A is somewhat more difficult because the slurry must be pushed constantly against the inclined lid to prevent gaps from forming (this is possible with the pisé or rammed earth technique).

In 1982 the German Egyptologists Rainer Stadelmann and Hourig Stadelmann-Sourozian discovered that the inscriptions on the casing blocks of the Red Pyramid of Sneferu were always on the bottom [78]. This applies to the Great Pyramid as well and could indicate that the casing blocks were cast in an inverted position (method B or method C) against neighboring blocks. Once they hardened and were demolded, they were turned upside down and positioned. To find inscriptions consistently on the bottom is good evidence of the method by which they were made. Had the casing blocks been carved, inscriptions would be found on various surfaces.

Positioning the casing blocks was the most difficult and time-consuming part of building a tier. I still do not know whether the casing blocks were inverted and set while the rest of the tier was built from the inside and whether the packing blocks were added between the core masonry and the casing blocks to complete a tier.

The ascending passageway leading to the Grand Gallery had been plugged with three enormous granite blocks each 1.20 meters (3.9 feet) thick, 1.05 meters (3.4 feet) wide, and totaling 4.34 meters (14.3 feet) long. Edwards wrote [79]: " The three plugs which still remain in position at the lower end of the Ascending Corridor are about one inch wider than its mouth and, consequently, could not have been introduced from the Descending Corridor ". Since the plugging should have occurred after the funeral ceremony, Edwards continues, " No alternative remained, therefore, but to store the plugs somewhere in the pyramid while it was under construction and to move them down the Ascending Corridor after the body had been put in the burial chamber ". Egyptologists have hotly debated where the plugs had been stored but have offered no satisfactory answer. Although no analyses have been made of the granite plugs in any of the pyramids, I could suggest that these plugs in the Great Pyramid were agglomerated in the Grand Gallery and later slid into position. Yet, I do not have any proof on that matter.

Evidence of molding appears in the ascending passageway. The blocks in this passageway are alternately set in either an inclined or vertical position. Although the inclined blocks have no structural function, the blocks set vertically support the passageway itself. There are large monolithic gates, consisting of two walls and a ceiling, made in a reverse-U shape. The evidence that these gates were molded are the mortises, later filled with cement, in the floor beneath them. Poles were inserted in these mortises to support the part of the mold needed to form the ceilings of the gates.

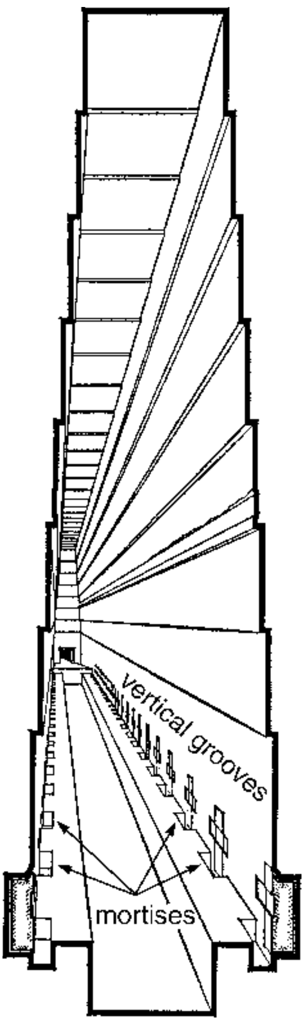


Figure 76: Mortises and vertical grooves in the Grand Gallery (I.E.S. Edwards).

In addition, the sample provided by Lauer was from the wall of the Ascending Passageway. I have already described the sophisticated geopolymeric binder I detected, the stress bubbles, organic fibers, and wood-grain impressions exhibited in the sample.

The Grand Gallery is the most spectacular masonry feature of the interior of any pyramid. It measures 47.5 meters (156 feet) long, 8.5 meters (28 feet) high, and 2.1 meters (7 feet) wide at the floor level. Its walls are corbeled. One of Jomard's comments about the Great Pyramid was [80]: " Everything is mysterious about the construction of this monument. The oblique, horizontal and bent passageways, different in dimensions, the narrow shaft, the twenty-five mortises dug in the banks of the Grand Gallery… " Jomard was referring to the mortises carefully plotted on the drawings made by Cecile for Description de l'Egypte (Fig. 76).

Jomard did not notice that each square mortise in the floor corresponds with a vertical groove in the walls (Fig. 77). The two French architects, Gilles Dormion and Jean-Patrice Goidin, who drilled a hole in the wall of the Queen's Chamber in 1987 in their search for hidden chambers, proposed that the purpose of the mortises was to stabilize poles that supported a wooden floor leading to a hidden passageway, which they failed to find [81]. Any hidden chambers which may be found would add to the complexity of building the pyramid according to the accepted theory.

Probably, these mortises and grooves were necessary for casting blocks. To produce a rectangular block, the mold must be oriented horizontally because, like water, a slurry will seek its own horizontal level when poured. If a block were cast on an incline, a misshapen block would result (Fig. 77). The blocks for the corbeled gallery were cast, therefore, in the horizontal position. The support mechanism was a wooden plank secured to the appropriate groove in the wall. The top of each groove is horizontal to the next mortise up. The plank was weighted, perhaps with a sandbag. Removing the weight disengaged the wooden structure so the finished block could be lowered and pushed into position.

The French architects previously mentioned used special devices provided by the French electricity company EDF, to measure the overall density of the pyramid. They found a bulk density twenty percent lighter than expected

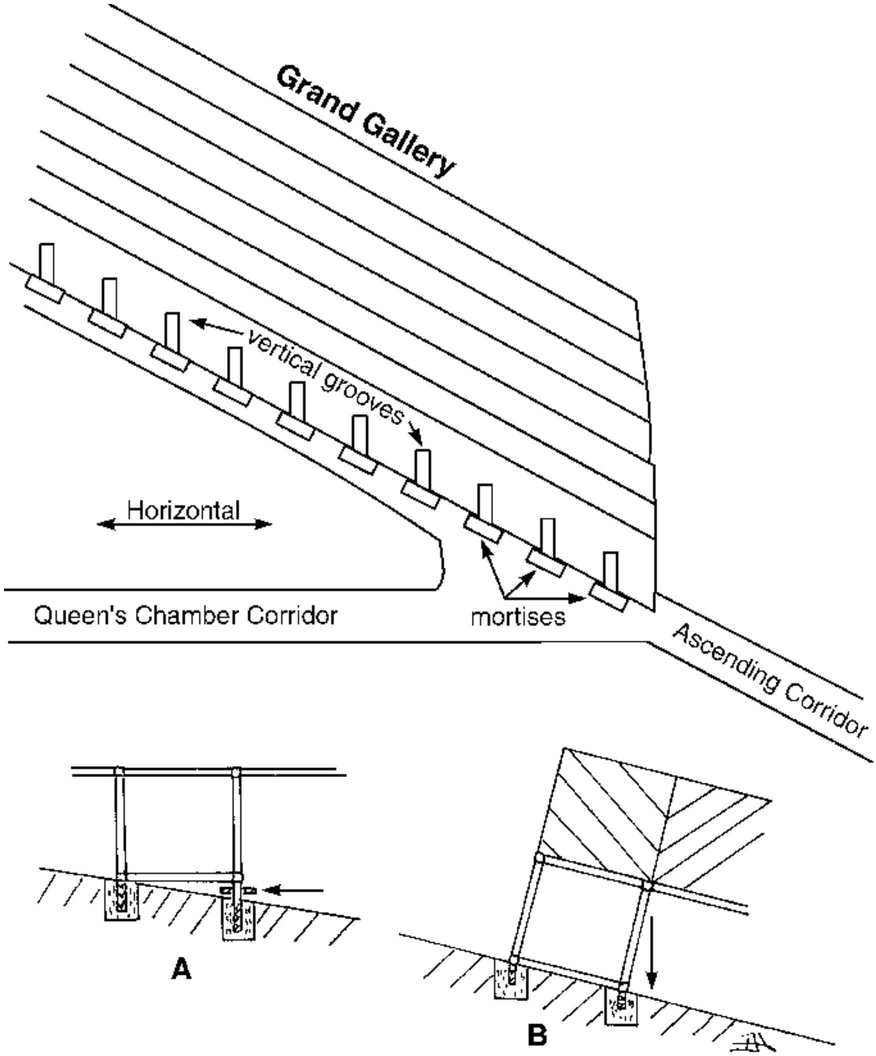


Figure 77: Blocks were cast horizontally (A), and after setting, they were moved into the inclined position (B) to build the walls of the Grand Gallery.

for limestone. An Associated Press article published in December 1986, titled " 480,000 Stones Unaccounted for in Pyramid", reported the team as saying, " Holes. We have holes. Maybe the size of a fist; maybe the size of Notre Dame… Or the answer might be that some of the stones are of a lighter rock than the predominant limestone or that spaces appearing empty in the readings are filled with rubble ".

Though they found no chambers or enormous holes, that core blocks are lighter than the bedrock was recognized in 1974 by the SRI International team. SRI International found the density of the blocks of Khafra's pyramid twenty percent lighter than the bedrock [82]. Lighter density is a consequence of agglomeration. Cast and rammed blocks are always twenty to twenty-five percent lighter than natural rock.

The Grand Gallery leads up to the so-called King's Chamber, deep in the interior and about two-thirds of the way up the pyramid. The blocks composing the flat roof of the King's Chamber are impressive, among the largest in the entire structure. The roof consists of nine monolithic slabs weighing about fifty tons each, totaling about 450 tons. The floors and walls of the King's Chamber are made similarly of finely jointed red granite that appears to be polished.

If one considers size, design and construction time limits, it becomes clear that if the Great Pyramids were dependent on primitive methods of carving and hoisting, they would not exist. In the Great Pyramid, hundreds of blocks that make up the core masonry weigh twenty tons and more and are found at the level of the Grand Gallery and higher. We have examined how the first pyramids were constructed of blocks weighing only a few pounds apiece. As engineering methods and design improved, casting stone directly in place in larger and larger units resulted in, to a civilization in the final phases of the Stone Age, monuments that stun modern observers, monuments that cannot be sufficiently explained today by experts or effectively duplicated within the appropriate amount of time by carving and hoisting natural stone. Now, we will examine the reason why, like the extinction of a mighty species, pyramid building in the sands of Egypt ceased.

Chapter 15

The Decline

The pyramid building decline was barely noticeable at first. Khufu's son, Djedefra, was enthroned and built a monument about five miles north of the Great Pyramid, at Aba Roash. He named it the *Pyramid Which Is the Sehedu-Star*. Because Djedefra reigned only eight years, the monument was never completed, although substantial progress was made. The causeway was probably the most elaborate ever, measuring 1.5 kilometers (1640 yards) long. The base of the pyramid measures 100 meters (109 yards) square, and was planned to be considerably smaller than the Great Pyramid.

Several blocks of red granite remaining on the eastern face suggest that the pyramid was at least partially cased with this material, which would help to make any low, unfinished structure even more attractive for exploitation. Today the pyramid is mostly dismantled. The site was used as a quarry even in modern times. In Pyramids and Temples of Giza Petrie reported that he was told that as many as 300 camel loads of stone were being removed from the site daily. This gives us additional appreciation of the difficulty that quarrying stone with primitive tools poses. Even in modern times it has proved far easier to remove and transport pyramid blocks than to quarry hard stone from bedrock close to a building site and dress it.

The next pharaoh to reign was another son of Khufu named Khafra (also Ra'Kha'ef, and, in Greek, Khephren), who built the second largest pyramid (Fig. 78). Today it is usually called the Second Pyramid of Giza, but the pharaoh named his monument the Great Pyramid. Its interior is not as elaborate as that of Khufu's pyramid, although, the complex, with its impressive features, is the most well preserved of the Giza group.

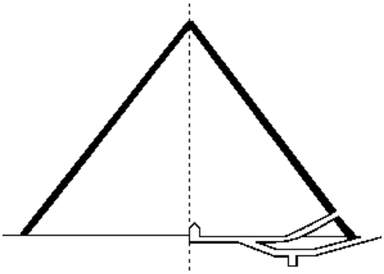



Figure 78: Pyramid of Pharaoh Khafra (Khefren or Chephren), the Second Pyramid at Giza and cross section (1984).

In the Valley temple south of the Great Sphinx, two levels are made of blocks weighing fifty to eighty tons apiece and assembled with tongue-and-groove joints. As mentioned, some blocks weigh up to 500 tons. And Jomard, in Description de l'Egypte, remarked, " Because of their size, I first thought these blocks were protrusions of bedrock, rough-cut and squared. I would have remained ignorant about this if I had not noticed the mortar which joins the layers ".

Despite these joints, the stones are considered to have been cut in situ because of their great size (Fig. 79). The issue of the transport and placement of these stones is, therefore, conveniently avoided. However, the joints, there to reduce stress, are perfectly obvious and are filled with mortar. Their presence indicates irrefutably that these blocks were not carved in situ. Furthermore, these blocks are clearly defined from the bedrock, or, in other words, unattached. Certainly, the transport and placement of these blocks would pose enormous problems with means available to the Egyptians of the Fourth Dynasty. This entire issue is settled by the use of cast stone.

Figure 79: From Khafra's Mortuary Temple to the east are (A) back of the Sphinx, (B) causeway leading to Khafra's Valley Temple (C) (1984).

Indeed, as discussed in Chapter 8, the lift lines in these blocks are not horizontal like the strata of Giza. They are instead wavy, caused by construction interruptions. The heights of the lift lines do not match the strata of Giza. And these blocks exhibit the same erosion pattern as do the pyramid blocks. Although the causeway might contain some protrusions of natural bedrock, for the most part, this same argument can be made for the blocks of the causeway.

The Valley temple was first excavated by Mariette in 1853. He found the famous diorite statue of Khafra in a well in the entranceway. The Valley temple was originally cased inside and out with finely jointed granite blocks, most of which have been removed from the outside. Inside, the granite blocks are in perfect condition, exhibiting the fabulous jigsaw joints, already described, which go around corners.

These and many other features in the pyramid and complex support the use of cast stone (Fig. 80). The two-ton portcullis mentioned in Chapter 1 is positioned in a narrow passageway and requires the efforts of at least forty men to raise it. The passageway itself has room for no more than eight men to work together. In the light of the evidence for cast stone already presented, it makes sense that the heavy portcullises of this and other pyramids were cast in place.

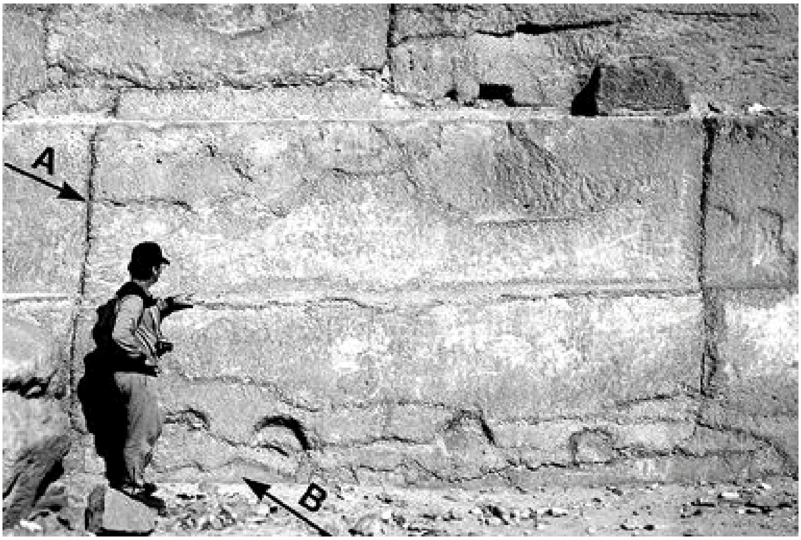


Figure 80: The author examines enormous blocks of the first step on the East Side of Khafra's pyramid. The curved angle joint at (A) suggests stones were cast against bare neighboring stones to produce close fit. (B) Shows thick mortar sealing the bottom of the mold (1984).

Too, features such as the uniform widths of blocks of the Second Pyramid demonstrate overwhelming evidence for stones cast in molds, and like the Great Pyramid blocks, the heights of the Second Pyramid blocks are staggered.

Several tiers of casing stones remain at the summit of the pyramid. Some are mottled and discolored by the growth of large patches of small, red lichen plants. Most, however, still maintain their smooth surface after thousands of years and reflect sunlight and white moonlight. The casing blocks fit together with tongue-and-groove joints. Certainly, casting these blocks makes more sense than carving them with primitive tools.

The pyramid itself measures 143.5 meters (157 yards) high and has a square base of 215.5 x 215.5 meters (235 square yards). Though not planned to be as large as Khufu's pyramid, the Second Pyramid is built on higher ground, making the two superstructures appear as gigantic twins from a distance. No Egyptian pharaoh would ever again come close to buil-

Figure 81: The three great pyramids of Giza, from left, are of Khufu, Khafra, and Menkure (Royal Air Force, 1924).

ding on this tremendous scale.

Suddenly, the decline becomes dramatic. The next king was Menkure (Mykerinos or Mycerinus in Greek). His pyramid, called by him the Divine Pyramid and today the Third Pyramid of Giza, was built of blocks of staggered dimensions, similar to the pyramids of Khufu and Khafra (Fig. 81). It measures only 108.5 meters (118 yards) square and originally stood 66.5 meters (72 yards) high. It is seven percent the size of the Great Pyramid (Fig. 82).

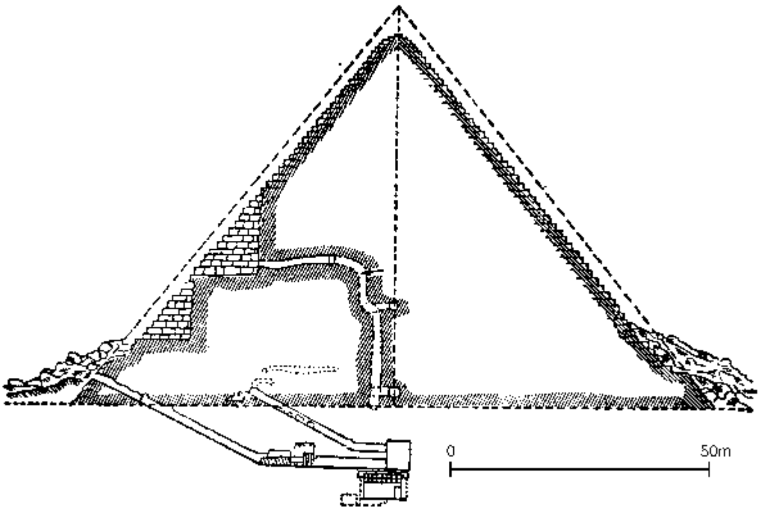


Figure 82: Cross section of Menkure's pyramid (Perring).

Menkure reigned for eighteen years, from 2490 to 2472 BC. Considering the amount of construction work accomplished during Khufu's twenty-year reign, Menkure would certainly have had time to build a larger monument, and yet, a sudden, dramatic decline occurred.

Menkure's small pyramid is no aberration. The last king of the Fourth Dynasty was Shepsekaf, who reigned a little over four years. He did not plan a large pyramid. Instead, he built a different type of royal monument that was neither a pyramid nor a true mastaba. The structure he called the Purified Pyramid is today called Mastabet Fara'un, and it looks instead like a giant, rectangular sarcophagus of fine-quality stone. The structure measures 100 x 72 meters (109 x 78 yards) and is only 18 meters (19.6 yards) high.

The Fifth Dynasty (2465-2323 BC) marks the end of the Pyramid Age. In the order of their reign, Fifth Dynasty kings known to have built pyramids were Userkaf, who built at Saqqara; Sahur, Neferirkare, Niuserre, each of who built at Abusir; and Djedkara-Isesi and Unas, who also built at Saqqara. Their pyramids were much inferiors, shoddy by comparison with those of the Fourth Dynasty All were planned to be smaller than Menkure's pyramid except for the one started for Neferirkare at Abusir.

Even though Menkure's pyramid is small, it consists of solid core masonry, but the monument of Neferirkare, which was never completed, and those of the other Fifth Dynasty kings were built of loose stone rubble and sand, sandwiched between stone walls. The casing stones have been mostly removed and the structures are in ruin today. Most are little more than heaps of rubble, because this type of construction rapidly degrades once the casing is badly damaged or removed. The remaining casing stones and the stone of descending tunnels, rafters, burial chambers, and sarcophagi appear to be agglomerated.

More emphasis was placed on building the surrounding funerary complex, in this period, of both stone and sun-dried mud brick. These once elegant structures also are in almost complete ruin. The funerary complexes required far less stone than did pyramids and, therefore, do not compensate for the reduced size of the pyramids. Causeways, which require a great deal of stone, were sometimes altered to accommodate more than one pyramid, and advantage was taken of the bedrock in causeway construction. Sahure's causeway, for instance, changes direction twice to take advantage of natural features. It also contains blocks taken from Zoser's complex. This relates to what I have termed the sixth false proof of Egyptology, discussed in Chapter 4, which discusses the blocks hauled to Unas's pyramid.

Certain building blocks are much larger than those used in earlier pyramids. The burial chambers, for instance, have pointed ceilings made of enormous limestone support beams, sometimes measuring from 10 to 15 meters (11 to 16 yards) in length and weighing from forty to eighty tons apiece. The design of the ceilings consists of three layers of massive beams that support one another and increase in size as they ascend (Fig. 83).

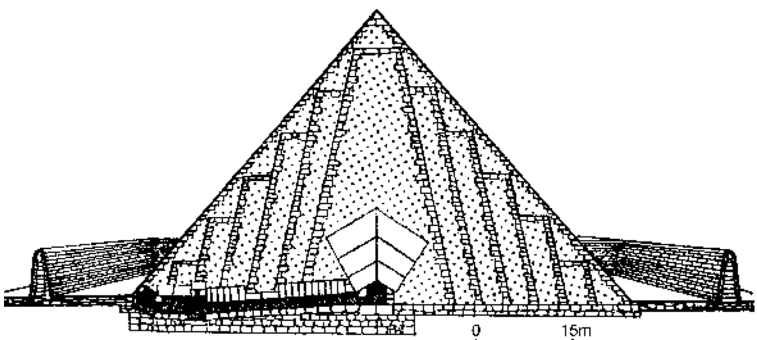


Figure 83: Sahure's pyramid shows burial chamber of massive beams increasing in size as they ascend. (Borchardt)

Though these are not great pyramids, some have notable features. Userkaf's pyramid complex, located about 200 meters (218 yards) from the northeast corner of Zoser's complex, exhibits beautiful reliefs in stone walls of the mortuary temple. And this type of fine artwork typifies Fifth Dynasty funerary complexes. Reliefs in the complexes of Sahure and Niuserre are even more elaborate. The reliefs in Sahure's complex alone were estimated originally to have covered about 10,000 square meters (2.47 acres) of wall surface.

Egyptologists cannot explain why the Egyptians of this period dedicated themselves to lavishing decorations on temple walls instead of concentrating on building great pyramids, nor can they explain why the workers resorted to removing blocks from previous monuments to complete their construction work. The reason, however, will become obvious.

The remarkably small pyramid of Unas is notable for the thousands of engraved hieroglyphs, painted blue, that cover the vestibule and white limestone walls of the burial chamber. These inscriptions, known as the Pyramid Texts, constitute the world's oldest surviving religious writings. Egyptologists surmise that these sacred texts date to the earliest Egyptian times. The writings, compiled by the priests of Heliopolis, contain such archaic word forms, indicating extreme antiquity, as those praising Khnum, which are far more remote than the reign of Unas. Many portions preserved in Unas's pyramid are not repeated on the walls of later monuments.

The power of the king began to dissipate after the Fourth Dynasty. The Fifth Dynasty kings could not hope to command the same degree of power and prestige as predecessors who had built the Great Pyramids. The governors of nomes gained local power and this is believed to have diminished central authority Kings started marrying the daughters of these rich, powerful governors apparently in an attempt to strengthen their own royal power.

Still, the times were prosperous, and despite some minor border skirmishes, the period was not characterized by war. Instead, the Fifth Dynasty is characterized by a revolution in art and literature. Trade flourished and there was an Egyptian fleet in the Mediterranean. At least four of the Fifth Dynasty kings are known to have sent expeditions to the Sinai. And royal expeditions sent to Nubia and Punt (Somaliland) brought back exotic goods.

The chart of Fig. 84 representing the evolution of the bulk volume in pyramid building poses great questions. Why, with all of the prosperity, combined with the Egyptian's accumulated expertise in engineering, organizational, and other skills, was there a great decline in building?

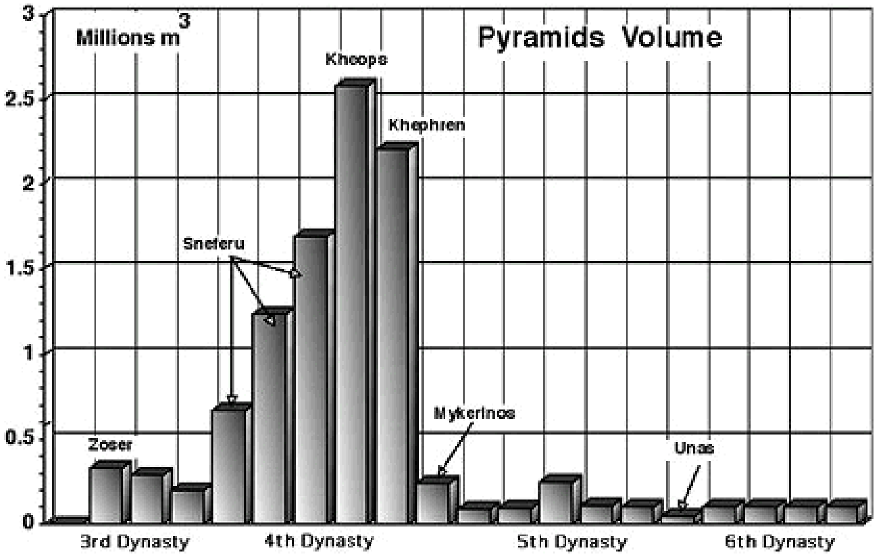


Figure 84: The rise and fall of the pyramids. Volume in Millions of cubic meters of stone.
Sneferu, Khufu, Khafra, together accomplished the bulk of pyramid building within less than 100 years.

It is difficult for Egyptologists to pinpoint the reason that Menkure (Mykerinos) and Fifth Dynasty pyramids were built inferior to former structures. Most advocate that the reduced size is attributed to a decline in the civilization itself. This is not a valid explanation because scholars evaluate the decline of the civilization not by hard evidence, but by the lack of building. Some scholars conjecture that the building trend was due to the consumption of something that leaves no trace. All agree that there is no one simple explanation.

A logical explanation comes to light with an understanding of how the pyramids were really built: the building decline may well have been caused by a depletion of mineral resources. Industrial quantities of mafkat minerals were removed from the Sinai mines during the Third and Fourth Dynasties, especially by Sneferu and the next few kings to follow. The mines of Wadi Maghara had been exploited by such kings as Zanakht, Zoser, Sekhemkhet, Sneferu, and

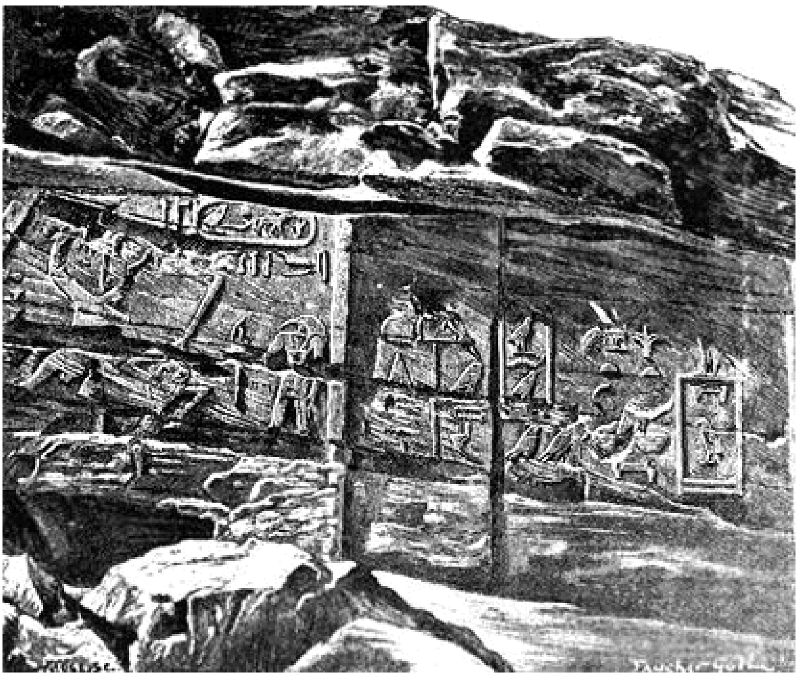


Figure 85: The only surviving record of the activities of Khufu (Kheops of Cheops) is scenes engraved in the Sinai indicating vigorous mining expeditions.

Khufu, who proudly planted their reliefs there. The only surviving records of Khufu's activities are the reliefs at Wadi Maghara, indicative of important mining expeditions (Fig. 85). Sneferu heavily exploited the nearby mines of Serabit el-Khadim, where he was later worshipped by the local Sinai people. The decline was caused by the consumption of something quite traceable after all (Fig. 86).

How else can the tremendous quantity of mafkat

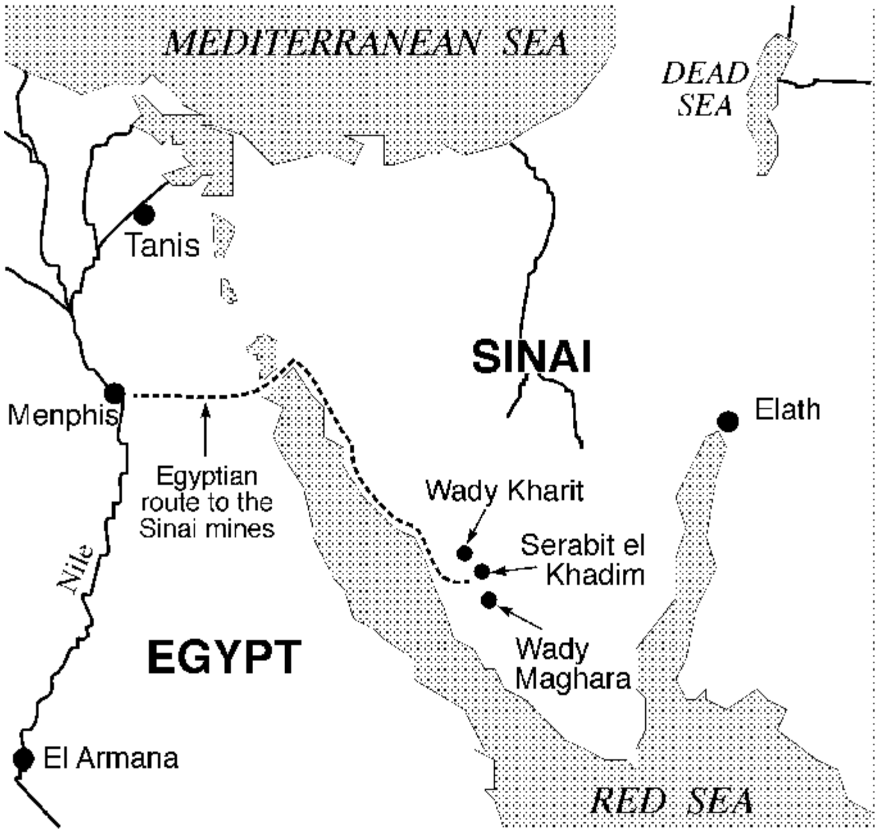


Figure 86: Map of the Sinai region and location of the mines exploited by the Egyptians.

excavated in the Sinai be accounted for? The existence of great desert mining industries is well established. Expeditions yielded gold and silver, and semiprecious gems such as jasper, carnelian, and rock crystal. The major mineral outcrop in the Sinai was mafkat ores. The town of Gebtu (Coptos in Greek and Quift in modern times) was prominent throughout Egyptian history because of its geographical location closest to the Sinai. Mining operations were conducted by the army dispatched from Gebtu. The task force labored under Egyptian foremen in fortified camps along with the Sinai bedouins. Huge shipments of turquoise, green and blue malachite, and the other mafkat minerals listed in Table II were transported to Gebtu.

The exhaustive quantity of extracted mafkat is unaccounted for. Did it disappear through trade with other nations? Certainly the number of surviving jewelry items, amulets, and other artifacts made of or exhibiting turquoise and other blue or blue-green minerals is disproportionate to the amount of mafkat that was excavated. And artifacts found in regions known to have ancient trade with Egypt cannot account for the unusually high amount of mafkat extracted.

It has been estimated that more than 100,000 tons of mafkat ore were extracted, roughly the same as the amount of copper ore. If one assumes that mafkat made up ten percent of the cement, then the 100,000 tons would yield 1 million tons of cement. If one assumes that as much as ten percent of the pyramid limestone concrete is cement, then 1 million tons of cement would have yielded 10 million tons of limestone concrete. Because mafkat was only needed for high quality stone such as protective casing, the minerals from the Sinai mines would have served to build all of the pyramids and related stonework, such as interior and exterior casing stones, temples, capstones, and statuary.

If other minerals which react at ambient temperatures such as opal (hydrated silicon oxide), flint, volcanic glass, and amorphous materials were added to the mafkat, enough material was available to build all of the Great Pyramids. Copper slag from smelting also reacts at ambient temperatures with alkalis. Slag could also have been used to increase cement yield.

However, the most basic products to any agglomerated limestone pyramid blocks are the chemicals natron (the sodium carbonate salt very abundant in Egypt) and lime (calcium oxide CaO). These same elements were used by the Egyptians in other processes. Natron was a sacred product used not only for flux, but also for mummification and deification rites. Many of the same elements applicable for alchemical stone-making later played a role in glassmaking, enamels and ceramics. Advanced technology plays no part in the production of geopolymeric alchemical reactions. The natron salt is extraordinarily abundant in the deserts and salt lakes. Natron reacts with lime and water to produce caustic soda, the main ingredient for alchemically making stone (called the " Second Alchemical Invention " in Appendix 1).

The calcination of limestone into lime CaO requires temperatures in the range of 750°C-850°C (1380°F-1560°F), far less than the temperatures needed for smelting copper, but higher than those for making gypsum mortar. Yet, Egyptology postulates that lime was not calcined in Ancient Egypt until the Ptolomaic time. The experts rely on A. Lucas' statements by which the main reason for the lack of lime is the scarcity of fuel (wood) [83]. But the Egyptians had several trees at their disposal: the acacia, the carob, two species of palm, the date and the doum, the zizyphus, the willow, the sycamore, the persea and the tamarisk. An abundance of lime-ash (CaO in ashes) would have been available by burning these woods for bread making and cooking in simple hearths. The apparent contradiction is due to the lack of adequate scientific method in the search for lime in the Old Kingdom pyramids. I had previously tackled this difficult issue in an earlier scientific study [41] and stated the following with respect to the detection of artificial limestone:

> " … A problem of analysis, assuming that this stone is made by agglomerating limestone (aggregates) using lime as a binder, is that lime hardens over a period of time and becomes recarbonated into calcium carbonate [limestone]. It is impossible to distinguish a natural calcite microcrystal and a microcrystal of calcite which is the result of the recarbonation of lime. This is an obstacle involved in the detection of geopolymeric setting and a new technique must be developed

to resolve it... ".

In a recently published study, geochemist D.D. Klemm claimed having implemented a scientific technique for the detection of carbonated lime [84]. With his new method, Klemm found lime in mortars at Zoser, Meidum, Khafra (Khefren or Chephren), more generally in pyramids of the Third, Fourth and Fifth Dynasties, whereas, according to Klemm: " ... in the Sixth Dynasty lime disappears nearly within the mortars. May this be interpreted as a variation of accessibility of fuel [wood] and consequently of economic potential? "

Referring to the postulate enacted by A. Lucas on the absence of sufficient wood to carry out the limestone calcination, Klemm mentioned in his study:

> " ... This paradigm of the nonexistence of lime mortar before Ptolomaic time was always repeated in literature until recently... J. Davidovits shocked the international Egyptological community with the hypothesis that the limestone that constitutes the major pyramids of the Old Kingdom should be artificial man-made stone. The authors of this article [D.D. Klemm and R. Klemm] investigated nearly 1200 limestones samples of the Old Kingdom pyramids, compared them with the respective quarry material from where they were mined and could prove his hypothesis to be obsolete (in 1988)... But on the other hand J. Davidovits is an international well reputed cement specialist, therefore the analytical data presented by him should be taken as serious... "

Apparently, Klemm was able to develop a method for detecting lime in mortar only, not in the stones themselves. Yet he proved that lime mortar had been manufactured and he demonstrated that the pyramid builders of the Third, Fourth and Fifth Dynasties, did had the wood combustible to provide the lime-ash CaO. On the other hand, he did not find any lime in Sixth Dynasty mortars. Were they no longer capable of cooking their breads in hearths? Was wood becoming scarce or did an erratic change of climate produce an agricultural disaster? I.E.S. Edwards mentioned a severe famine at the end of the Fifth Dynasty (Unas) [85]:

> " … Possibly the most graphic scene of all illustrated the victims of a famine, whose bodies were so emaciated that they were reduced to little more than skin and bone… "

Was the fall in pyramid construction actually attributed to the decrease of lime-ash CaO production, due to a severe shortage in wood combustible? This is quite possible. Under Sneferu, Khufu (Kheops or Cheops) and Khafra (Khefren or Chephren), the entire country was indoctrinated with the gigantic task of supplying fuel for lime calcination. This intensive exploitation of agricultural resources may have generated an ecological disaster.

By the Sixth Dynasty, Egypt was less powerful and the power of the kings seems no longer to have been absolute. The decline of architecture worsened and even artwork was adversely affected. Statues dating to the Fifth and Sixth Dynasties are relatively rare, and the finest date from the early Fifth Dynasty. In contrast, it was estimated through an analysis of fragments that almost 500 statues originally adorned the three Great Pyramid complexes at Giza, collectively. Sixth Dynasty kings were Teti, Pepi I, Merenre, and Pepi II. Their pyramids were constructed like those of the Fifth Dynasty kings (Fig. 87). The surrounding funerary complexes and their reliefs, however, were far less elaborate.

High officials of this period undertook very ambitious, continuous foreign expeditions and quarry activities for which they were better rewarded by the kings than were their counterparts in earlier times. The foreign expeditions, which yielded various goods, may have been motivated by the need for new mineral sources. If this were the case, the pharaohs would indeed have been extremely dependent on their administrators, explaining why such officials were allowed increased privileges and far more lavish tombs.

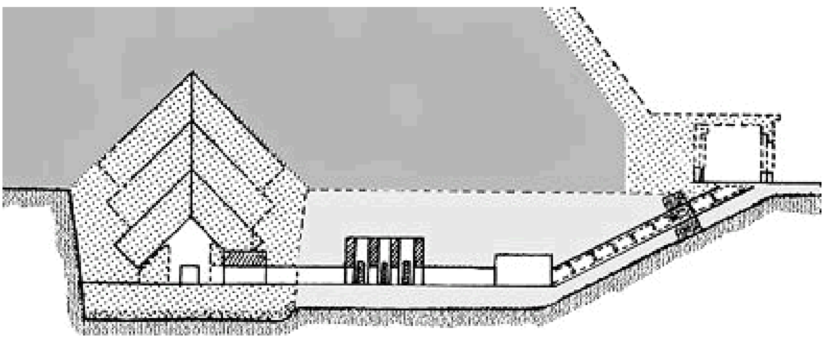


Figure 87: Cross section of the pyramid of Teti shows enormous support beams (J.P. Lauer).

Accounts of ambitious foreign enterprises are inscribed in many tombs. Teti's officers visited Byblos, Nubia, and probably Punt, and exploited eastern desert quarries. Pepi I carried on these activities and extended forces to Palestine. Menenru recorded a visit to Elephantine to meet with Nubian chiefs to develop further trade. Menenra and Pepi I left their inscriptions at the depleting Sinai mining sites and apparently found sufficient minerals, which could have been used for producing stone for the most vital parts of their pyramids.

Objects found in Lebanon and bearing the name of Pepi II suggest a long, continuous trade in timber suitable for wood combustible or for molds. Pepi II's pyramid was built better than most of this period, and it is relatively well preserved with some large limestone casing blocks still remaining on the western side. Of all the pharaohs, Pepi II would have had time to become Egypt's most prolific builder had the means been available. Extraordinarily, he reigned for ninety-four years, the longest reign in history.

Pepi II was to be the last great pharaoh of the Old Kingdom. Within a few years after his death, Egypt was no longer a united nation. The country was in a state of anarchy, lasting more than 200 years. Political and social revolution and high mortality rates characterize the epoch.

The social disruption persisted from the Seventh through Tenth dynasties, called the First Intermediate Period. It appears that during the Seventh Dynasty ephemeral nobles of Memphis attempted to restore order and authority. According to inscriptions found at Gebtu, Eighth Dynasty kings of Memphis, also reigning for brief periods, extended control in Upper Egypt. Petty monarchs defended the nomes in which they resided not against foreign invaders, but against the many perils accompanying a breakdown in civilization.

The sparse monuments built during this era were made of poor-quality materials. Pottery replaced stone, metal, and faience in vessels. Structures never stood higher than 10 meters (10.9 yards), and most were left unfinished or have perished.

The town of Henen-Hesut (Heracleopolis) was the seat of government in Middle Egypt in the Ninth and Tenth Dynasties; the Thebans held control in the south. There was intermittent but intense fighting by these two factions until a Theban victory reunited Egypt in the Eleventh Dynasty, founding the period known as the Middle Kingdom. Thebes was established as the capital of Egypt and a king named Muntuhotep was enthroned. He ambitiously reorganized the land and sent expeditions to Sinai, Nubia, Syria, and Lybia. It was in this time that a new royal building tradition was first effectively and dramatically used to bury a king.

Chapter 16

The Mudbrick Pyramids of the Middle Kingdom

Like those of previous structures, the sacred monolithic sarcophagi, canopic chests, and rooms of limestone, granite, and other varieties of stone were often found intact in Middle Kingdom pyramids and are of superb quality. In the Twelfth Dynasty yet another remarkable feature was introduced into pyramid construction. Egyptologists are hard pressed to explain it.

All technologies have some degree of historical impact, and the great stonemaking technology is hardly an exception. A severe decline in any important technology strongly affects social evolution. To understand how the abatement of stone-making technology affected Egyptian civilization, one needs only to imagine how radically a prolonged shortage of oil would affect us in modern times.

The decline of one technology yields to the rise of another. In ancient Egypt, metallurgy, used to produce improved stonecutting implements, gradually replaced alchemical stonemaking. In the light of the abatement of the old science, once misunderstood historical developments make perfect sense.

The Heracleopolitan dynasty was defeated around 2000 BC. It is generally assumed that no rival ideologies were involved in the power struggle that led to this war. A statement to this effect can be found in an authoritative Encyclopaedia Britannica discussion of Egyptian history. The Heracleopolitan defeat marked a critical point in history between factions fostering two distinctly different ideologies and also two different technologies. An overview shows that the history of Egypt actually takes on a whole new dimension.

The ruling family of Heracleopolis claimed to be the legitimate successors of the last great pharaoh, Pepi II. As such, their plan was to perpetuate ancestral religious traditions. Their goal was thwarted when the rival Theban prince, Mentuhotep, became the first king in more than 200 years to rule over a united Egypt.

The new king, born in the south, was devoted to southern culture with its Nubian influence. At this point in history, Mentuhotep's royal residence was a small provincial town, Waset, which the Greeks later called Thebai or Thebes. Memphis, the capital of Egypt since Archaic times, was replaced by this small, underdeveloped community. Mentuhotep concentrated building operations at Thebes and other parts of the south during a lengthy reign of fifty-one years. Though only a few monuments of Thebes can be dated to the latter part of the Old Kingdom, the town would rise to prominence during the Eleventh Dynasty.

As Mentuhotep's administration restored tranquillity throughout the land, the cult of the minor, local, Theban god, Amun, gained in influence. Though Thebes was Amun's only significant center of worship during early times, great antiquity could be claimed for the god. In line 558 of the Pyramid Texts of Unas's pyramid, Amun's name is surrounded by those of gods of remote antiquity, placing Amun among the primeval gods.

The Heracleopolitan rivals of the north preserved the ancient worship of Khnum. Various forms of Khnum were revered in Egypt, including Khnum-Ra, Khnum-Hapi, and Hershef Heracleopolis, the setting for a number of significant mythological events, was the center of Khnum worship in the form of Hershef.

The doctrines of Khnum and Amun fostered fundamentally different religious philosophies. Documents dating from the Old Kingdom depict Khnum's doctrine, comparable to the biblical tradition advocating that humankind was created through an agglomeration of earth. In Khnum's tradition, the eternal bodies, or *ka*, represented by the king's statues, were produced like the sacred eternal pyramids and temples, through an agglomeration of stone.

Nothing is known about the attributes or the form of Amun worship during the Old Kingdom. The doctrine of the Amun clergy, which was either preserved or which developed and emerged as the priesthood became Egypt's most powerful in later times, advocated a creative process different from that of Khnum, carving.

According to Theban mythology, sandstone and pink granite represented the body of Amun. Blocks of sandstone were quarried with great care so as not to injure the body of the deity. Obelisks made of Aswan granite were sometimes referred to as The Finger of Amun. After the introduction of bronze tools by the New Kingdom, statues were so piously quarried that the vivid chisel impressions in the quarries actually allowed Egyptologists to match statues to their place of origin.

In the soft sandstone hills of the western bank, opposite Karnak (el-Tarif), the Theban princes of the First Intermediate Period emulated their ancestors as they hollowed out their tombs. In the Memphite tradition, only common people were buried in a hollowed-out pit tomb. With Egypt under Theban rule, the common custom was followed to bury the new king elaborately. Mentuhotep's chief architect selected the royal burial site in the northern part of the Theban necropolis at Deir el-Bahari. In a large, deep bay in the cliffs, the workers began hollowing out a vast tomb. Architects altered the plans several times until the final outcome was a new form of royal tomb, a mastaba temple.

The monument was approached by an open causeway about 1,200 meters (0.75 mile) long, extending through a formal grove of sycamore and tamarisk trees planted in rows of circular pits. A ramp approached the temple. Basically a large, rock-cut platform with some masonry filling, the temple rises in three terraces, the first two of which are partially furnished on the exterior with colonnades. The third terrace is surmounted by the remains of the most predominant feature, a ruined structure believed to have been a mastaba. It consisted of a core of rubble and flint boulders and was cased with two outer layers of limestone.

Initially, the structure was assumed to be the remains of a pyramid devoid of chambers or passages. Calculations by Dieter Arnold, however, determined that the terrace could not have withstood the weight of a pyramid. The mastaba temple style can be classified as a synthesis of Theban portico tombs and the ancient mastabas of Abydos. Abydos was an important burial ground beginning in the early dynastic period. It bordered the two rival territories and changed hands several times during fighting until recaptured by Mentuhotep.

Unlike Memphite burials, no mastabas were built for officials and nobles. Their tombs were hollowed from the soft rock of the vicinity. Instead of limestone, the statues of the king are sandstone. Certain features, including the mastaba, indicate a carry-over of the old tradition. This suggests a certain amount of religious compromise between the Thebans and Heracleopolitans and perhaps explains Mentuhotep's expeditions in the Sinai. Reliefs adorn the base of the temple, and some are crude whereas others are sophisticated, the latter believed to have been done by Memphite artisans. It is likely that some of the reliefs were carved and others agglomerated.

It was in this time that sculptor Irtysen claimed on his funerary stele (see in a previous chapter) (Stele C14 in the Louvre Museum, Paris):

> " … I know the parts belonging to the technique of molding (with castable) fluid (stone), namely the weighing (of the ingredients) according to the exact receipt; the (making) of mold parts that must be introduced inside (during casting and hardening) and withdrawn before demolding so that a member come in its place... This (secret) knowledge was not revealed to anyone except (to) me alone and my eldest son of my body; the god (Pharaoh Mentuhotep) had commanded that he stands before him, and took the revelation about it… "

Casting statues was a secret religious technique and was to be authorized by Pharaoh Mentuhotep himself.

Towering above the site is an unusual feature. On top of the western cliffs stands a naturally formed pyramid. Anciently the pyramid was called the Holy Mountain or the Peak of the West. Today it is known as el-Quern, meaning " the horn" in Arabic. The curious pyramid overlooks the tombs of Deir el-Bahari and the Valley of the Kings.

No other tombs of the dynasty were completed. After the death of Mentuhotep's successor, a brief dark period of history passed when Egyptian again opposed Egyptian. When the confusion cleared, it appears that the last king of the Eleventh Dynasty around 1900 BC, also named Mentuhotep, employed a man named Amenemhet (Amenemmes in Greek) as his vizier and as commander of the army. There are few clues about Amenemhet's knowledge and affiliations. However, he may have been associated with alchemical stonemaking, because he was chosen to obtain hard stone for the king's sarcophagus and its lid from quarries at Wadi el-Hammamat. He is believed to come from a prominent family of Elephantine and, therefore, would have been devoted to Khnum.

Almost nothing is known of the circumstances that brought him to the throne, although 10,000 men were under his command and the change was accompanied by some violence. Although his name shows an association with the Theban god, Amun, it appears that Amenemhet took the name to gain political acceptance. Once he was crowned king, Amenemhet I immediately re-established dominion over most of the nome governors and moved the royal residence to a town near the old capital of Memphis called Ithtawi, not far from modern el Lisht, which is in the vicinity of the Faiyum. He mined in the Sinai and built his pyramid in the nearby necropolis, returning as far as politically possible to Old Kingdom traditions.

His classical pyramid and complex are highly decorated in Old Kingdom style. The pyramid is called a museum of Old Kingdom art because it exhibits so many decorated blocks removed from monuments of Saqqara, Dahshur, and Giza. Some Egyptologists surmise that certain blocks were taken from the valley temples of Khufu and

Khafra. The mortuary temple was decorated with relief drawings copied from the Old Kingdom.

Like the Sixth Dynasty pyramids, Amenemhet I's pyramid is made of masonry walls and a loose filling of rubble and sand, all reinforced with a casing of fine limestone. Today it is in ruins with its enormous granite plugs remaining in situ and its burial chamber hopelessly submerged in water, caused by a significant rise in the level of the Nile bed.

Amenemhet I apparently promoted religious compromise, and Egyptologists recognize in his pyramid layout an influence of Mentuhotep's tomb because the causeway has no roof and the pyramid was built on rising ground. Its buildings are on two separate levels, the upper level supporting the pyramid itself. The levels have rows of tombs. About 100 mastabas of nobles and officials were built around the pyramid in the age-old tradition.

In addition to the design compromise, which in any case economized on the amount of stone required, Amenemhet I founded the great temple of Amun at Thebes and greatly increased Egypt's internal development. His name remained associated with Amun. Even with this level of compromise, the power struggle was not over.

In about the thirtieth year of his reign, Amenemhet I was murdered in his sleep one night by his chamberlains. At the time, his son, Senusert (Sesostris in Greek), was on a campaign in Libya. Realizing the conspirators' attempt to overturn the dynasty, Senusert gave orders to silence the news, then raced to the capital. Senusert successfully halted the takeover through swift action. After twenty years of rule, Amenemhet I had made his son co-ruler, and they had already ruled together for ten years. Amenemhet was the first to enact such a policy, which was adopted by Twelfth Dynasty successors and also by New Kingdom kings to help safeguard the dynasty during these times of political rivalry.

Senusert I, who would reign for another thirty-five years, sent expeditions to the Wadi Kharit mines in the Sinai and had his pyramid built near his father's at el-Lisht. The causeway was built of fine white limestone and the mortuary temple replicated those of the Sixth Dynasty. The remarkable interior of the pyramid is made of walls that radiate like spokes from the center of the structure to form compartments. These are reinforced with mud brick and stone rubble. Two layers of heavy casing of fine limestone reinforced the entire structure, some of which remains on the western side. The passage descending to the burial chamber, also submerged in water, is lined with perfectly fitting red granite slabs. Near the pyramid are two interesting mastabas belonging to high priests of Memphis and of Heliopolis; the latter carried forth the name Imhotep and was probably a descendant.

Sensusert I carried on the religious compromise. He beautified Heliopolis with a magnificent Sun temple and obelisks. One of the latter is the only thing standing at the site. His architects energetically built monuments throughout the land, not neglecting Thebes. Investigations to determine which monuments were carved and which were cast would provide relevant insight about this political period.

His son, Amenemhet II, also maintained the old traditions at Dahshur, but there was further critical decline in stonemaking technology. It is believed that casing blocks were taken from the Northern Pyramid of Seneferu in the vicinity, because roads dating from Amenemhet II's time link the two monuments. However, not a single casing stone was found during excavation. The pyramid is in such total ruin that its dimensions can only be estimated.

The next ruler was Senusert II (Sesostris II) around

Figure 88: the mud-brick pyramid of Senusert II at el-Lahun (Faucher Gudin).

1870 BC, who introduced a revolutionary element. Overlooking the channel that leads to the entrance of the Fayum basin near the village of el-Lahun, his pyramid is made almost entirely of mud-brick. Some 800 years after Khasekhemwuy's mudbrick enclosure, it is the first of the giant mudbrick pyramids built by the rulers of the Twelfth and Thirteenth Dynasties (Fig. 88). Entering the granite burial chamber, Petrie found an exquisite red granite sarcophagus that amazed him. He called it one of the finest pieces of work ever executed in such a difficult, hostile material. He calculated its parallelism to be almost perfect, with errors in form equaling no more than 0.01 cubit .

The king's successor, Senusert III, was one of the greatest pharaohs of the Middle Kingdom. He built his mudbrick pyramid at Dahshur. The structure, now in ruins, was cased with limestone blocks and red granite was used for its exquisite burial chamber and sarcophagus.

This pharaoh energetically expanded Egypt's southern territory and completed several projects started by his great-great-grandfather, Amenemhet I. In the First Cataract region, Senusert III expanded channels for the passage of ships, and in the region of the Second Cataract he enlarged a series of mudbrick forts to help secure the southern borders. Above the Third Cataract, he established permanent garrisons and customs ports. He fortified Egypt's usual routes in and out of the country along the northeastern frontier with large mudbrick walls to regulate the entry of foreigners.

Since the beginning of the dynasty, the kings' envoys made regular trading missions to Syria. Contact with Syria, Palestine, and parts of Asia were mostly peaceful. Trade flourished, but there was also some conflict. The need arose for the pharaoh to enact sweeping government reforms, which secured the power of the throne and the administrative capital at Ithtawi.

It was a time of prosperity when literature and the arts flourished. Agricultural progress increased, with much effort spent on irrigating large tracks of land in the Faiyum. The land recovery program converted the district into one of Egypt's most bountiful. Like his father and grandfather before him, Senusert III mined vigorously in the Sinai, expending more effort but obtaining far less mafkat even though during this era metal tools replaced flint for ore extraction. Documents show that several expeditions were unsuccessful.

Senusert III is also known for defeating a stronghold of rival monarchs at Hermopolis, the town where Amun was one of the primeval group of eight deities, or ogdoad. Like the pharaohs, the defiant monarchs of Hermopolis dated Egyptian events to their own years of rule. They maintained fleets of ships and armed forces. Artisans of this town, carrying on their religions tradition, carved the great colossus of their ruler Djehutihotep from soft alabaster quarried at Hatnub. It is a bas-relief in the tomb of this ruler, depicting the transport of the great colossus, that I call false proof of Egyptology 2. We see that the techniques of rivals of the pyramid-building pharaohs have been used as proof of how the pyramids were built.

Favorable conditions had been set up for the brilliant forty-six year reign of the next pharaoh, Amenemhet III. This great pharaoh is not remembered for campaigns or reforms but for outstanding art and construction. The classical historians credit him with producing the large Lake Moeris in the Faiyum region. Though it is not as large today, the lake gleamed silver with fish and was so large that it tempered hot winds blowing in from the west, creating a balmy climate. The lake transformed the surrounding area into a garden paradise of lush vegetation. Scholars wonder if the lake existed earlier, but they do not question the pharaoh's involvement with one of Egypt's truly great memorials, the fabulous Labyrinth in the Faiyum, at Hawara.

At the end of the Labyrinth was the finest pyramid ever made of mud brick, the pyramid of Amenemhet III. This pyramid has a truly remarkable feature. Unlike other mudbrick pyramids, Amenemhet III's pyramid at Hawara has not decomposed, although 3,800 years have passed. Why? Because there was an innovation in Khnum's technology. Khnum was held in the highest religious regard by Amenemhat III, as shown by a text attributed to one of his administrators [86]:

> " … I am addressing these important words to you and I count on you to understand them…. Venerate the King in your body, that he might live forever, and be faithful in your souls to His Majesty. He is the intelligence in the hearts (of men) and his gaze penetrates all bodies. He is Ra by the rays by which one sees. Iris he who illuminates the two earths (better still than) the solar disc…. He feeds those who serve him and he submits to the needs of those who follow his road. The King is Ka and his word is life. Whosoever be born is his work, for he is (the god) Khnum from whom come all the bodies, the progenitor…. "

At this point in history, Amun's clergy had not gained sufficient power to proclaim Amun as the progenitor. It was

Khnum who created mankind, through an agglomeration process. To perpetuate the ancient rite of agglomeration, bricks were made for the eternal pyramid by mixing caustic soda (natron, lime, water) with mud from Lake Moeris. Partly because of the mineralogical composition of the mud, their efforts were most effective.

In the interior of the pyramid, a complex system of galleries concealed access to the burial chamber. The architects designed uncanny corridor arrangements, with dummy corridors leading to dead ends. Enormous sliding slabs, a trap door, and false burial shafts were incorporated to hide any structural clues that could reveal the true burial chamber entrance.

Petrie entered the pyramid and made his way through the devious maze of corridors. Much water had entered the pyramid and the passages were so blocked with mud that he had to slide through naked, all the time feeling for artifacts with his toes. He was astounded at what he found when he reached the burial chamber. This extraordinary structure was made of a single piece of yellow quartzite. If the block was carved, it would have weighed originally about 110 tons. Petrie wrote:

> “ The sepulchre is an elaborate and massive construction. The chamber itself is a monolith 267.5 inches [6.8 meters] long, 94.2 inches [2.4 meters] wide and 73.9 inches [1.9 meters] high to the top of the enormous block with a course of bricks 18.5 inches [0.5 meters] high upon that. The thickness of the chamber is about 25 inches [0.6 meters]. It would accordingly weigh about 110 tonnes [metric tons]. The workmanship is excellent; the sides are flat and regular and the inner corners so sharply wrought that — though I looked at them — I never suspected that there was not a joint there until I failed to find any joints in the sides. ”

Petrie was referring to the original mass when he estimated the weight of the block, because the chamber itself weighs seventy-two metric tons. If this chamber was carved, the work would have required precision tooling, inside and out, on a solid mass of hard quartzite, the hardest type of rock. This is the type of artifact that has added fuel to theories advocating the existence of ultramodern machinery and super Space Age sciences during antiquity. Petrie could not explain its manufacture. Lowering the enormous structure into the confined space would have been the least of the difficult problems. If the mass had been quarried, the quarry site should remain. Egypt's quartzite quarries show no signs of quarrying blocks or statues according to members of the Napoleonic expedition, who made a thorough investigation of Egypt's quartzite ranges. On the other hand, loose, weathered quartzite is available in great quantities near all quartzite quarries, and was ready for agglomeration.

Following the extravagant use of stone by the builders of the Old Empire, the return to mudbrick is a severe shock for anybody involved in the study of pharaonic architecture. One would have expected stone carving with bronze tools. This paradox is illustrated in Fig. 89. In Zoser's pyramid, Imhotep's limestone bricks were made in a way similar to the mudbricks in Khasekhemwuy's enclosure. Then, the dimensions of the limestone bricks (and of the molds) increased little by little. Fourth Dynasty pyramids introduced blocks cast in place with huge temple blocks weighing several hundred tonnes. In the Fifth and Sixth Dynasties the mortuary chamber was protected by enormous beams. In Twelfth Dynasty pyramids the hard stone mortuary chamber became monolithic and the core evolved from rubble to mudbrick.

The mudbrick pyramids seem to be aberrations unless one considers the agglomeration of mudbrick as being part of the alchemical stonemaking. This being the case,

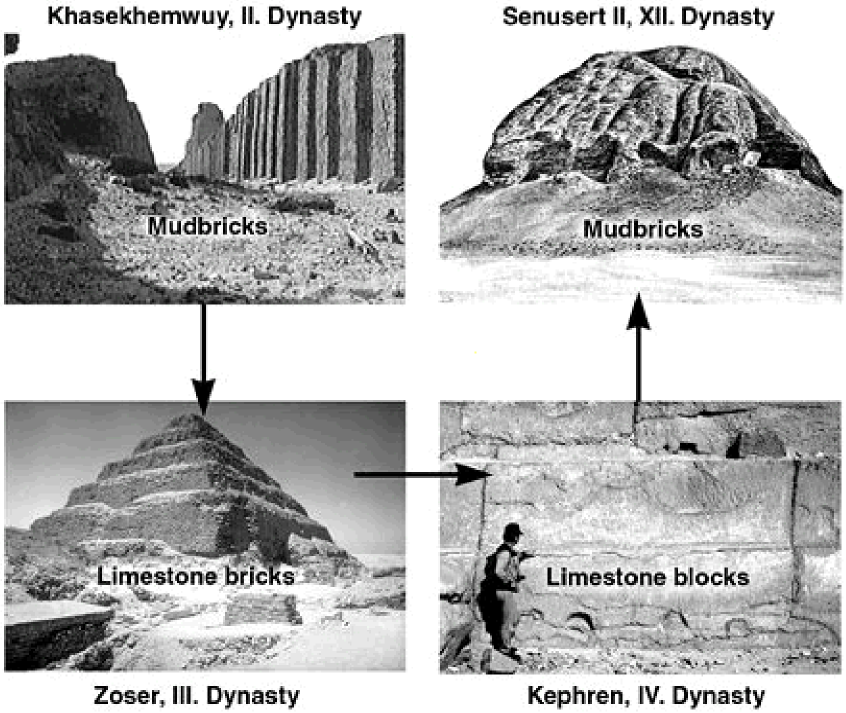


Figure 89: The paradox of pyramids construction. 700 years after the invention of limestone bricks by Imhotep, the pyramid material of the 12th. and 13th Dynasties returned to mud-brick.

Herodotus' statement (Book II, chapter CXXXVI) on the mudbrick pyramids becomes relevant:

> " ... This prince [Amenemhet III) wishing to surpass all the kings who had reigned in Egypt before him, left as a monument a pyramid of bricks, with this inscription engraved in a stone: do not scorn me in comparing me with the pyramids of stone; I am as high above them as Jupiter is above the other gods, for I was built of bricks made from the silt from the bottom of the lake... "

Amenemhet III also built another mudbrick pyramid at Dahshur with a similar interior design, which is still standing though now in ruins. Its summit was crowned by a magnificent pyramidion made of lovely dark-gray granite and now in the Cairo Museum. Some Egyptologists surmise that because of structural weaknesses, Amenemhet III abandoned the structure at Dahshur and built a second pyramid at Hawara, where he was presumably buried. His death marked the end of the Middle Kingdom.

Another mudbrick pyramid with a complex interior arrangement, called the Unfinished Pyramid, was tentatively assigned to one of Amenemhet III's successors. If carved, the monolithic block used to produce the burial chamber would originally have weighed a massive 180 tons. Yet, it is this pyramid that contained the small models of copper tools mentioned earlier.

At Mazghuna, about three miles south of Dahshur, two ruined mudbrick pyramids are attributed tentatively to Amenemhet III's Twelfth Dynasty successors. Reasons for the Twelfth Dynasty overturn are uncertain. Pharaohs of the Thirteenth Dynasty maintained their capital in the north, and a few managed to build mudbrick pyramids. One pyramid attributed to Khendjer, built at Saqqara, contains a monolithic burial room made of hard quartzite that would have weighed about sixty tons if it were carved from a single block.

In the Thirteenth Dynasty, which lasted about 150 years, about seventy kings ruled in rapid succession. At the end of the Thirteenth Dynasty, or perhaps a little later, the land again passed through a severe, dark time, known as the Second Intermediate Period. This period differed from the former anarchical period. This time trouble erupted from political division coupled with foreign intrusion.

Chapter 17

Egypt after the Pyramids Carving Stone for God Amun

After the time of the pyramids, from the Thirteenth through the Seventeenth Dynasties (1700-1550 BC), a period of nearly two hundred years, Egypt lived under the domination of the Hyksos invaders. The Hyksos won many military victories over Egypt, as they possessed chariots which were completely unknown to the Egyptians, a highly superior range of bronze weapons, and a very effective bow that further increased the power of their army. Stronger in number, the Hyksos made heavy gains and lived in fortified camps, leaving the conquered Egyptian temples to become abandoned. With the victory of the Hyksos invasion, Egypt was cut into north and south. The Hyksos settled in the north (Lower Egypt), where they imparted a worship which was similar to the religion of the Syrian god Baal. The north was the most populated area and included the Delta and Middle Egypt. The Egyptians who populated northern Egypt were forced into an existence dominated by the Hyksos, and were forbidden to acknowledge their god Ra-Harakthes and his institutions at Heliopolis.

During the two hundred year Hyksos occupation of the northern half of Egypt, the populace seems to have assimilated certain foreign religious rites. There is still controversy as to the origin of the Hyksos. Archaeologists have distinguished two types of Hyksos, the most recent of whom are very close to the Huri culture (septentrional Mesopotamia). Whatever the case, the hordes which unfolded into Egypt did not belong to a pure transcaucasian race. Nomadic tribes joined them during their slow progress toward the south. By the time the Hyksos had penetrated the Nile Valley their numbers probably included a very high proportion of Huri, Semites and other " displaced persons ", who had joined their ranks in Syria and Palestine. It is not in the least surprising that the Hyksos culture, and even their name, reveals a considerable mixture of various ethnic elements.

According to John A. Wilson, the American historian [87]:

> " It would be unjust to imply that the Hyksos were crude barbarians, indifferent to the civilization of the conquered country. If indeed they were formed of a complex mixture of people from all regions where their chariots rolled, we may believe that many of them had been in contact with Egypt and Mesopotamia. They by no means looked down on all the customs of the country, and were not finally, a foreign body in their new setting. Commercial activities were not totally interrupted. One type of Hyksos vase traveled to the south as far as the Third Cataract, and north to Cyprus. The name of one of their kings — Khayan, is engraved on the monuments of Gebelein in meridional Egypt, and Gezer in Palestine, on a granite lion discovered at Baghdad, on the lid of an alabaster vase found at Knossos in Crete, and in a cylindrical seal discovered at Athens, and all these descriptions are in

> hieroglyphic writing. It is highly likely that trade played an important role in the second wave of the Hyksos. The old Egyptian standard unit weight disappeared during the Second Intermediate Period, making way for a new unit doubtless of Mesopotamian origin. The arts suffered no eclipse, and during the Hyksos occupation the careful copying of various scientific documents was undertaken… ”

This mixing-up of the “ Asiatic ” population with the Egyptian people resulted in certain commonalties in the religions of the two groups. The god Baal was identified with the Egyptian god Seth. In both religions the creation of humanity was an act of agglomeration, from clay by the god Ia in Mesopotamia, and from the silt of the Nile by the god Khnum in Egypt. At a time, which corresponds to the exhaustion of the Sinai mineral deposits, the Egyptians encountered difficulties obtaining the minerals necessary for the ritual of the agglomeration of stone, according to the principles of the god Khnum. Serious troubles began, and the role of the god Khnum, his ability as progenitor might have been questioned. Khnum was in further trouble due to a similarity to the Mesopotamian religion.

In the south of Egypt, the Hyksos allowed the pharaohs in Thebes to exercise a phantom power, thus preserving the worship of the god Amun. Amun was a local god worshipped at Thebes until the Middle Kingdom, when he became assimilated to the god Ra by acquiring the name Amun-Ra (Fig. 90). The Amun clergy enacted a national resistance to the invaders at about 1600 BC, when a movement of emancipation began to spread from Thebes under King Kamose. He broke the truce with the monarch of the Hyksos under which Egypt was shared. Kamose announced his intention of marching to the north in the name of the fatherland. In so doing, Kamose was carrying out “ Amun’s orders ”. He

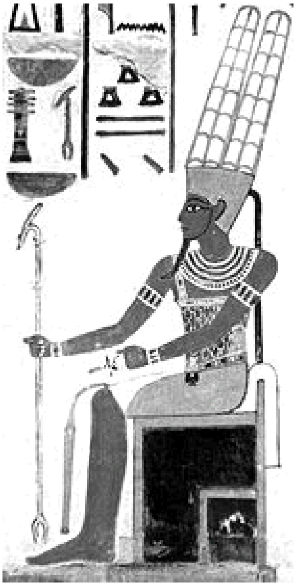


Figure 90: the god Amun

attacked the Hyksos retainers, and reinstated the fifteenth, sixteenth, and seventeenth nomes of Upper Egypt.

The conquest of the territories previously belonging to Upper Egypt, that had the protection of the Amun clergy, recognized Amun' s power as supreme and universal. Yet, under the dynasties of the Middle Kingdom, the god Amun-Ra was a powerful god of Thebes, but he was not the begetter. The creator of the bodies of gods, pharaohs, and of men was the flat-horned ram-headed god Khnum, sire of Elephantine. His hieroglyphic name is a stone vase.

After the Hyksos invasion, Amun was the only remaining god of national character. His prestige as a liberating deity grew under King Kamose, and further intensified under the following kings of the Eighteenth Dynasty:

Amosis 1580-1558, Amenhotep I 1558-1530,
Tuthmosis I 1530-1520, Tuthmosis II 1520-1505,
Hatschepsut 1505-1483,
Tuthmosis III 1483-1450, Amenhotep II 1450-1425.

Amun, the liberator during Pharaoh Amosis' reign, further became the god who subjugated foreign people and delivered them to the domination of his sons, the Pharaohs Amenhotep I and II and Tuthmosis I, II and III. Amun's priesthood profited to a hitherto unequalled extent, becoming richer than the kings themselves. Each victory brought him the spoils of the battlefields, taxes exacted on the vassals and enemy prisoner slaves. When, after having razed Megiddo, Tuthmosis III organized the methodical pillage of the surrounding countryside, it was for Amun-Ra's profit that the crops were harvested and the wheat was sent to Egypt. The useful plants and rare animals that he collected during his travels garnished the woods and gardens of Amun as well as his own. He kept nothing that had been acquired by force of arms entirely for himself, but always put up part of the treasure for Amun. His successors acted in a similar way, and from Amenhotep II, to Tuthmosis IV and Amenhotep III, the Theban priesthood ceaselessly added to their heritage.

The pharaohs were obligated to pay their officials everyday, and never kept the profits of their enterprises for long: gold and silver, land, stonework and slaves slipped through their hands almost as soon as they had been captured. Their fortune, almost the whole of which had been acquired by war, did not increase. As Maspero pointed out [88]

> " The god [the clergy] on the other hand, received all forever, and never gave anything back. He accumulated precious metal after precious metal, vineyards, fields, fishponds, palm forests, villages and farms: each successive reign saw the list of his acquisitions lengthen. He had peasants, artisans, fishermen, soldiers, and scribes. He had a hierarchy of wise fathers, priests, and prophets, and ruled over all this world and organized his worship."

One priest, chosen by the sovereign amongst the prophets, administered this huge domain. This was a sort of state within a state for which he was the responsible chief. His spiritual ambition had grown with his material authority. Seeing the pharaohs of men command the homage of the masters of the earth, the priests eventually persuaded each other that Amun was worthy of the title of the " Masters of Heaven ". Amun was the supreme being beside whom others no longer mattered. Amun, the only victorious god always and everywhere, seemed to them the only god. The kings could only see this rapid evolution of priestly power with displeasure. However pious they might have been to the patron of their city, concern for their own authority made them look elsewhere for a divinity whose influence could partly counterbalance that of Amun. The only one who, for the Thebans, could rival him in the antiquity of his worship and the rank that he occupied in public esteem, was the Sun [god Ra], sire of Heliopolis and chief of the First Enneade. Tuthmosis IV was indebted for his crown to him [Sun Ra, or Ra-Harakhtes], and he recompensed him by sweeping away the Sphinx where the spirit of Ra-Harakhtes dwelt.

Resistance to the Hyksos necessitated protection by the warrior gods, Amun and Ptah. Ptah was the Memphis god of blacksmiths, stone cutters, and for all those who were taking advantage of the new bronze tools, and swords. The first act after peace established by Pharaoh Amosis was to open the soft limestone quarries of Tura. The bas-relief depicting this act is one of the first documents in which the technique of carving was made explicit. Amosis opened quarries at Tura, and obtained good white stone for the temples of Amun at Thebes and Ptah at Memphis. According to Maspero [89]:

> " By a curious turn of fortune, it was the Asiatic prisoners who were made to dig out the vein and repair the ruins that their fathers built. The pictures sculpted in the steles of Amosis show them in the middle of their forced labor [Fig. 91]… "

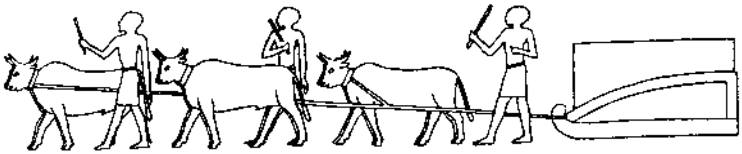


Figure 91: Amosis Stele at the Tura quarries

As their power and subjugation increased, the priests of Amun added the act of creation to the achievements of their god. Soon painted bas-reliefs appeared, which showed Amun in blue. Only two divinities in all of the history of Egypt were depicted in the blue color, namely Khnum and Amun. This has been somehow overlooked by Egyptology. At the 5th Egyptology Congress held in Cairo in 1988, Monika Dolinska [90] stated

> " … Yet, somehow, no one has taken notice of the fact that the original color of Amun was red, and that blue became his feature not sooner than after the Armana Period. Actually there is no one example of blue Amun in the Middle Kingdom or in the Eighteen Dynasty, up to Amenhotep III time… "

Blue was the color of mafkat. This mineral was discussed at large in Chapter 9 and Table II. Amun assumed the role of progenitor, but did not use the same method of creation as did Khnum. The Book of Thoth stresses the act of creation by Amun as the following:

> " A mountain of mud began to rise up from the shadowy waters, the mountain of mud swelled up, casting out bubbles, and took the form of the first god: Amun. And Amun pulled out [carved] the limbs and all the parts of his body, and these parts of the body of Amun were transformed into men, animals and all creation, and all living things on earth. Amun [signifies] 'he who comes from the darkness'. He is the creation and all that exists eternally in all things. "

Khnum agglomerated, producing humanity with Nile silt and other minerals, like mafkat and natron. Amun was a mountain and carved each being from himself, the mountain. In order to understand this obscure part of Egyptian history, let us consider the hypothesis that Khnum and all of the divine incarnations of Ra (Ra-Harakthes) were materialized by the act of the agglomeration of stone. Stone was the sacred material, designated for statues, tombs, temples and pyramids. On the other hand, let us consider that Amun, and all the divine incarnations of Amun-Ra, were materialized through the act of carving the stone constituting the sacred monuments of the New Kingdom. Within this assumption, all detailed stone carving had to be completed in the mountain, directly on and in the body of Amun. The tombs would no longer be placed under pyramids, the symbols of agglomeration. The tombs would become located in grottos that were carved into the mountain, in the west. In the mountain of Deir el Bahari the tombs of the pharaohs of the Eighteenth Dynasty, Tuthmosis I, II, and III, Hatschepsut, and Amenhotep I and II are found, and in the Valley of the Kings rest Amenhotep III and the Ramses' pharaohs.

The favorite New Kingdom stone material was the monumental sandstone, also called psammite sandstone. The datation study by D. D. Klemm of the different sandstone quarries of Silsilis, including dating various types of chisel marks was mentioned previously in Chapter 4 and Figure 7. On one side of a quarry, fine chisel marks representing the finest way of cutting stone are found (carving into Amun's body), and on the other side of a quarry, wedges, or wooden dowel rods were employed. The wooden dowel rods were inserted into the quarry and the wood was made wet with water, and when the wood swelled, the stone cracked. The dowel rod technique was a primitive method of cutting stone, incorrectly presented by many archaeologists as being the oldest " proof " of the carving technique and the stoneworking method practiced in pyramid building. This primitive method of cutting stone was operated only by the Romans, during the Roman occupation of Egypt, from the First Century BC, to the Third Century AD. The fine technique of cutting stone with chisels was adopted fourteen hundred years earlier by the Egyptians of the Eighteenth Dynasty.

It becomes apparent why each stone, great and small, was carved directly in the mountain (quarry). To extract a large stone, and cut it into several pieces away from the quarry would have been considered as sacrilege to the body of Amun. This explains why obelisks, sometimes called the " finger of Amun ", were carved in one piece directly in the mountain, and why the colossal statues, representing the *ka* of the pharaohs of the New Kingdom, found in front, or inside of their funeral temples, were sculpted directly in the mountain. The exact origin of each obelisk and colossus has been found in the corresponding syenite and monumental sandstone quarries of the New Kingdom, where the imprint of each statue and obelisk remains today. Every monument of this period has been associated to its original quarry, except for the two tremendous Colossi of Memnon.

The Pyramid of Zozer built near 2750 BC, the Pyramid of Khufu (Kheops or Cheops) in 2683 BC, the temples of Amenhotep III erected around 1408 BC, Seti I near 1300 BC, and Ramses II at about 1280 BC, were made of stone. On the other hand, the palaces and fortresses in which these kings resided were made of crude silt brick, sun-dried clay and wood. Stone, either agglomerated or carved, had a sacred value and could not be used for such nonsacred structures. It was not until the Ptolemaic reign under Greek domination, some two thousand years after the pyramids were built, and one thousand years after the construction of the Temples of Karnak, Luxor, and Abu Simbel, that stone became a constructional material used indifferently in temples, palaces, and garrisons.

The finest method of cutting stone, represented by fine chisel marks, was applied to stone by the Egyptians when stone had a religious significance. The dowel rod technique, representing the roughest and most primitive method of cutting stone, was used by the Greeks and Romans who did not consider stone to have the same metaphysical aspects as did the Egyptians.

Each block of stone was perfected in the quarry, the manifestation of Amun, as each hewn stone represented a limb or part of Amun. This belief explains why the Egyptians of the New Kingdom did not use the primitive wooden dowel rod method of cutting stone. To haphazardly cut a block of stone into pieces was an act of sacrilege, as unthinkable as to damage the body of Amun, the newly proclaimed progenitor.

Queen Hatschepsut's conversion

Pharaoh Tuthmosis I (1530-1520) had no sons, therefore one of his concubine's sons became King Tuthmosis II (1520-1505) after marrying his half sister, Princess Hatschepsut (the daughter of Tuthmosis I). Although Tuthmosis II seemed to have all of the exterior trappings of power and pomp, it was Hatschepsut alone who led the way. In 1505 BC, at the death of Tuthmosis II, Hatschepsut wed one of her daughters to the future Tuthmosis III, who was the son of Tuthmosis II and a morganatic wife. Hatschepsut, Tuthmosis III's mother-in-law and aunt, assumed the regency and left him in the background. According to the provisions of the morganatic system, a man of nobility might marry a woman of inferior social status. Although children of the marriage will be legitimate, neither the wife nor children might lay claim to his name or property. Hatschepsut became therefore the rightful heir to the throne. She assumed all of the insignia of a male pharaoh, and in official ceremonies appeared in male dress with a false beard on her chin. The only feminine habit she conserved was to speak of herself as " her majesty ". She was instated as the direct descendant of Amun, and the act of her divine lineage was engraved on the walls of her funeral temple at Deir el Bahari.

The inscriptions decorating her temple tell how on that night, Amun came down to Ahmasis (her mother) in a flood of perfume and light. She willingly submitted to his caresses, and the celestial husband upon leaving, predicted the birth and destiny of a daughter in whom his own valiance and force would live again down here on earth. Maspero tells us of the birth and childhood of this daughter of Amun [91]:

> " However, the child was born amid cries of joy, and the benevolent spirit nourished her with her double [her ka], and raised her. In due course, her cosmic father brought the officials

Figure 92: God Amun and Queen Hatschepsut. Top of Hatschepsut's fallen obelisk at Karnak (1979)

together in a solemn festival and presented to them his daughter as reigning with him over Egypt and the world. Hatschepsut would from then on, find every means to hide her gender.. She became the King Makere, who in public ceremonies wore the dress of a man… "

As the daughter of Amun, she carried out filial duties beyond the normal, especially at the beginning of her reign. On the obelisks at Karnak (Fig. 92-93) there is inscribed:

" … Here is what I have to say to the mortals who will come in the course of the centuries, whose hearts will be preoccupied with this monument that I have erected to my father, whose

Figure 93: Obelisks in the Temple at Karnak (carved or hewn granite).

speech will be full of exclamation, and who will then contemplate it: I, while seated at the palace and remembering he who created me, my heart made me erect for him two obelisks whose tips will pierce the firmament in the August Portal, between the two great pylons of the King Tuthmosis I. And my heart directed me to address these words to the humans who will look upon my monument in the years to come, and will speak of my achievement. Refrain from saying, " I know not why this resolution to model a mountain entirely in gold was carried out! "These two obelisks, my majesty made of silver-gilt to my father Amun, in order that my name be upheld in this temple forever and ever; for it was made in a single block of granite with no obstacles, with no opposition to that which my majesty wanted to be performed for him, from the first of the second month of Pirit of the Year Five, to the thirtieth of the fourth month of Shumu, of the Year Six, which makes seven months from the moment when the quarry was attacked… "

The two obelisks referred to by Hatschepsut were fashioned (carved, hewn or pounded?) in a quarry under the direction of the architect Sanmut. One of these two monoliths still stands in the middle of the ruins of Karnak (Fig.93). It measures 29.50 meters (ninety-seven feet) high and is one of the largest obelisks ever erected. Only those of Tuthmosis III were larger: 37.77 meters (124 feet). These measurements are approximations due to the fact that the two obelisks are broken. The pyramidal tops were gilded with gold so that they could be seen from both banks of the river, and their brilliance would shine in Egypt in the north and south.

Several years after the great ceremony to Amun, Hatschepsut visited the north of Egypt, which hundreds of years before had been under the domination of the Hyksos. It came to her attention that none of her predecessors cared about the religion or the well-being of this part of the

Egyptian populace, who were cut off from their Masters of Avaris. For practically one hundred years the northern Egyptians were suspected of collaboration with foreign gods, and therefore received no revenue from the throne. No money was available to undertake the public works so necessary throughout the north. The canals were salted up, marshes and deserts had encroached upon the cultivation, and the towns had become impoverished. No temples had been maintained and all were badly in need of repair. The compassionate Hatschepsut undertook their restoration. Lines 35-39 of the hieroglyphic text at Stabl-Antar describe the declarations of Hatschepsut previous to the ninth year of her reign [92], that is four years after the erection of the two Amun obelisks at Karnak:

> " … I have restored what had been destroyed, I have rebuilt what had fallen into ruins since the Asiatics occupied Avaris in the heart of the Delta, and what wandering gangs mixed with troops had brought down, for they governed without (the worship of the god) Ra and the latter ceased to carry out the divine decrees up to (the reign of) my majesty. I have cast aside those who abandoned the god and the earth has erased their footprints… "

Since the liberation, the worship of Ra-Harakthes had ceased, in all likelihood, for more than three to four hundred years. Hatschepsut was previously indoctrinated solely to the theology of Amun-Ra, and she erected two magnificent carved obelisks from the body of Amun. She then discovered the unknown world of the ancient worship of Ra-Harakthes, the divine incarnation in agglomerated stone (limestone bound through alchemical reactions), and the attributes of the god Khnum, the flat-horned ram head. She turned her attention to the Sinai mines, where exploitation had ceased after Ammenemes III, builder of crude-brick pyramids more than three hundred and fifty years prior. A stele engraved in the sixteenth year of Hatschepsut's reign, located at Wadi Maghara, indeed shows that an officer of the royal household was dispatched to the site of the ancient Sinai mines to inspect the veins, restore the temple of the goddess Hathor, and return with a precious cargo of mafkat stones of green or blue color.

She built her funeral temple on the site of the tombs of Tuthmosis I and Tuthmosis II at Deir el Bahari, at the foot of a rocky cliff (Fig. 94). A wide avenue of sphinxes situated in the valley leads from the Queen's Sanctuary to a magnificent funeral temple surrounded by gardens, orchards, and a large enclosure wall. There was also a courtyard surrounded by a double row of columns constructed of white limestone. At the entrance, ramps led to the first and second terraces. The

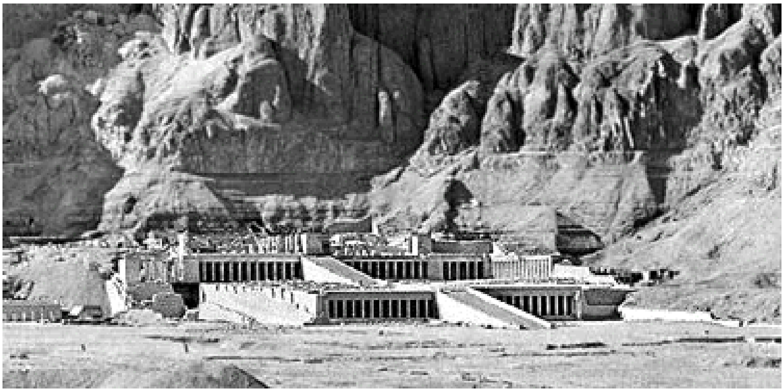


Figure 94: Hatschepsut's Temple at Deir el Bahari

retaining walls of the terraces consist of finely polished blocks of limestone with simple ornaments. The two colonnades of the second terrace (the Central Court) are on the right, the Birth Colonnade, and on the left the Colonnade of the Punt. The Birth Colonnade contains eleven pairs of square pillars supporting the roof. The inscriptions and representations on the walls of the colonnade refer to the procreation and birth of the queen. A bas-relief depicts the god Khnum accompanied by Ekhet, one of his wives, as he fashioned the body of Queen Hatschepsut and her ka (Fig. 95). A cartouche can be found there on which one reads: “ Khnumu-Amunuit Hatschepsut ”, meaning, “ May the god Khnum protect her, daughter of Amun ”. This name, “ Khnumu- Amunuit Hatschepsut ”, is her true name, and resembles the name of the great builder of the pyramid of Khufu (Kheops or Cheops): “ Khnumu-Khufui ”, meaning, “ May the god Khnum protect Khufu ”.

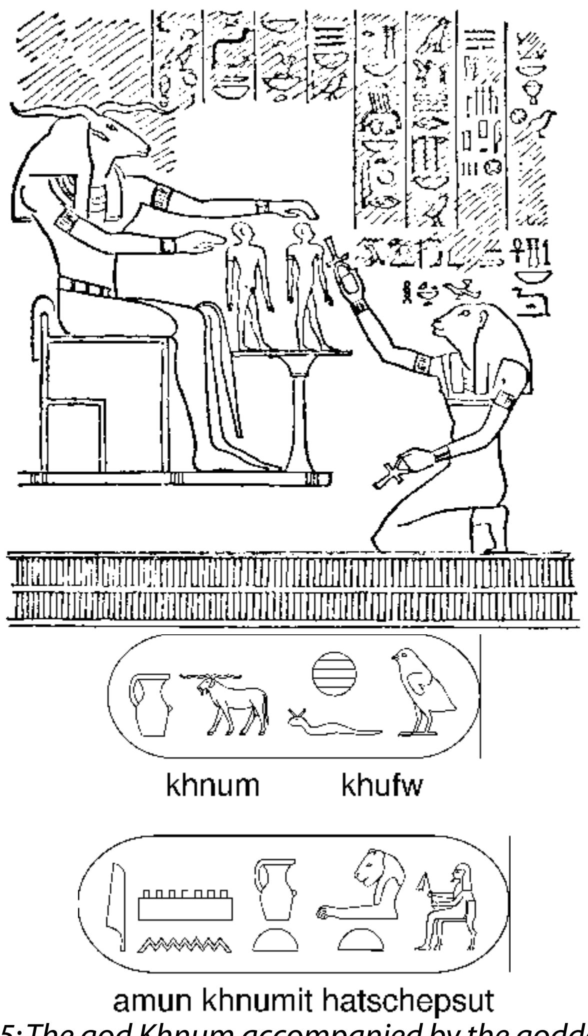


Figure 95: The god Khnum accompanied by the goddess Ekhet fashioned the body and the ka of Queen Hatschepsut. Deir el Bahari.

At the end of the upper Court, a granite portal forms the entrance of the Sanctuary with 3 chambers. The 3rd Room was added under the Ptolemaic pharaoh Euergetes II and was dedicated to the deified scribes and architects Imhotep and Amenhotep son of Hapu. The reliefs and inscriptions of this late period compare very unfavorably with the masterly sculptures of Hatschepsut.

The mortuary Temple of Hatschepsut made of agglomerated limestone

Usually, the monuments and temples built in Thebes are made of fine sandstone blocks hewn in the quarries of Silsilis, not of limestone blocks. The temple of Hatschepsut is one among few exceptions to this rule. It is built of finely polished limestone blocks. If, as stated above, Hatschepsut rediscovered the incarnation of the divine in agglomerated stone, it would be logical to have her constructed her temple with agglomerated limestone blocks, not with carved blocks. Is this assumption supported by any archaeological records? First, there is the interesting clue that in her temple one finds all together Khnum, Imhotep and Amenhotep son of Hapu, god and semi-gods associated with the agglomeration technique. Are there any scientific data favoring the use of agglomerated stone? Yes, indeed.

The most recent analysis of the Hatschepsut temple limestone was carried out by the German geologist D.D. Klemm and published in his book (with R. Klemm) " Steine und Steinbrüche im Alten Ägypten " (Stones and stone quarries in Ancient Egypt), 1993 [93]. My English translation of the German text of pages 183-185, quotes the following:

" 3.5.42 Qurna, Hatschepsut's quarries.
Location: apr. 3 km north west from Qurna (Thebes west)
Stone type: grey-white porous limestone.
In a wadi East from the Valley of the Kings Tombs there is a

> large quarry, which, according to the local inhabitants, was the place where the stones for the Hatschepsut terrace Temple came from…. It is a relatively soft limestone, strikingly very friable, which at first glance would not be suitable for building purpose. Comparative analysis made on this quarry stone shows that it is actually the same material as the limestone of the Hatschepsut Temple at Deir-el-Bahari, confirming that this is evidently the Hatschepsut's quarry… "

The method used by Klemm requires a powerful microscope. It is based on the presence in both materials (the quarry stone and the temple stone) of well formed rhomb-shaped dolomite crystals (calcium-magnesium carbonate). The rhombs crystals range from about 0.005 to 0.02 mm in length. " With this method " Klemm continues " it is very easy to determine that the samples taken from the Hatschepsut temple were extracted in this quarry. " Klemm continues his investigation by comparing how both materials eroded under the same climatic conditions. The erosion completely destroyed the structure of the ancient quarry limestone. This bad property of the material would according to Klemm " make it not recommendable at all for any constructional purpose ". On the other hand, the temple limestone is still intact, finely polished and is practically uneroded.

Klemm and his wife, the Egyptologist R. Klemm, did not give any explanation on this obvious divergence. Geologically, scientifically, the quarry stone matches the temple stone. Mechanically, architectonically, the quarry stones and temple stones are different. The quarry stone is soft and friable, easily eroded; the temple stone is polished, homogeneous, stable to erosion. I would suggest that the builders of the Hatschepsut temple extracted this soft and friable limestone precisely because it provides an ideal raw material for the manufacture of agglomerated limestone. It is naturally so friable and porous that it easily disintegrates under desertic climatic erosion.

Civil engineers today often use a laboratory standard to evaluate the desertic erosion of building stones. According to this procedure, the stone is soaked 24 hours long in water, then dried out at 60°C (140°F) for 23 hours, followed by 1 hour standing at room temperature. If after one complete cycle the stone remains intact, it is subjected to a second and more cycles, until it disintegrates. In the modern jargon this procedure is called the " wet-dry test ". I expect that only 1 to 3 cycles would be necessary to disintegrate the natural limestone described by Klemm in the Hatschepsut quarry. This material does not need to be crushed at all. Because the raw material was not crushed, the hardened agglomerated limestone will retain intact its original geological features, such as the minute fossil shells and the rhomb-shaped dolomite crystals.

Tuthmosis III abolished Hatschepsut's monuments

Hatschepsut favored the ancient religion, and towards the end of her reign, Amun was diminished in Egypt to the level that he occupied before the Hyksos invasion, causing great displeasure to its clergy.

Meanwhile, Tuthmosis III grew within the auspices of the clergy of Amun, and upon the death of Hatschepsut in the year 1486 BC, he became powerful enough to reign alone. Directly after Hatschepsut's death there was a dramatic change. Hatschepsut did not like war, and tried to re-establish internal religious peace. The newly instated Tuthmosis III sorely wanted to impose the worship of Amun within Egypt and the world, and saw to it that Amun again became the most powerful god. At the end of the year of Hatschepsut's death, Tuthmosis embarked upon a campaign against the former heretical invaders. He journeyed toward Syria to the

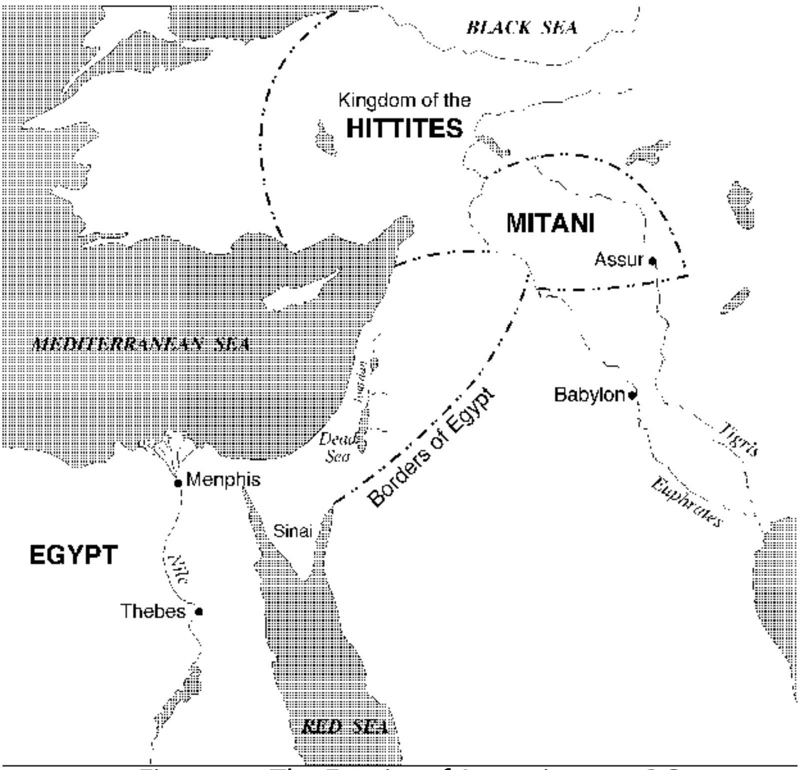


Figure 96: The Empire of Amun in 1472 BC

site of the famous battle of Megiddo, and captured numerous rebel (heretic) leaders, led by the king of Mitani, with the exception of the king of Quadesh, who managed to escape. Episodes from this first campaign of " Amunization " (conversion to the worship of Amun) were engraved upon the walls of the Temple of Karnak. Tuthmosis III carried out seventeen Amunization campaigns, each one that victoriously led to the submission of Mitani, Assyria, Asia Minor, and Babylon. In 1472 BC, he erected a stele upon a bank of the Euphrates River which marked the new borders of the empire of Amun (Fig. 96).

Most of the bounty of war was delivered to the Amun clergy. This redistribution of wealth served to compensate for the acts of Queen Hatschepsut in favor of the ancient worship during her reign. It seems that although Tuthmosis III was not originally heir to the throne, but the son of a morganatic marriage, he was given the favor of official instatement to the divine lineage by the Amun clergy, whom he richly repaid with the spoils of war. The triumph was the sword of Amun within Egypt, and over the god Ia in the surrounding countries. Queen Hatschepsut was viewed as a traitor to Amun, and her memory was persecuted. This internal religious conflict in Egypt was accompanied by a destruction provoked by religious fanaticism. Every monument built by Hatschepsut in which Amun was not glorified was destroyed. Because the temple at Deir-el-Bahari was also dedicated to Amun, it was not demolished, but her name was replaced by the name of Toutmosis III. The two obelisks erected at the beginning of her reign, which stood in front of the pylon built by Tuthmosis I before the temple of Amun at Karnak, could not be overturned, as they were erected to the splendor of Amun, and therefore, Tuthmosis III surrounded these obelisks by a wall.

Amenhotep II, the son of Tuthmosis III, consolidated the power of the Amun clergy by giving supremacy to southern Egypt over northern Egypt. Peace with Mitani was established after repressing several revolts in Syria and Upper Nubia. Amenhotep II fathered two daughters from a marriage with his aunt. He also fathered male children born from concubines, and one of these sons was named Tuthmosis. Tuthmosis was raised in Memphis, and one day while walking near the Great Pyramid, he stopped to rest in the shadow of the Sphinx. The Sphinx was considered to be the image of the god Khopre, also called Ra-Harakhtes, the ancient and omnipotent god of Memphis. Only the head of the Sphinx cast a shadow upon the prince, for the rest of its entire physical structure was covered with sand. The prince fell asleep in the sand beneath the Sphinx and these words, spoken by Ra-

Harakhtes, were heard in his dream:

> " … Look at me, contemplate me, O my son, Tuthmosis. Then I, your father Ra-Harakhtes Khopre Toumou, will give you rulership over the two countries of the southern and northern part, and you will bear the white crown and the red crown on the throne of Sibou, the sovereign which possesses the earth in its length and its width. The brightening of the dye of your master, who you will let reign over you all the wealth of Egypt, the huge tributes of all foreign countries, and a life as the one chosen by the Sun during many years, because my face is yours, my heart is yours, no one else than you is mine. But the sand of the mountain over which I am is beleaguering me, and all this prize I have given to you so that you will do what my heart is wishing, then I will know that you are my son, my protector. Come close to me and hear that I am with you. I am your well loved father… "

The prince understood from this dream that if he cleared away the sand from the Sphinx, that he would be crowned pharaoh of Egypt. He appropriately married Khouit, heiress to the throne. After being enthroned, Tuthmosis IV cleared away the sand from the Sphinx and erected a chapel between its legs. He inscribed his achievement on a syenite stele. For the first time since the beginning of the Eighteenth Dynasty, the pharaoh was not the son of Amun, but the son of the Memphis Ra of ancient worship. Like Hatschepsut, Tuthmosis IV was drawn to the Sinai mines, and this was depicted on a stele found at Serabit el Khadim. Tuthmosis IV's father, Amenhotep II, made peace with Mitani. Tuthmosis IV made an alliance with Mitani and married one of her royal princesses, who was given the Egyptian name Montenouia, mother of the succeeding great pharaoh, Amenhotep III.

Chapter 18

A Rebirth of Agglomerated Stone with AMENHOTEP III and AKHENATON

Twelve hundred years after the great pyramids, agglomerated stone was still in use under Amun's rulership. Because Amenhotep III (1410-1370 BC) was the son of a foreign princess and Tuthmosis IV, a king born under the Memphis god Ra-Harakhtes, he had little chance to succeed to the throne. To become pharaoh he had to legitimize his ancestry, and he did so by assuming the same circumstances surrounding Hatschepsut's birth, which was Amun's intervention in his inception.

The bas-reliefs at Luxor, like those at Deir el Bahari, show the Queen Moutenowia in the arms of the Divine Lover. The confinement was assisted by the god Khnum and the goddess Hathor (Fig. 97), and her son Amenhotep was given

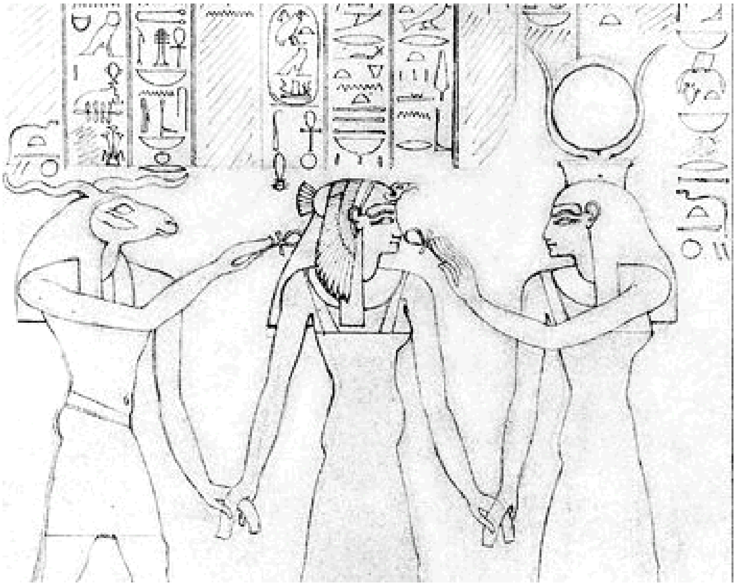


Figure 97: Queen Montenowia with god Khnum and goddess Hathor (Lepsius).

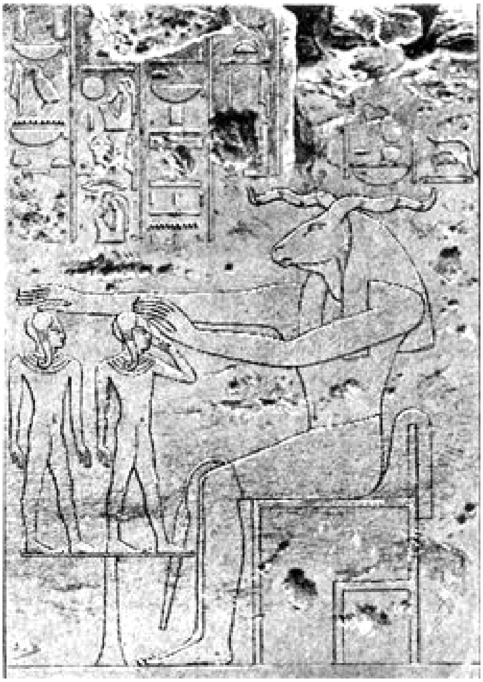


Figure 98: God Khnum fashions the body and the ka of Pharaoh Amenhotep III

over to the hands of two Nile gods. Amenhotep III's royal legitimacy was warranted due to his kinship to Amun. But it was Khnum who created Amenhotep's divine body, and the body of his *ka*. His divine birth is shown in Fig. 98. The reign of Amenhotep III was a reign of peace, among the wealthiest that Egypt had ever known under the rulership of the Theban dynasties. Amenhotep III preferred to go hunting rather than to make war, and he married a Mitanian princess, the fascinating Queen Tiy (Teje). His harem consisted of alien princesses that various kings of the vassal countries sent to Thebes as a pledge of their alliance and obedience. During this period, Egypt was indeed prosperous, for unlike his predecessors, Amenhotep III reinvested part of the national wealth to enhance the industry and agriculture which yielded such good fortune.

To surround himself with wise and trusted assistants, Amenhotep III sought the help of an exceptional man named Huy, whom he later named Amenhotep, son of Hapu. Due to the genius of Amenhotep, son of Hapu, the glory of Amenhotep III's reign was characterized by the magnificence of its buildings. The Temple of Luxor, dedicated to Amun, surpassed all of the Egyptian monuments built during the New Kingdom in elegance.

Amenhotep III returned the town of Elephantine to its original grandeur and dedicated two temples which he erected to the god Khnum. The Napoleonic work, *Description de l'Egypte*, is the only document which describes the Temples of Khnum at Elephantine in detail. One temple (Fig .99) was unique in its design, according to the texts of Jomard of the Napoleonic Egyptian Expedition [94]:

> " … I have noticed that this building is well preserved. Only two pillars were destroyed. What has suffered the most are the stairs which led to the Parvis. We only see the fifth and sixth upper steps, the rest were hidden by a large amount of

rubble. Inside, there is practically no trace of destruction. The edges of the corners of the walls are still intact. The sculptures have been slightly damaged, especially on the side facing north. The dark color of all these walls indicates extreme age. There are very few Egyptian monuments where the color of the stone has been as darkened… ”

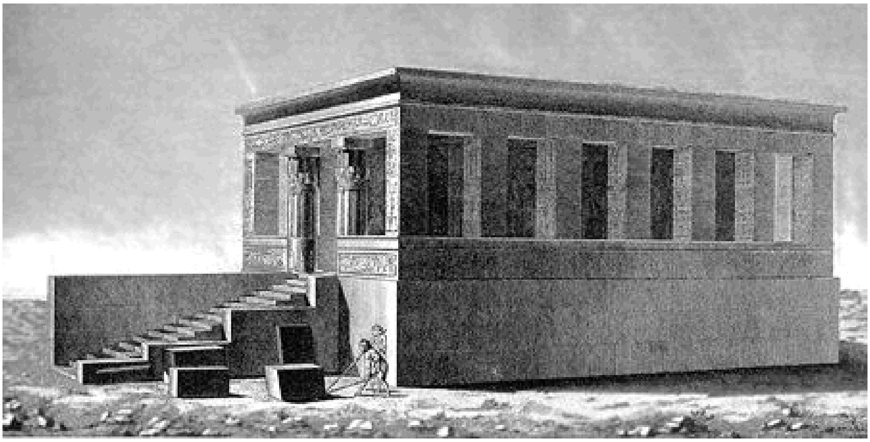


Figure 99: The Temple of the God Khnum at Elephantine (Description d'Egypte).

This Temple was still standing at the beginning of the Nineteenth Century. Yet, both of Khnum's Temples were destroyed between 1822-1825 AD by the Turkish governor of Aswan, who built a garrison and storehouses at Syena from their stone. In the absence of any modern archaeological record, I may suppose that the Temple of Khnum was built with the agglomeration technique which characterized this god. The extremely dark color of the stone observed at the temple may indicate that it was produced by agglomeration, using perhaps loose sand and Nile silt of brownish color. The Temple had square pillars such as those of the Old Kingdom when agglomeration was in use. The quote from Jomard continues:

“ … The pillars are decorated with two standing beings and several columns of hieroglyphic writing. A great vulture with his wings spread out is at the summit. Before describing other sculptures of the Temple, we have to examine the columns which are very unusual to find.. Here I can observe that the capitals of the pillars at Elephantine may represent reed stalks which are strongly tightened with links that form an angle, as was usually done with these plants… ”

In ancient Egypt, all things had a mythological significance. The capitals of these columns, representing reed stalks strongly tightened with links, may signify two of the alchemical products necessary to the agglomeration process characteristic of Khnum. These products were natron (caustic soda) and sodium silicate (see in Appendix I, The Alchemical Inventions). The ashes of the burnt reed contain a very high amount (70 to 75 per cent by weight) of reactive silica $SiO2$. Natron lakes were covered with reeds, and natron covered these plants in thin layers. To harvest natron, reed stalks were gathered and tightened into bundles, exactly like the stone images of bundles found in the pillars of the Temple of Khnum. The bas-reliefs in the Temple at Elephantine depict Amenhotep III being welcomed by Khnum and Khnum's wives and daughters, as shown in Fig. 100. According to Jomard:

“ … The main element in the bas-relief is a symbolic ark ornamented at the stern with a ram's head facing the entrance of the temple. It [the ark] is laid on an altar which is shorter than it is wide… On the stern there is a different theme. A human carrying an ankh is standing between two figures, who both have one hand on his [Amenhotep III's] shoulder and are welcoming him into their arms. A vulture spreads out its wings over him at the left of the bas-relief. The god [Khnum] has the head of a ram, and is painted with a blue color… ”

I mentioned previously the significance of the color blue associated with Khnum and later with the god Amun, when in Thebes he became Amun the progenitor. Amenhotep

III established a religious compromise which allowed the worship of Amun and Ra-Harakhtes simultaneously. It was for “ political reasons ” that his scribe and architect, Amenhotep, son of Hapu, engineered the Temple of Luxor and one pylon at Karnak for the Temple of Amun. But Amenhotep III’s choice of personal worship was Ra-Harakhtes, of the Old Kingdom.

Figure 100: Pharaoh Amenhotep III is welcomed by the god Khnum at Elephantine (Description de l'Egypte).

The colossal statues of Memnon

Amenhotep III’s funeral temple (now destroyed) at the foot of the Valley of the Kings, must have been a tremendous monument. It stood behind two unusual colossal statues, the famous Colossi of Memnon, the sole remains of the Necropolis (Fig. 101). The dedication stele of this temple states [95]: “ … My majesty [Amenhotep III] filled it with monuments, with my statues from the mountain of gritstone [quartzite]… ”

These two colossal statues, representing Amenhotep III, were engineered as monolithic figures by Amenhotep, son of Hapu. They are made with an exceptionally hard stone, which is a siliceous quartzite conglomerate. These two colossal statues have suffered severely from the hand of time and have lost their artistic value. The two immense figures, the cubical thrones on which they are seated, the pedestals, are

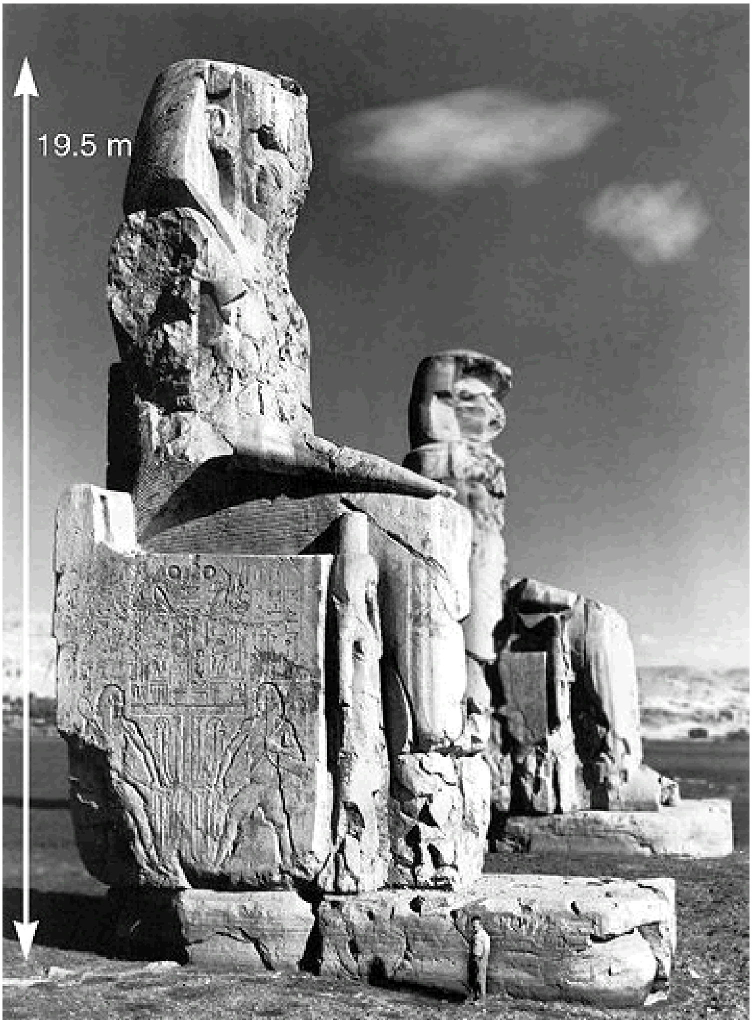


Figure 101: The colossi of Memnon; Northern on background and Southern on foreground, with author in foreground (1979).

fashioned out of a pebbly and quartzose sandstone-conglomerate of a yellowish-brown color and very difficult if not impossible to carve. The Southern Colossus is in better preservation than the Northern one, but there is little difference between them in point of size. The dimensions of the former, in which the original form is more easily seen, are as follows: height of the figure 15.5 m (51 ft.), height of the pedestal (partly hidden) on which the feet rest 4 m (13 ft), height of the entire monument 19.5 m (64 ft). But when the figure was adorned with the long-since vanished crown, the original height may have reached 21 m (69 ft). The legs from the sole of the foot to the knee measure 6 m (19 1/2 ft.), and each foot is 3.2 m (10 1/2 ft). long. The breadth of the shoulders is 6 m (20 ft).; the middle finger on one hand is 1.4 m (4 1/2ft). long; and the arm from the tip of the finger to the elbow measures 4.7 m (15 1/2 ft).

The Northern Colossus is the famous vocal statue of Memnon. To the left of the king stands his mother Montenowia, to the right his wife Teye; a third figure, between the legs, has been destroyed. On each side of the seat two Nile-gods were represented in sunken relief, twining the representative plants of Egypt (sedge and papyrus) round the hieroglyph for " to unite ", a symbol of the union of Upper and Lower Egypt. The statue in the north was damaged during an earthquake that occurred in 27 BC, when the upper part fell. After the earthquake, this statue became universally renowned. Attention began to be directed to the Musical Phenomenon, after it had been broken. When it became known that the Northern colossus emitted a musical note at sunrise, a new myth was invented to explain the fact. Memnon, who had fallen at Troy, appeared as a stone image at Thebes and greeted his mother Eos with a sweet and plaintive note when she appeared at dawn. The goddess heard the sound and the morning dews are the tears she shed upon her beloved child. If the sound was not heard, it was taken as a sign that the god was angry. The Greek geographer Strabo, who is the first author to mention the phenomenon, expresses doubt as to its genuineness. Owing to its extreme hardness, Plinius, in *Natural History*, [96] described the stone in the Colossi of Memnon as basalt: :

> " … The Egyptians have found a stone in Ethiopia that has the color and hardness of iron, and consequently, it was called basalt. It is said that there exists at Thebes, in the Temple of Serapis, a statue which was made with this same stone. It represents Memnon, and makes a sound all during the day when touched by sunbeams… ".

The phenomenon ceased altogether, in the middle of the Third Century AD, after the time of Septimius Severus, who caused the restoration of the upper portions. The restoration was rather clumsily carried out with five courses of quartzite blocks. None of the various attempts made to explain the resonance of the stone are scientifically satisfactory.

The numerous Greek and Latin inscriptions in prose and verse inscribed upon the legs of the figure by travelers under the Roman Empire, are peculiarly interesting. These are more numerous on the left than on the right leg, and none are beyond the reach of a man standing at the foot of the statue. The earliest was carved in the 11th year of the reign of Roman Emperor Nero, the latest in those of Roman Emperor Septimius Severus and Caracalla, and the most numerous in that of Hadrian (A.D. 130). The colossus was frequently dumb, in which case the visitor usually waited until a more favorable occasion. Some were so struck with the phenomenon that they were not content till they had heard it three or four times. Roman Emperor Hadrian spent several days here along with his wife Sahina and a large retinue.

Members of the Napoleonic Egyptian Expedition (1798-1802), documented the first precise description of the material which constitutes the Colossi. Before this investigation, the composition of this material was indefinite. The text of Jollois and Devilliers reads as follows [97]:

> " … The Colossi are facing the southeast, and are standing parallel to the Nile. They are known in this country by the names of Tama and Chama. Chama is the southern Colossus, and Tama is the northern Colossus. Both are alike in many ways. They show differences in their dimensions that we will indicate step by step: both are made from a variety of conglomerate consisting of a mass of agatized flint, bound together by a cement of exceptional hardness. This material is very dense, and has a highly heterogeneous structure which is much more difficult to sculpt than granite. What we have witnessed shows that the Egyptian sculptors have mastered their task with the greatest success… "

The pedestal of the Southern Colossus consists of 216 cubic meters of stone weighing 556 metric tons. The monolithic statue itself consists of 292 cubic meters and weighs 749 metric tons, so that the pedestal and the Colossus together weigh more than 1,305 metric tons in total (four times the weight of the New-York Statue of Liberty). The Northern Colossus was broken in the middle. The upper part, beginning with the arms up to the head, was rebuilt with carved quartzite stones.

For each obelisk and colossus made of pink syenite from the quarries near Aswan, there are visible traces which allow us to locate the exact site of quarrying. This is not the case for the Colossi of Memnon. Let us continue the study made by the Napoleonic Egyptian Expedition:

> " … None of the quartzite hills or quarries show tool marks, as are so common in the sandstone and granite quarries. We have to conclude that a material so hard and unworkable by sharp tools must have been exploited by a process other than that generally used for sandstone, or even granite…. Even if we have not determined the means used, we are forced to ad-

mire the results. Nothing is more apt to give us an idea of the high level of the mechanical arts during antiquity than the beautiful execution of the figures, and the clean, pure sketch of the engraved hieroglyphs on this material. The hardness is such that it is more difficult to work than granite. That fact did not discourage the Egyptians who did not seem ever to be perplexed by difficulties that may have stood in their way. When the tool of the engraver in the middle of a hieroglyphic character hit a flint or an agate that constitutes this conglomerate, the line was never hindered, but on the contrary, continued in all its purity. Neither the agate fragments nor the stone itself was even slightly broken by engraving. ”

This exceptional method of “ engraving ” corresponds exactly to the result obtained with the technique of casting moldable stone. When the so called “ engraving ” is obtained by casting stone into a mold, the crystals and heterogeneous fragments of the conglomerate yield exactly to the shape of the mold. Do we have any clues that would suggest any usage of the agglomeration technique by Amenhotep, son of Hapu? Perhaps. On his third statue at Karnak, Amenhotep son of Hapu glorifies his third promotion:

“ … My lord made me chief of all works … I did not imitate that which had been done before. I fashioned for him a mountain of gritstone (quartzite) … there was not one who had done the like since the time of the foundation of the Two Lands. I conducted the work of his statues, immense in width, taller than his column … In the august mountain of gritstone [Gebel el Ahmar, near Cairo] (I found) material 40 cubits in length. I built an eight vessel, I brought it [the material or the statues?] up-river; it was set up in this great house… ”

Although this text seems very clear, several archaeologists and geologists disagree and do not take for granted that Amenhotep, son of Hapu, extracted the statues, at the Red Mountain of quartzite, Gebel el Ahmar, near Cairo.

For them, the 1,305 metric tons of each Colossus were not carried 440 miles up-river, against the flow of the Nile, from Cairo to Thebes, a truly incredible " feat ". Possible quarries might have been located only fifty miles south to Thebes, at Silsilis or at Aswan. The geologists from the Napoleonic expedition (*Description de l'Egypte)* favored the quarry found near Aswan as the likely origin. Modern French and German scholars follow De Rozière's claim. On the other hand, English and American scholars defend the hypothesis that the quarry located at Gebel el Ahmar, a few kilometers from Cairo, is the accurate site.

A study carried out with neutronic activation by a team of American scientists from the University of California, Berkeley, (Heizer, Bowman, Stross, 1979, 1984, 1988), came to the conclusion that the quarry used for the monolithic southern Colossus was truly that of the Gebel el Ahmar [18]. They confirmed Amenhotep's statement. They also determined that the restoration performed by the Roman Emperor Septimius Severus on the Northern Colossus, involved blocks extracted from a quarry near Aswan [98]. More recently the investigations published by the German team from the University of Munich, D.D. Klemm (1993), reactivated the controversy [99]. Klemm's analysis connects both types of quartzite stone (the monolithic and the carved blocks) to the same quarry, Gebel Tingar, located on the west side of the Nile, not far from the Elephantine Island, at Aswan. Klemm performed geochemical analysis on trace elements like lead, copper, zinc, zirconium; he rejected the written historical evidence provided by Amenhotep son of Hapu.

The use of the agglomeration technique by Amenhotep, son of Hapu to fabricate quartzite stone, and cast the giant Colossi of Memnon could explain the manufacture and placement of these seven-storey high statues. It could also solve the dilemma generated by the contradictory analytical results of the various teams of scientists. The Gebel el Ahmar, or red mountain located near Cairo, is composed of a conglomerate of agateous silica quartzite which had close relationship with the stone of Gebel Tingar at Aswan. This conglomerate of agateous silica is a very hard stone composed of flint and agate, that is bound together by a natural cement, which is the result of a chemical precipitation of silica.

This would also be the definition of stone obtained through an agglomeration process. I have learned through experience in my laboratory at the Geopolymer Institute, that flint is a mineral that lends itself best to the synthesis of hard stone. Amorphous silicates, such as opal, flint, and chalcedony are found in considerable quantities in Egypt. The Gebel Ahmar site is characterized by the presence of hard dense quartzite rock accompanied by a less dense, more porous variety which becomes eroded very easily. I could imagine that Amenhotep son of Hapu, did not excavate the statues in the hardest rock, but was lucky to find sufficient quantities of loose material (" … 40 cubits length… "). If naturally loose aggregates originating from the Gebel el Ahmar quarry were agglomerated with a binder produced with minerals from practically any part of Egypt, preferably from Gebel Tingar, then the study of the artificially agglomerated stone of the Memnon Colossi would be compatible with the analysis of both American and German mineralogists and geochemists. Amenhotep's description on his statue claimed the exceptional nature of this endeavor:

> " … I did not imitate that which had been done before. I fashioned for him a mountain of gritstone (quartzite) … there was not one who had done it the like since the time of the foundation of the Two Lands… "

This latter sentence is reminiscent of the very significant translation of the *Famine Stele*, located on the island of Sehel, discussed in a previous chapter. God Khnum is giving Zoser a list of minerals and ores:

> " I am Khnum, your creator. I am putting my hands upon you in order to strengthen your body, to take care of your limbs. I give you rare ore after rare ore… Never before since creation has anyone processed them (to make stone) in order to build the temples of the gods or to rebuild the ruined temples… "

Amenhotep IV-Akhenaton

An event occurred after Amenhotep III's time that had a major impact on Egyptian history, and an influence on the nucleus of the Judeo-Christian civilization. The ancient worship of Ra-Harakhtes had regained an honorable place within the Egyptian society, but the Amun clergy was like a state within a state, and his power dictated all activities of spiritual life. The aging pharaoh, Amenhotep III, abdicated in 1370 BC in favor of his twelve year old son, Amenhotep IV. For four to five years, Amenhotep IV maintained a regency with the Queen Teye which was characterized by the official introduction of the Ra-Harakhtes worship, popularly represented by the Sun Disk - Aton.

Amenhotep IV imparted many new rules of which two were exceptional. First, it became forbidden to represent gods using animal figures, especially to depict the Sun god in his usual anthropomorphic form of a human body with the head of a ram or falcon. Second, the finances of the different cults were centralized and reserved solely for the Sun Disk, Aton. These two new laws deeply affected the Amun clergy, especially combined with the fact that Amenhotep IV would build at least five monuments dedicated to the cult of Aton near the Temples of Karnak and Luxor. During the second and third years of his reign, Amenhotep IV held extravagant jubilees. It is estimated that Amenhotep IV dedicated eight monuments to Aton. They were later destroyed, but archaeologists have since located most of the stones, and all of them were engraved. The excavations undertaken by the Canadian archaeologist, Donald B. Redford, in 1972 at Karnak, enables a more precise location of these buildings. We know the names of five of these monuments: The two most important are Gem Po Atem, which means " the Solar Disk is found ", and Hatbenben, which represented the palace of the mythological Benben, the monument where, according to ancient mythology, the god Ra appeared for the first time. Since ancient times, Benben represented the sacred incarnation of Ra. In the fourth year of Amenhotep IV's reign, he changed his name to Akhenaton.

The worship of Amun was forbidden during Akhenaton's reign, and Amun's name was not to be spoken or written. Amun's name was destroyed everywhere possible. The clergy of the new god Aton was not satisfied to remain in Thebes, alongside the immense temples of Amun. So, Akhenaton decided to create a new town dedicated to his one god. This town (el Armana) was named " Khouit-Atonou ", meaning " the horizon of Aton ". There, Akhenaton built a palace for himself and a temple called " Hatbenben ", for his unique god. This temple was made mainly of fine white limestone, and was 800 m (2,620 feet) in length (including extensions). Akhenaton was a prolific builder due to the assistance he received from his grand viziers, Huy and Ay. Each large town in Egypt received a temple to Aton. Thebes alone acquired eight great temples. The town Khouit-Atonou (now called el Armana) is exemplary of the euphoric building attitude of Akhenaton. Its temple was vast and its palace was (in its time) the most glorious secular building in the world. The enormous dimensions of the pylons found in the ruins were surprising to the members of the Napoleonic Egyptian Expedition. Akhenaton's palace was built with bricks dried in the sun like all secular buildings, but the bricks found at el Armana were really very special. They were very hard and according to the *Description de l'Egypte*:

> " …The bricks themselves are gigantic. Indeed they are thirty-five to thirty-eight centimeters [fourteen to fifteen inches) long, and thirteen centimeters [five inches] wide, and sixteen to twenty centimeters [6.3 to 7.9 inches] high. They were very carefully piled in alternate layers, laid flat. Although they were made with a slightly sandy earth and are very old, these bricks are still very hard today… "

Man-made statues: Mansoor's collection

Let us consider the cultural and artistic explosion which characterizes the *el Armana* period. Ceramic and glass techniques were at their paramount. The bust of Queen Nefertiti, discovered in the ruins of el Armana, is a lasting testimony to the high level of the arts during this period. It is one of the most gracious and charming sculptures to have survived since antiquity to our times. It was found in the workshop of the Chief Sculptor Tuthmosis. This very busy master sculptor was helped in his task by numerous apprentices. In his studio, there were master portraits intended for copying by lesser craftsmen, plaster casts taken from sculpture, heads in a variety of materials (agglomerated stones?) in all stages of production, parts of composites statues, and plaster masks. These plaster masks were casts of clay or wax likenesses. The casting of stone slurries with geopolymeric binders in molds based on these plaster masks was feasible and would have yielded various artifacts in stone. This process, while retaining the spontaneity of the original clay, also enables the desired subtleties to be reproduced in a faithful way. Was it actually used? Probably yes, indeed.

The ancient Egyptian Limestone sculptures from Tel-El-Armana, representing Akhenaton, Nefertiti and members of their family I am referring to, are known as the Mansoor Collection (Fig. 102). They were brought to the United States at various times between 1947 and 1950. The Metropolitan

Museum of Arts in New York wanted to see some of the Armana sculptures. The Museum's curator could not make up his mind about their authenticity and asked that they be sent to Mr. William J. Young, Director of the Boston Museum of Fine Arts' Laboratory, for examination. Young's report was a terrible shock to the Mansoors [100-101]. He wrote:

> " The larger of the two heads was examined from a minute fragment and appears not to be a natural material. It shows all the indications of being a made stone which could have been fabricated in a great many ways."

Zaki Iskandar, former Chief Chemist of the Egyptian Department of Antiquities, who examined 66 of the objects for the Cairo Museum and wrote a report in 1950, supported the genuineness of the Mansoor's collection [102]. Several geologists confirmed Iskandar's study and tried to convince the Boston Museum, in vain. The German Palaeoanthropolgist Reiner Protsch [103], 26 years later, subjected 18 of the sculptures to what he called an "anthropological-morphological"

Figure 102: MANSOOR'S Collection: Akhenaton and Nefertiti

examination an made the following assumption: the "astonishing" anatomical knowledge of the sculptor who had carved the pieces he saw could be explained only by the assumption that the " Royal family was sitting for the artist" because such verisimilitude could be achieved only by copying " from a living individual". Protsch's assumption that the members of the royal family might have sat for their portraits is not taken seriously by the Egyptologists. In his catalogue for the 1973 Brooklyn Museum " Akhenaten and Nefertiti" exhibition, Cyril Aldred wrote that " no sitter could pose long enough for his statue to be chipped in stone or chiseled in wood", and certainly not the members of the royal family. Aldred believes the sculptors modeled their subjects very rapidly in clay or wax and then transferred the likenesses, suitably idealized, to more durable materials. These clay or wax models might have been used for the casting of plaster molds.

In 1973, a sculpture from the Mansoor collection was tested when it was submitted by its owner to the International Foundation for Art Research, a New York-based non-profit art authentication service [104]. The unnamed investigator who carried out the examination surprisingly brought the argument round full circle: 27 years after Young's original and much-scorned report, the foundation's expert seemed to vindicate his conclusions. The sculpture, a head of Akhenaton, was made, he said, of " Artificial Stone — or a man made product rather than a natural limestone. The composition was most probably crushed limestone with some bright red pigment to give it a pale pink tone and held together with organic adhesive".

The owner sent the sculpture to yet another examiner, a prominent geologist, Richard L. Hay, Professor of Geology, University of California, Berkeley. This investigator disagreed violently with the foundation's expert. The material of the head, he said, was most certainly natural limestone [105]. In his summary he stated (Feb. 10, 1975):

> “ I have gone farther than necessary in documenting what is really a simple matter. The intact nature of the delicate foram tests (shells) together with the euhedral shape (rhomb-shaped) dolomite crystals shows that this limestone could not have been made by cementing crushed limestone; … It can perhaps be conjectured that a technology might exist (say beings from another planet technologically much more highly advanced than *Homo sapiens*) for artificially duplicating the several geological processes required… ”

I would like to reply to R. Lay that this method existed and was probably used by Hatschepsut’s architects who build her terrace Temple at Deir-el-Bahari. R. Lay (Mansoor's collection) and D.D. Klemm (Hatschepsut's Temple) investigated their stones with the same technique. They microscopically identified the same rhomb-shaped dolomite crystals. The Mansoor collection consists entirely of royal portraits made of an unusual pinkish limestone material that was not used by Egyptian sculptors from other epochs. A more recent comparative analysis performed by mycropaleontologist P. Blanc (1986) on the fossil remains states [106]: “ a probable locality for the limestone raw material would be in the Luxor vicinity ”. In other words, in all likelihood, the limestone could come from Hatschepsut’s quarry. As mentioned previously this raw material is so friable that it is easily disaggregated with water. It does not need to be crushed, i.e. foram tests and rhomb-shaped dolomite crystals will remain intact. The outer space beings of R. Lay were Hatschepsut’s *Homo-faber*.

For Mr. Young, because they were “ made stone ” implied that the objects were of fairly modern origin, and thus forgeries. Several geological studies mandated by the Mansoors showed that the patina bore all the signs of a very antique and genuine “ desert varnish ” that could not be replicated by a modern forger. My conclusion to this study of the Mansoor collection confirms that these objects are genuine antique copies fabricated in one of the workshops of El-Armana, 3350 years ago, copies probably obtained by casting a geopolymeric limestone slurry in plaster molds. They are old, and could at the same time be " made-stone ". Chief sculptor Tuthmosis and his colleagues had replicated a technique described 700 years earlier by sculptor Irtysen in his Stele C14 (see in previous chapter). Irtysen wrote:

> " ... I know the parts belonging to the technique of molding... I know the making of molds to make reproductions cast in a material that will not be consumed by fire, nor washed by water either... "

In the temples of this period, Khnum, the ram-headed anthropomorphic god, has been forgotten and was obsolete, and it was the god Aton who was the creator of men. The doctrine of Akhenaton was absolutely monotheistic. Egypt and the exterior provinces had no more than one god — Aton, the setting sun, and this was by decree of the King. Akhenaton was not the originator of the monotheistic doctrine, which previously existed in philosophical form in the Books of Wisdom.

The rise of the Amun clergy introduced another system of worship, thus perpetuating polytheism in Egypt. Akhenaton died in about the eighteenth year of his reign at thirty years of age, and was buried east of el Armana. He had no sons, therefore two of his sons-in-law succeeded him to the throne. The first to reign was Semenkhekare from 1356-1352 BC, who continued the religious politics of Akhenaton. Next, the famous Tutankhamun reigned from 1352-1344 BC. He visited Thebes and established a compromise with the powerful Amun clergy and the Egyptian army.

Chapter 19

Closing the Knowledge Gap

How much more advanced our civilization might be today if there had been a continuum of science from antiquity instead of the destruction of knowledge by war, civil unrest, religious intolerance, and other circumstances. The burning of the Great Library of Alexandria, reputed at one time to hold about 900,000 manuscripts, is a classical example of the destruction of information. Most written works by pre-Socratic scholars have not survived. A few of the scholars are remembered only by their great reputations, and some are represented through fragments in classical literature.

In our own " Information Age ", even general knowledge is not flawlessly transmitted. For example, most contemporary history books credit Pythagoras with discovering that the earth is round, but, as shown by Herodotus's Melpomene this knowledge existed in ancient

Egypt during the reign of Pharaoh Necho II (610-595 BC), who lived before Pythagoras (c. 582-507 BC) [107]:

> " As for me, I cannot help but laugh when I hear the people who have given descriptions of the circumference of the Earth, claiming, without allowing themselves to be guided by reason, that the Earth is round, as if it had been shaped on a potter's wheel; that the ocean surrounds all of its parts.... As for Libya [during Herodotus's time the entire African continent was known as Libya], it is surrounded by the sea except for where it is joined to Asia. Nechos, the king of Egypt, was the first to our knowledge to have demonstrated this. When he ceased the construction of the canal joining the waters of the Nile to the Arabian Gulf [Red Sea], he sent a Phoenician crew with orders to sail around and return to Egypt through the Mediterranean Sea by way of the Pillars of Hercules [Strait of Gibraltar]. The Phoenicians navigated from the Red Sea to the Austral Sea [Indian Ocean] and every autumn they docked on the Libyan coast and sowed wheat, then waited for their harvest. Having collected their grain, they returned to sea again, and after two years they passed the Pillars of Hercules and in the third year returned to Egypt. The men had claimed, though I do not believe the statements they made, that in sailing westerly around the southern extent of Libya that the Sun was on their right. "

A true historian, Herodotus documented the report of the circumnavigation of Africa and its cosmographic implications despite his own belief in the possibility of a spherical world. The reported position of the Sun, which rose on the right once the fleet passed the equator, upholds the authenticity of the voyage and affords an accurate calculation of the shape of the earth. It was not until 2,000 years later that the general European populace slowly began to realize that they were living on a spherical world after the New World was discovered by Columbus in early Renaissance times.

The knowledge may have been taken for granted by learned astronomers and cosmographers of Babylon and Heliopolis. The Greeks held extraordinary reverence for the Egyptian sages, and Pythagoras, who visited Egypt and Babylon as a young man, may have been tutored in these lands. Today, some contemporary encyclopedias suggest that the dimensions of the Great Pyramid incorporate information on the spherical shape and size of the earth.

Other lost or obscured knowledge is exemplified by ancient products and processes that are little understood today. Some were mentioned in Chapter 1, and those not already explained will be covered in this chapter. The products of antiquity in question are the result of ancient chemistry or alchemy. Understanding them helps to close the knowledge gap between ancient and modern science, and some of the recovered technology can help solve complex modern problems. This was my main objective at the Institute for Applied Archaeological Sciences (IAPAS), which I founded at Barry University near Miami, Florida, in 1984. This is still one of my objectives at the Geopolymer Institute. Before considering the ancient technology, let us take a brief look at the history of alchemy from a broader historical perspective than ever before possible.

History recognizes that the birthplace of alchemy was ancient Egypt and that alchemy flourished in Alexandria in the Hellenistic period. Though Arabic, Indian, and other forms of alchemy are outgrowths of the old Egyptian science, scholars have been unable to approach the origins of alchemy with certitude. It now becomes clear that Hellenistic alchemy and its outgrowths were descendants of the alchemical processes of Khnum. This opens new avenues for exploring the relationship between the alchemy of pre-Alexandrian Egyptian and Western Europe. The root of the word alchemy, “ chemy ”, is uncertain but can be traced clearly to Khnum, who was spelled *shnum* during the Old Kingdom (see the discussion in the previous chapter 11). Hellenistic alchemy was especially kindled by documents such as the *Famine Stele* relating to Imhotep and Khnum. The rise of alchemy that historians recognize in Alexandria was actually the rebirth of alchemy under the Ptolemies.

Why is the founder of alchemy considered to be Hermes Trismegistus, the Ptolemaic equivalent of the Egyptian god Thoth, instead of Khnum? The influence of Khnum saw a brief resurgence during the New Kingdom, but the power of Amun was paramount. The knowledge of Khnum, however, was retained in the Books of Thoth. And Thoth gained prestige under the dominion of Amun, because Thoth was the god of Hermopolis, where Amun was one of the primeval ogdoad. This explains why the knowledge of Khnum was held in the library of Hermopolis, the seat of political rivalry during the Middle Kingdom.

As Amun became more powerful, his clergy usurped for him all of the attributes of the other Egyptian gods, and the influence of Amun is seen even in alchemical literature. The name Amun, for instance, is the root of the word ammonia. Sal ammoniac (ammonium chloride), a product crucial to alchemists attempting to transmute baser metals into gold, literally means the salt of Amun. The whole notion of transmutating baser metals to gold may reflect the extent of the influence on alchemy of Amun, the god presiding over metallurgy. In addition, translation errors from old Egyptian texts into Greek or Arabic may account for the belief that base metals could be transmuted into gold.

Is the legendary Philosopher's Stone, the agent believed to transmute baser metals into gold and to prolong life indefinitely, synonymous with the pyramid stone? The Philosopher's Stone had various names in many languages. Zosimos of Panopolis, an early Hellenistic alchemist, called it The Tincture. Some Hellenistic alchemists also called it The Powder. The Arab alchemists called it the Elixir of Life. With science and philosophy united as one body of knowledge, the substance later became known to western European alchemists as the Philosopher's Stone and sometimes just The Stone. But its various names always characterize the pyramid stone, because they are usually associated with some form of minerals, liquid, or stone.

There is no doubt about its inorganic nature, and mysterious descriptions in alchemical literature, such as " a stone which is not a stone", now become clear. It also becomes clear why alchemists commonly ascribed alchemical works to Khufu (Kheops or Cheops) or other great personality of Egyptian antiquity who was involved with alchemical stonemaking.

When Empedocles influenced the alchemical doctrine by proposing that air, earth, fire, and water composed all matter, he recognized these elements in the primeval Egyptian gods of creation. The links between the creation beliefs of the Old Testament authors and the mythology of Khnum were pointed out in Chapter 9. Other profound esoteric implications involving alchemy will be discussed in the future.

Mysteries of the ancient world unfold as we understand more about ancient technology. The challenge to the age of the Sphinx, which centers on the question of the damaging water's source is an example. The large amount of water at the site can be explained easily by the fact that the limestone of Giza was disaggregated in situ with water to construct the monuments of Giza (see the discussion in Appendix 2, The Circuit of the Pyramid Plateau).

The so-called pyramid power issue is also settled. Wheat, which is thousands of years old, has been found in good condition stored in stone vessels within pyramids. The grain. was in such excellent condition that researchers made an abeit unsuccessful attempt to germinate it. Well-preserved flowers and other organic materials have also been found. The popular theory of pyramid power, which attributes preservation, in part, to the shape of the pyramid, resembles teachings of the Pythagorean school, which ascribed special attributes to numbers and geometrical shapes. The real secret lies in chemistry.

The principle is this: one of several possible formulas for the making of stone vessels is based on the synthesis of zeolites, secondary rock-forming minerals that readily gain and loose moisture. The water absorbed, ten to twenty percent by weight of the zeolite, is easily released when heat is applied. The zeolites, therefore, allow any vessel made of geopolymeric material, to store organic material through harmony with natural atmospheric heat and moisture.

The Nile valley is characterized by extreme dryness during the day. At night the humidity level rises. The zeolitic reconstituted stone absorbs humidity at night or any time the humidity rises. During the day, the material absorbs calories from the atmosphere, which has been heated by the Sun, and the previously absorbed humidity evaporates. In the stored material, this exchange maintains a temperature that is constant with that of the atmosphere. It eliminates sweating on the inner walls of the structure and, therefore, mold growth. The material provides for an exchange of humidity from the interior of the vase to the exterior-in other words, automatic humidity and temperature control. There is no renewal of oxygen in a hermetically sealed vessel, and the material has more than adequate strength to prevent invasion from gnawing insects and rodents. These parameters combined with the longevity of geopolymeric materials provide ideal conditions for storage.

The zeolitic make-up of geopolymers also explains the method of desalination attributed to the pots described by Plinius. He called the method " remedying unfit water ", but the chemical process involved is now called ion exchange. A more sophisticated method of ion exchange is widely used in water softening today. In the chemical reaction at work in the vessels, ions, electrically charged atoms or groups of atoms, were reversibly transferred between the vessel and the salt water, allowing only salt-free water to enter the vase.

The vessels Pliny described would have behaved in exactly the same manner as would the 8,000-year-old white lime vessels from Tel-Ramad, Syria. The fragments I examined contain up to forty-one percent of analcime, one of the many zeolites capable of ion exchange with solutions.

Zeolites were synthesized in the Near and Middle East 8,000 years ago and more to produce chemical reactions now known as geopolymeric. Why were geopolymeric chemical reactions not developed by modern science earlier? The reason is that mineralogy has been neglected by industry. Until developments in recent years, there were no extraordinary breakthroughs in the cement, glass, and ceramic industries for 150 years.

Since the synthesis of urea in the 1800s, industry has invested in research and development of organic chemistry, yielding dye stuffs, drugs, plastics, synthetic fibers, and the like. Industry considered mineralogy useful mostly for classifying rocks and minerals and for producing synthetic jewels, but though analysis of rocks serves to classify them, their major elements were studied primarily. About ten percent of a stone is made up of mineral elements that bind that stone together. This ten percent is what interests me, and when I first began my chemical research in mineralogy, there was absolutely no competition. The five to ten percent of mineral elements binding the pyramid blocks, though different from the micritic cement in the bedrock, is every bit as effective.

Another explainable issue is the discrepancy between the dates provided by the recent carbon-14 dating of the pyramids with those historically established. Mortar sampling was carefully performed by the American Research Center in Egypt (ARCE) team for the project sponsored by the Edgar Cayce Foundation. The latter group hoped to date the pyramids to 10,000 BC, the date provided for the construction of the Great Pyramid by Edgar Cayce, a well known reputed American psychic.

The November/December 1985 issue of Venture Inward, published by the Edgar Case Foundation, carried an article describing how the samples were taken and other aspects of the project. In a follow-up article titled " The Great Pyramid Reveals Her Age", appearing in 1986 in the same publication, former Edgar Cayce Foundation member and Egyptologist Mark Lehner remarked:

> " You can look at this almost like a bell curve, and when you cut it down the middle you can summarize the results by saying, " Our dates are 400 to 450 years too early for the Old Kingdom pyramids, especially those of the Fourth Dynasty " The discrepancy here is in hundreds of years, not in 8,000 years, but it's really significant and everybody is excited about it. "

When asked if he thought the established chronology was wrong, Lehner said he thought they could be wrong within 400 or 500 years, dating the Great Pyramid to about 3100 BC instead of to the Fourth Dynasty at 2650 BC. Lehner, et al, have since published a report in the British Archaeological Report International, Series 379, in which the average difference is 374 years older, instead of 400 to 450 years [108].

When these articles were brought to my attention, I realized their problem. The problem is one of contamination, not through careless sampling, but because of chemical make-up. One of the ingredients used to make the mortar is natron (sodium carbonate), which contains carbon. The actual date of the geological formation of the natron in the samples is uncertain, and very small quantities dramatically affect the age evaluated by carbon-14 dating. Carbon dating could only produce such illogical results as the mortar at the top of the Great Pyramid dating older than that at the bottom. The illogical dates obtained for some of their samples suggest that established chronology is off from 200 to 1,200 years. Although the charcoal and reeds found in the mortar were subjected to acid leaching to remove carbon contamination prior to the dating process, there is no pretreatment that can eliminate contamination due to a concentrated alkaline solution of sodium or potassium carbonate. The scientific literature describes several cases of error in dating aquatic plants that grew in hard water lakes similar to the Egyptian lakes where natron was harvested [109]. Calcined trees and reeds from a natron lake typically date older. In addition, cellulose fibers are known to chemically react with the highly alkaline sodium carbonate. Because it is highly porous, charcoal absorbs not only a great deal of natron solution, but also a lot of carbon dioxide, resulting from the decomposition of natron.

Have all of the mysteries of pyramid construction been solved by my research? The examples of Egyptian artifacts previously presenting baffling problems are numerous: the man-made sandstone statuettes of the Thinite epoch examined by Le Chatelier; hard stone vases with long, thin necks and bulbous belies that no known tool could have produced; the diorite statue of Pharaoh Khafra (Khefren or Chephren) supposedly carved with stone or copper tools; other hard stone statues with inlaid eyes; monolithic stone sarcophagi situated in confined spaces disallowing their ingress and egress; heavy portcullises situated in spaces in pyramids too small to accommodate the manpower required for lifting them; huge, perfectly formed monolithic burial rooms made of extremely hard stone materials in Twelfth Dynasty pyramids; the seven story high Colossi of Memnon exhibiting inscriptions that are impossible to produce through carving and which, though originally monolithic were not (based on de Roziere's examination of the quartzite quarries) quarried in monolithic form; coatings and cements lasting for thousands of years though some were exposed to blistering sunlight and harsh sandstorms through the ages; great temples with blocks too enormous to move; and most popular and conspicuous of all, the massive Great Pyramid structures themselves, each built during the reign of a pharaoh, with their casing stones exhibiting no tool marks and fitting as to closely as 0.01mm. The problems these and other artifacts posed became increasingly more baffling and complex as scientific methods of investigation improved.

The quantity of popular books generated in the last fifteen years about the mysteries of the pyramids and other ancient feats of engineering demonstrate the ongoing quest for a solution. Few Egyptologists take part in this quest. They are willing to accept standard, inadequate explanations of the enigmatic artifacts and are mostly satisfied with logistical studies on the pyramids. However, the problems of logistics accompanying the carving and hoisting theory prove to be larger in scope than has been studied so far. In fact, based on the uniform sizes of pyramid blocks and Klemm's initial study concluding that the stone used for the Great Pyramid was quarried from all over Egypt, the problems are insurmountable.

The measurements of Coutelle and le Père of the Napoleonic expedition show that many of the largest stones in the Great Pyramid are situated thirty stories high. These measurements, obtained 150 years ago are rarely acknowledged. The problems calculated by Dieter Arnold, who proposed doubling or tripling the life span of pharaohs, merely leave the subject open for debate among Egyptologists, that is, debate based on the carving theory. And Le Chatelier's revelation of 100 years ago was never applied to other artifacts, even though the use of man-made stone should have been considered as a possible explanation to the age — old riddle of pyramid construction.

Though the standard theory is speculative, with no scientific merit, from every perspective — engineering logistics, geochemistry and geology, Egyptology and other history, feasibility and common sense — all of the mysteries of pyramid construction dissolve when the casting theory is applied.

In 1978, I discovered that Pliny's description of the murrhine vases was mistranslated. That was 145 years after the publication of the Panckook edition of *Natural History* in 1832, resulting from the translations of the French Academy of Sciences. How long it will take for my corrected translation to be accepted remains to be seen. And Pliny's text is in Latin, a language used and understood by many scholars. With fewer expert Egyptian hieroglyphic linguists, identifying and redeciphering relevant texts will take longer.

I am certain that, as well as the *Famine Stele* and the *Irtysen Stele*, hieroglyphic texts exist and contain information about the alchemical stone-making process of Khnum, but are mistranslated. As is stated in the Hermetic writings,

> " Hermes … used to say that those who read my books find them clear and very easy to understand… whereas they will become absolutely abstruse when the Greeks translate them from Egyptian into their language, and this will yield a complete distortion of the original text and a complete misunderstanding of its meaning."

When hieroglyphic and cuneiform texts describing metallurgical processes were first translated, thanks to the deciphering of Champollion and Grotefend, metallurgists and chemists were consulted to ensure the correctness of technical words and information. While careful translations were carried out with the help of experts from appropriate scientific disciplines, such translations may not be possible for a long time with texts involving geopolymerization because of the time it will take to produce experts in this field. In fact, it may take several years before experts and organizations involved with Egyptology recognize projects dealing with this topic as valid.

Historians must depend on information derived from Egypt's ecology, geography, artifacts, and inscriptions, the latter of which are known often to be ritual. Very little of Egypt's actual history is known until Ptolemaic times. The historian Manetho compiled a chronological list of pharaohs which sheds some light upon some more ancient history. Egyptologists must, therefore, qualify and conditionalize their historical writings. They have never found a historical document that they recognize as describing their theory of how the Great Pyramids were built. But the *Famine Stele* and the *Irtysen Stele* support the alchemical method of agglomerating stone, and the historical reports by Herodotus and Pliny, previously ambiguous, now make perfect sense.

Some years ago, I came across the following quote:

> " … You might reasonably think that the decipherment of the script would have been greeted with open arms by archaeologists. Not a bit of it! The reaction of the digging fraternity (and sorority) to the most exciting development in archaeology this century has been … rejection. It is not that they claim, like Champollion's opponents that the decipherment has not taken place, they simply believe it is

not worthy of notice (at least overtly)."

This quote is from Michael D. Coe's book *Breaking the Maya Code* [110]. Coe, from Yale University, wrote a compulsive account of the decisive breakthrough accomplished by Yuri Knorosov in deciphering the hieroglyphic Maya carvings.

We have reached back into the history of science at its roots. We have followed the evolution of alchemical stonemaking in Egypt from the production of the prehistoric stone to vessels of Khnum to a probable transition of door jambs and floors in royal mastabas, to an entire building made of cast stone, the first pyramid. With the construction method eluding historians, the reasons for the rise and decline of pyramid building are misunderstood.

In general, Egyptologists advocate that early pyramid building put an intolerable burden on manpower and the economy, causing the decline. Some scholars conjecture that erratic changes in climate produced food shortages against which the kings were powerless. Though such elements may be valid, consider that Egypt's economy became increasingly more depressed because of the erosion of its once enormous construction industry, which in time would jeopardize faith in government. Instead of the decline in the civilization causing the building decline, the opposite is more likely to be accurate.

The reasons for the rise and decline of pyramid construction crystallize when one considers the developments associated with the use of cast stone. The building degeneration may have been caused by a depletion of mineral resources. With the depletion of the Sinai mines the decline originated in the consumption of something quite traceable after all. We know that pyramids were built entirely of man-made reconstituted stone during the Third and Fourth Dynasties, when the Sinai mines were abundant in minerals.

The Fifth and Sixth Dynasties are characterized by a dramatic decrease in the amount of cast stone used in the pyramids, corresponding to the depletion of the mines. But on the other hand, under Sneferu, Khufu (Kheops or Cheops) and Khafra (Khefren or Chephren), the entire country was indoctrinated with the gigantic task of supplying combustible for lime calcination. This intensive exploitation of agricultural resources may have generated an ecological disaster. It is easy to see why during the Fifth Dynasty kings began to remove stone from the monuments of their ancestors, though this has never before been adequately explained, and why, with less material to work with, they concentrated on building surrounding funerary complexes, paying special attention to making exquisite bas-reliefs. By the Sixth Dynasty stone was conserved for the most vital parts of pyramids, such as casing stones and burial chambers.

Little stone was used in the Twelfth Dynasty pyramids. During the reign of Senusert I, the discovery of a small vein at Serabit el-Khadim in the Sinai provided only enough stone for the royal burial chamber. The end of pyramid building marked the end of any appreciable amount of mineral quarrying in the Sinai.

Was the fall in pyramid construction actually attributed to the decrease of lime-ash CaO production, due to a severe shortage in wood fuel? This is quite possible. We start to understand the evolution of pyramid construction and why these great structures were no longer built. Too, we see the transparency of the evidence for the standard theory of pyramid construction presented by Egyptology. Additionally unaware of the two different masonry methods, agglomerated stone and carved stone, Egyptologists recognize only a few stylistic alterations in the monuments of Theban kings, which they attribute to differences in Theban ideas about the afterlife from those of Memphite predecessors. Egyptologists have never fully understood the sudden rise to pre-eminence of the Amun clergy. With the abatement of alchemical stonemaking, the pyramid tradition became increasingly less practical. The Amun clergy, however, could endlessly perpetuate their religious tradition by carving very soft stone.

The Pyramid of Zozer built near 2750 BC, the Pyramid of Khufu (Kheops or Cheops) in 2683 BC, the temples of Amenhotep III erected around 1408 BC, Seti I near 1300 BC, and Ramses II at about 1280 BC, were made of stone. On the other hand, the palaces and fortresses in which these kings resided were made of crude silt brick, sun-dried clay and wood. Stone, either agglomerated or carved, had a sacred value and could not be used for such nonsacred structures. It was not until the Ptolemaic reign under Greek domination, some two thousand years after the pyramids were built, and one thousand years after the construction of the Temples of Karnak, Luxor, and Abu Simbel, that stone became a constructional material used indifferently in temples, palaces, and garrisons.

The finest method of cutting stone, represented by fine chisel marks, was applied to stone by the Egyptians when stone had a religious significance. The dowel rod technique, representing the roughest and most primitive method of cutting stone, was used by the Greeks and Romans who did not consider stone to have the same metaphysical aspects as did the Egyptians.

Each block of stone was perfected in the quarry, the manifestation of Amun, as each hewn stone represented a limb or part of Amun. This belief explains why the Egyptians of the New Kingdom did not use the primitive wooden dowel rod method of cutting stone. To haphazardly cut a block of stone into pieces was an act of sacrilege, as unthinkable as to damage the body of Amun, the newly proclaimed progenitor.

We have gained precious insight into the old religion of Khnum and also into the religious objectives for producing faience, stone, and glass. Mystery upon mystery is solved. After thousands of years, a substantial part of the secret of the pyramids is revealed and their true story told. However, for the Egyptian authorities (Dr. Z. Hawass and colleagues) only 30 per cent of the archaeological remains have been unearthed and 70 per cent still remain buried under the desert sand.

I am ending this book, the product of many years of research and reflections, feeling both perplexed and hopeful. The outlook on the history of Egyptian civilizations, that was opened here, should offer young researchers a large and fascinating realm of investigation. Large because of the size of the task that remains to be accomplished. Fascinating because of the undeniable necessity to challenge our views on the civilizations from which we directly proceed. And my perplexity originates in that challenge, in the relationship that men of the past had with the sacred, which was not quite the one our civilization claims to be.

But do Egyptologists see me as the visionary who solved the pyramid riddle? So far, the reaction appears to reflect the NIH (Not Invented Here) factor, if we are to judge by comments appearing in magazine and newspaper articles. Some Egyptologists have commented in the press that my theory is “ a hunch carried too far ” and is “ against reason and logic ”. Their only knowledge, however, of my research comes from the press.

A criticism of me by the general public is that I have taken all of the fun and mystery out of the pyramids. My response is this: carving and hoisting stone is grueling labor that is in no way glamorous or romantic, but ingeniously building pyramids through chemistry, and thereby fooling even brilliant modern minds, is a great credit to the researchers of antiquity. Whether or not this presentation will convince anyone who does not want to be convinced is hardly predictable. The German philosopher Schopenhauer (1788 - 1860) wrote, " There are three steps in the revelation of any truth: in the first, it is ridiculed; in the second, resisted; in the third, it is considered self-evident ". It was ridiculed from 1979 to 1988, resisted from 1989 to 1996 and seems to become self-evident now.

I directed my investigation somewhat in the way Sherlock Holmes might have: when all the logical conjectures have been set aside, the one that remains, as improbable as it may seem, is likely to be true.

Appendix 1

The Ancient Alchemical Inventions

Before discussing the first alchemical invention, enamel, let us look at Le Chatelier's experience with the self-glazing enameled sandstone statuettes. After Le Chatelier discovered that the statuettes of the Thinite epoch were agglomerated sandstone, he had to convince his colleagues. He used microscopy to prove his point, and wrote [111]:

> " The basic material of which the statuettes are made is fine angular grains of sand, indicating careful grinding. Some claim that this indicates that the objects were carved of natural sandstone and enameled. I have shown that the statuettes contain numerous spherical bubbles, which means that, irrefutably, they are made of an artificial ceramic matrix. "

A natural sandstone matrix does not exhibit bubbles.

Only when either ground sandstone or loose sand is mixed with a binder do air bubbles appear. Le Chatelier carried out bulk chemical analysis in an attempt to demonstrate how the statuettes were made. The mineralogical composition follows:

Silica	($SiO2$)	93.3 to	95.3%
Iron oxide	(Fe_2O3)	0.1 to	0.4%
Aluminumoxide	(Al_2O_3)	1.0 to	2.5%
Lime	(CaO)	0.6 to	1.7%
Magnesium oxide	(MgO)	0.4 to	0.8%
Soda	(Na_2O)	0.6 to	2.5%

Assuming that the small amount of aluminum in the analysis constituted the binder, he tried to reproduce the formula by blending:

Modeling clay	10%
Ground sand	30%
Fontainebleau sand.	60%
.... Total	100%

His formula contained twice as much alumina as the statuettes, and his opponents were therefore not impressed. Because of the fine, angular grain structure observed in the statuettes, they continued to argue in favor of natural sandstone. Le Chatelier, however was not alone. His colleague Pukall made several trials in an attempt to reconstitute a siliceous ceramic paste comparable to the matrix of the statuettes.

After long deliberations, Le Chatelier and Pukall finally reached an agreement with their opponents. Pukall proposed the use of soluble sodium silicate (water glass) and the appropriate amount of aluminous clay. Pukall's proposal seemed plausible, but the opposing scientists were still not willing to concede that this formula was used during antiquity. It seemed more likely to them that an intermediate product was used, which, when ground and blended with water, would produce soluble sodium silicate. This intermediate product became known as alkaline frit (sandy frit), a partly fused combination of fluxes and sand. With vague data, the opposing scientists estimated that alkaline frit was invented in the Nagadian epoch (c. 4000 - 3600 BC). With regard to the statuettes, Dictionnaire des Techniques Archeologiques states [112]:

> " The basic material was natural hard stone (quartz) or natural soft stone (steatite), or more generally any hard stone (sandstone, flint, or quartz sand) powdered finely and agglomerated with an adhesive."

By whatever chemistry it was assumed produced the statuettes, it was established in the early 1900s that the Egyptians produced man-made reconstituted stone.

Le Chatelier also performed bulk chemical analysis on blue ceramic tiles from the subterranean chambers of Zoser's pyramid at Saqqara. His analysis shows raw materials involved in geopolymerization:

Silica	(SiO2)	92.5%
Alumina	(Al_20_3)	1.2%
Lime	(CaO)	0.6%
Soda	(Na_2O)	2.5%
Manganese oxide..	(MnO_2)	2.4%
Copper oxide	(CuO_2)	0.8%

This analysis is useful for pinpointing the origin of raw materials used to make the statuettes and tiles (see Table III)

First Alchemical Invention Enamel, a By-product of Copper Smelting, Invented 6,000 Years Ago

Before the statuettes were made, blue enamel had been invented and applied to beads and pebbles, such as those found in neolithic tombs of about 4000 BC. Scholarship maintains that the discovery of enamel was accidental. It is assumed that malachite and natron, ground together on large, flat sandstone millstones to make eye paint, happened to mix with silica debris from the millstones themselves, producing a layer of enamel.

This explanation, however, does not conform to analysis. Silica is anhydrous and requires a temperature of 1,300°C (2,370°F) to melt, because only in the molten state can it mix with a flux (natron or other). This temperature was not achievable in Egypt in 4000 BC. To reach it, large bellows were needed, not yet invented in 4000 BC. It is much easier to fuse natron and chrysocolla than natron and silica, malachite, or other copper carbonates. Chrysocolla, in its natural hydrated state, mixes easily with a flux.

Table III. Sources of Raw Materials for Statuettes

Chemical substance	Raw material	Source
silica	quartz	Nile sand
silica	sodium silicate from opal, calcedoine or chrysocolla	reaction of silica with caustic soda
soda	natron (plus lime)	Natron is abundant in deserts and lakes
alumina	turquoise	Sinai mines
manganese oxide	pyrolusite	Sinai mines
copper oxide	turquoise/chrysocolla	Sinai mines

Chemists might assume that a combination of natron and chrysocolla would not fuse because sodium carbonate melts at 850°C (1,500°F), a temperature higher than that achievable in 4000 BC. This temperature must be reached before natron can act on either silicate or silica. By the time it is reached, water in the crystalline structure of chrysocolla has evaporated, eliminating the possibility of a reaction with natron for the production of enamel.

The assumption would be correct if the sodium carbonate were manufactured by the modern Solvay process, which produces a pure product that melts at 850°C (1,560°F). This is not, however, the case with Egyptian natron. The invention of enamel was possible because of the composition of Egyptian natron, which is [113]:

Hypocarbonate of soda	23.35%
Sufate of soda	11.29%
Muriate of soda	51.66%
Clayish and siliceous sand	2.90%
Carbonate of lime	0.89%
Oxide of iron	0.20%
Water	9.71%

Egyptian natron possesses a particularity that is not generally known. Its composition of sodium carbonate, sodium sulfate, and sodium chloride produces a fortunate eutectic point. When mixed together, two pure substances can have a melting point that is lower than they have individually. The melting point of sodium chloride is 800°C (1,470°F), and melting point of sodium sulfate is 850°C (1,560°F). But a eutectic mixture of sodium chloride and sodium carbonate melts at 634°C (1,173°F). The eutectic point of sodium chloride and sodium sulfate is 628°C (1,162°F). The eutectic point of all three salts combined is only 612°C (1,133°F). This affords a reaction with chrysocolla, allowing the invention of enamel to have occurred not at 850°C (1,560°F), but at only 612°C (1,133°F).

Second Alchemical Invention
Caustic Soda Used for Enamel Production
5,600 Years Ago

Today caustic soda is made using electrolysis (the action of electric current on sodium chloride). Anciently, a simpler method was used: natron was mixed with lime CaO (calcined limestone or wood ashes) and water.

Less material is required for enamel production when using caustic soda. This is because caustic soda is more reactive than natron. Caustic soda, when made with natron, lime CaO (wood ash), and water, always retains a small amount of lime and, therefore, reacts with various siliceous materials between 50°C (122°F) and 150°C (302°F). This type of caustic soda was also used by the chemists of the nineteenth century to produce alkaline frit and soluble sodium or potassium silicate (water glass), which they called stone liquor. In ancient Egypt, caustic soda was the main part of the reaction for agglomerating stone.

Third Alchemical Invention
Sodium Silicate Produced
5,600 Years Ago

Archaeologists, assuming that alkaline frit was anciently used to agglomerate stone, used the term agglomeration to imply a process capable of yielding sodium silicate (water glass). To manufacture sodium silicate today, a mixture of quartz sand and sodium carbonate is fused at 1,300°C (2,370°F).

Quartz sand has a compact structure and reacts with difficulty at moderate temperatures. On the other hand, hydrous siliceous mineral varieties, because of the water in their crystalline structure, are readily attacked at moderate temperatures by caustic soda and therefore easily form sodium silicate. Some of these are diatomaceous earth; opals and flints; chalcedony, such as carnelian, agate, and onyx; volcanic glasses, such as obsidian; chrysocolla; and allophanes (typically as stalactites or as encrustations on chalk and sandstone). Ashes from reed, wheat and barley hulls and straw also contain a high amount (between 65 and 75 per cent by weight) of very reactive silica (plant opal)

Amorphous (having no definite crystalline structure) silica, opal, flint, and chalcedony are found in considerable quantities in Egypt. De Roziere commented [114]:

> " A multitude of agate pebbles, either oval or rather flattened, were spread over the surface of the ancient town of Thebes… All of the pebbles seem to have a common origin. They could not have been transported to the rather high ground of the ancient towns by any natural means, and they are found mostly on the heaps of ruins and debris of ancient monuments, sometimes even in the isles of the Nile, such as the Isle of Philae, and especially the Isle of Elephantine, where they seem to be strewn in very considerable quantities over the site where this Egyptian town stood. "

Agate is just one form of amorphous silica abundant in Egypt. Plant ashes (reed, wheat hulls, barley hulls, straw) and diatomaceous earth are also abundant. Because caustic soda reacts easily with these materials, there were numerous possibilities for producing sodium silicate for cement.

Fourth Alchemical Invention Agglomeration Using Turquoise, 5,600 Years Ago

Le Chatelier was unable to recreate the formula composing the statuettes, partly because he assumed that a binder based on clay was essential. While it is true that kaolin clay was used in some cements, the binder for the statuettes was based on sodium silicate.

It is relatively easy to cause a thin layer of sodium silicate to set in open air. It is more difficult in a closed mold, such as required for statuettes. This is because neither sodium silicate nor lime are hydraulic binders. Hydraulic setting takes place only if the water in the mixture does not evaporate, and even then, the resulting product is not always water resistant unless geopolymerization is introduced. Geopolymerization produces a water-resistant cement in a humid environment by transforming sodium silicate into a synthetic zeolite. This is achieved with an aluminum phosphate, which, for ancient Egypt, was turquoise.

Fifth Alchemical Invention
Agglomeration with Aluminous Limestone by Imhotep, 4,700 Years Ago

Imhotep discovered the properties of the two natural limestone stratas that alternate on the Saqqarah plateau. One is a sand-limestone comprising up to 30 percent sand, 60 per cent limestone and 10 percent clay. The second is a clay-limestone comprising 20 to 60 percent clay and 40 to 80 per cent limestone. The major clayish ingredient is of the reactive kaolinitic type.

These limestones are very sensitive to climatic erosion and are very easily disaggregated with water, yielding the muddy limestone paste suitable for the fabrication of limestone bricks. The alumina and silica in the clay binding the bedrock are activated by caustic soda (addition of natron and lime CaO, wood-ash), forming a (sodium-calcium) alumino-silicate, a basic geopolymeric cement. The muddy limestone paste was rammed in the wooden molds used for making mudbricks. The limestone paste hardened in the shade and the limestone bricks were transported to the pyramid site.

In modern times, the author intensively studied this reaction and developed several processes that he coined

L.T.G.S., an acronym for Low Temperature Geopolymeric Setting of clay and bricks. Several patents were granted on the making of bricks made of various soils and earth [115].

Sixth Alchemical Invention
Arsenic Used to Speed Setting
4,600 Years Ago

As long as only small limestone bricks were being produced, a slow rate of hydraulic setting did not present problems because small bricks dry rapidly. From Sneferu's time forward pyramid blocks became larger, and hydraulic setting was modified to avoid shrinkage and cracking. Sodium arsenate is an activating ingredient that could have been used to induce rapid hydraulic setting. In ancient Egypt, this product was obtained by reacting an arsenic mineral ore, such as scorodite and olivenite, with caustic soda.

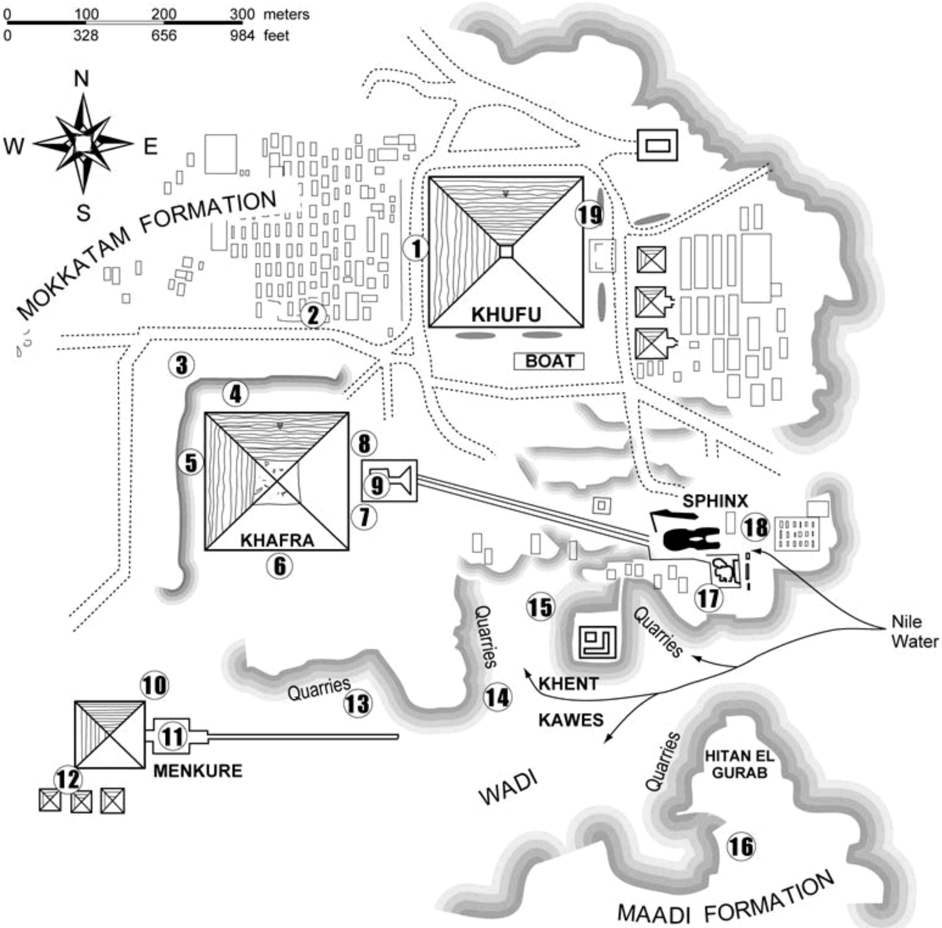
Seventh Alchemical Invention
Borax Slowed Setting Time
4,600 Years Ago

Borax slows the setting time of geopolymeric binders. It was probably used to fabricate enormous temple blocks and the beams forming the roofs of the burial chambers of the Fifth and Sixth Dynasty pyramids.

Appendix 2

Circuit of the Pyramid Plateau at Giza, Egypt

An Introduction to the Study of Pyramid Construction Methods



Giza Plateau Circuit
Stages 1 to 19

The present circuit is the compilation of several excursions performed by the author between 1979 and 1991, namely:

1 - a regular touristical visit in 1979.

2 - a 7 day long survey in October 1984 performed with an Egyptian geology student and subsequent discussions with members of the Geology Faculty at Ain Shams University, Cairo.

3 - a 7 day stay in November 1988, in connection with the 5th International Congress of Egyptologists (the author presented a paper on the subject) [50].

4 - a 4 day visit in October 1991, in connection with the shooting of the TV show NOVA entitled "This Old Pyramid" and produced by the American team for the PBS network. (aired in September 1992), see the discussion below.

Preliminary recommendations

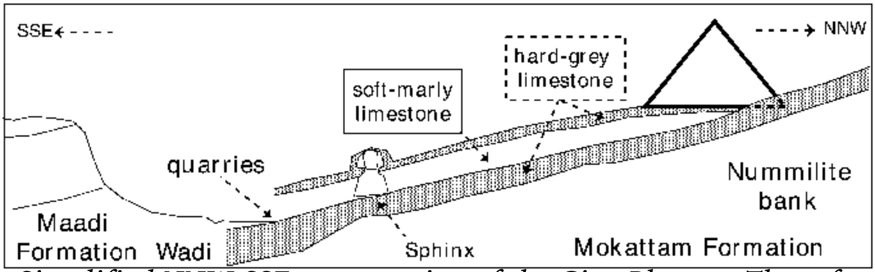
This excursion requires at least five hours. It is not a substitute for the regular touristical tour that any pyramid visitor should undertake before focusing on the several issues which are raised in this circuit. A minimum stay of 2 days in a hotel located in the vicinity of the site is recommended, the first day being dedicated to the enjoyment of the touristic discovery. I would recommend starting the tour early in the morning (when the site opens) with Stage 1 and to follow the order of the Stages, from 1 to 18. Excursionists should be dressed correctly for protection from the harsh burn of the sun glowing over the sand. They should also take sufficient drinking water with them for the tour. Starting at 8 am will bring them back to Khufu pyramid, at around 1 PM. The best time for taking pictures is either early in the morning for locations looking east and south, and late in the afternoon (after 4 PM) for areas looking west and north; otherwise, there is a risk of getting overexposed pictures with no contrasted features. Amateurs may anticipate a second trip to the site in the afternoon after the appropriate rest.

In the following text I used the hieroglyphic names of the pharaohs, namely :

- Khufu for Cheops/Kheops
- Khafra for Chephren/Khefren
- Menkure for Mykerinos.

Basic geological knowledge of the Pyramid Plateau

The Giza Plateau is an outcrop of the Middle Eocene Mokattam Formation. A second outcrop of the Upper Eocene Maadi Formation borders the Pyramids Plateau on the South-South West. A large sandy wadi separates the Mokattam Formation from the Maadi Formation, created by the South-East dip of the Mokattam Formation (see on the general map of the Giza Plateau). The North side of the wadi, or the southern line of the Mokattam Formation outcrop, and the South side of the wadi, or the northern line of the Maadi Formation outcrop, where both Formations dip into the wadi, were extensively quarried during the erection of the Giza pyramids. According to Aigner [116] and Lehner [117], the original ground surface of the Mokattam Formation that constitutes the basement of the pyramids, is made of a very hard and



Simplified NNW-SSE cross-section of the Giza Plateau. The soft-marly limestone bed that was extensively quarried (Stage 18 Sphinx, Stages 14 to 16 Wadi quarries) is sandwiched between two hard-grey limestone beds.

massive limestone bank of the nummulite type (see the Stages 3, 4, 5 and 6). On the other hand, the outcrop that dips into the wadi, where the quarries are located, consists of softer thickly bedded nummulite layers (see the Stages 13, 14, 15, 16, and also the trench around the Sphinx in Stage 18) with a relative high amount of clay. Concurring to the traditional carving theory, Lehner states "... the builders took advantage of the thickly bedded softer limestones of the south part of the Mokattam Formation, while founding the pyramids on the hard nummulite bank to the north.." [118]

Lehner postulates that the builders did not use the nearby hard limestone but favored the softer material. In other words, Lehner's remark suggests that quarrying and carving the hard Mokattam limestone would have required more labor than the transport of the softer material from the wadi up to the pyramid plateau. In general, during antiquity, quarries where chosen because of the ease with which the blocks could be transported, downwards, from the top of the hill down to the valley. The Aswan granite quarries, the Silsilis sandstone quarries, south of Thebes, or even the Tourah quarries located on the opposite side of the Nile Valley, in front of the Giza Plateau, are typical examples for this theorem.

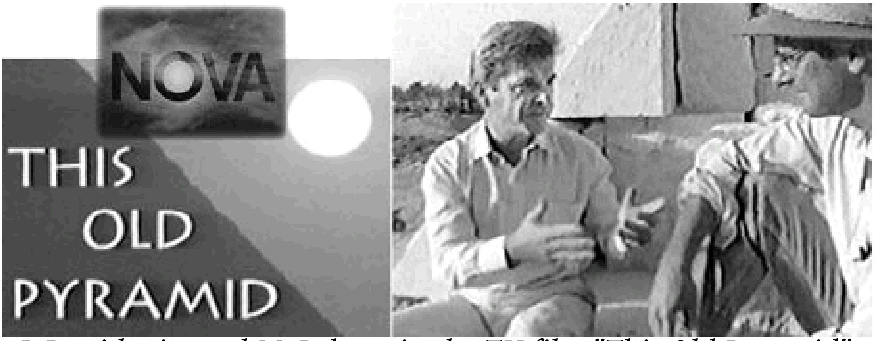
Why did the Khufu and Khafra architects refrain from using the limestone located up hill, nearby on the west, taking advantage of the natural inclination of the plateau, and the ease of transport?

Why did they select the limestone from the wadi edges, downhill, with the supplementary burden of having to carry the blocks to a 40-50 meter height upwards on long ramps, in opposition to traditional quarrying methods?

The agglomeration theory provides a good answer to this issue, namely:

a) - the hard limestone nearby the basement is not suitable for the production of agglomerated blocks because it does not disaggregate easily in water;

b) - on the other hand, the softer marly limestone of the wadi edges is a suitable raw material for agglomerated limestone blocks because part of it disaggregates in water, within a short period of time. The disaggregated muddy limestone (including the fossil-shells) would be further mixed with other limestone aggregates, lime and zeolite-forming materials such as kaolin clay, silt, and the Egyptian salt natron (sodium carbonate).



J. Davidovits and M. Lehner in the TV film "This Old Pyramid", WGBH, Boston, 1992.

After 24 hour soaking in a plastic bag with water, the limestone chunk separated into clay and nummulites. In the presence of an excess of water, the heavier clay settles, leaving the nummulites separated from each other. "This Old Pyramid" WGBH, Boston, 1992.

In October 1991, during the shooting of the TV production " This Old Pyramid " by NOVA, aired on the American

PBS network on September 1992, I had the opportunity to present this unique property of the Giza limestone. A chunk of limestone taken in the quarry at Stage 15, was very easily disaggregated within 24 hours, leaving the nummulites and the clay gently separated from each other, whereas a chunk of the hard Mokattam limestone did not disintegrate at all.

The Circuit starts at Stage 1 and ends at Stage 19. It is an introduction to the issues related to the study of the pyramid construction methods. It should be undertaken by those who favor the casting and packing system as well as by those who defend the traditional carving and hoisting method. Visitors often wish to take stone samples for further analysis. However, do not take fragments from the Pyramids because the Egyptian authorities do not allow unauthorized sampling. Those interested in the soaking experimentation should collect their samples at Stage 15.

Stage 1: Khufu west (Kheops)

The variation in quality of the blocks composing the Giza pyramids is striking. Some blocks are unweathered whereas the majority has become extremely eroded by wind, rain, and the sunlight; the degradation is most severe from the south and west [Fig. 1b].

I observed those blocks on the west side of Khufu and Khafra's pyramids that have been protected during centuries from weathering. Until about 100 years ago, the first several tiers on the west sides were buried under desert sand. This can be clearly seen on the drawings made by the French Description de l'Egypte in 1802 or by the German Expedition Lepsius around 1845, which distinctly show the bottom of each pyramid covered with sand, up to a very high level, that I have represented by the line on Fig. 1a. Little erosion occurred after the sand was cleared. Because the blocks were exposed quite recently, the blocks located underneath the line are relatively unweathered (Fig. 1c).

Figure 1a: Stage 1 looking to the west side of Khufu pyramid, from across the road, standing on a mound (remains of a stone mastaba) (1984).

Figure 1b: weathered blocks located above the sand cover (1984).

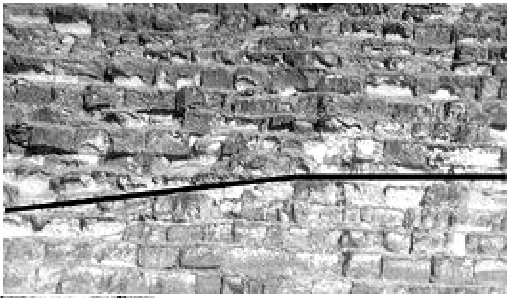


Figure 1c: (bottom) unweathered blocks protected by sand (1984).

However, the majority of these unweathered blocks exhibit a light, weak top layer, which cannot be attributed to weathering, despite the geologist's statement that " .. To us, most of the spongy zones seem to be the effects of differential weathering of a relatively soft limestone layer.. " caused by the burrowing and churning of animals during the Eocene [119].

In the agglomerated stone scenario, this top layer is characteristic of the technology employed. One type of mold is illustrated in Figure 1d. The side planks of the mold are blocked by an existing stone (A) or fixed with a hole digged in below step (B). During casting or packing, the bottom and center part of the blocks become denser, while the top does not get the same compression, resulting in a lighter density. It is striking that the height of this layer is rather uniform, from one block to another.

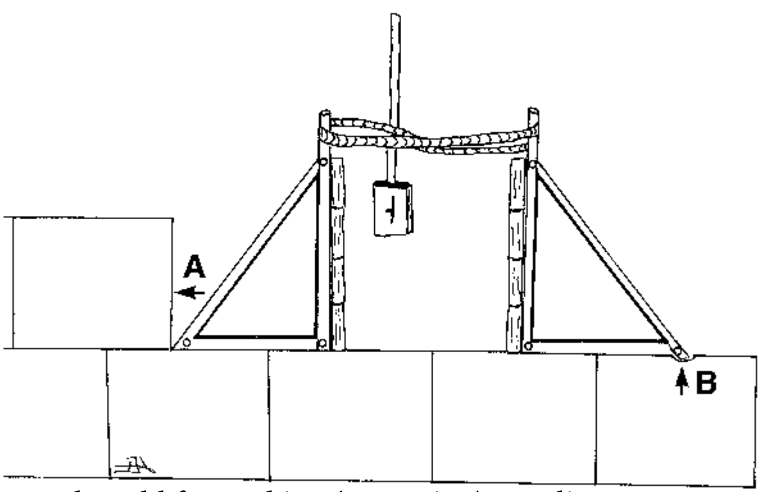


Figure 1d: mold for packing (or casting) wet limestone material.

In the pyramids of Khufu, Khafra, and Menkure, one sees from time to time a thick, pink mortar. This mortar was used to fill cracks and level imperfect blocks and also to cement a minority of rough trapezoidal-shaped core blocks to neighboring blocks. Sometimes, the mortar was applied to a thickness of up to 20 millimeters (0.78 inch) beneath the base of the trapezoidal blocks. These blocks are positioned with their widest area upward. The mortar was applied to be thickest at the bottom, with that thickness gradually decreasing as it neared the top of the blocks. Practically no mortar is visible at their top edges, because this area is very small. The presence of this thick mortar indicates that these particular blocks were moved into place, as opposed to having been cast in situ.

That these trapezoidal blocks are bound by mortar does not invalidate the agglomerated stone theory because the blocks represent only a small minority. Instead, the blocks provide insight into the plan by which the pyramids were constructed. The blocks were probably cast nearby and placed during the final construction phase to plug passageways that had remained open to provide ventilation and allow ingress and egress of materials.

Stage 2: Khufu west, a view on the height of the steps

The list of anomalies about the Great Pyramid lengthens when we consider the dimensions of the blocks. There is a misconception about the blocks of the Pyramids which archaeologists perpetuate. They advocate that the heights of the blocks at the base are always greater than those near the summit. If accurate, this would make logistical problems far less complex.

It is true that the height of the blocks at the base of Khufu is 1.41 meters (1.54 yards) and that the heights of blocks progressively diminish to 0.59 meter (1.93 feet) in the first seventeen steps. The only way to determine the exact heights of the steps is by measuring them. Because it is difficult and potentially dangerous to climb to the top of the pyramid, it is likely that most specialists have mounted only the first few steps. With the exception of the huge cornerstones, the weight of blocks in the first seventeen steps diminishes from approximately six to two tons. Beyond the seventeenth step, however, blocks weigh from fifteen to twenty tons apiece (Step

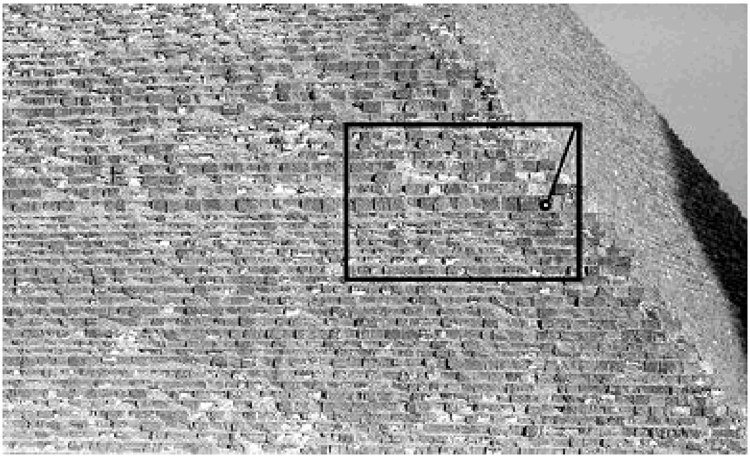


Figure 2a: Stage 2, looking to Khufu Pyramid, standing 300 meters west, on the rocky plateau (1984).

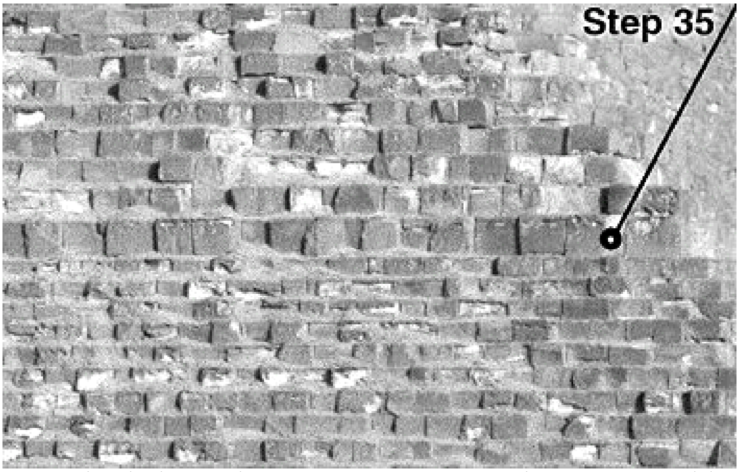


Figure 2b: (below) close-up on step 35 with its greater blocks (1984).

35 on the picture) showing that block size does not consistently diminish as the pyramid ascends.

This is not obvious when one is standing at the bottom of the pyramid looking up, because the heights of blocks forming the tiers appear to diminish. However, this does become obvious when standing at Stage 2 (Fig. 2a, 2b, taken with a teleobjective). The Egyptologists' remark that, " as is natural, the heights continuously decrease " was meant as a general statement, which was not intended to account for all blocks in the pyramid. It certainly does not apply to hundreds of blocks weighing from fifteen to twenty tons situated near the King's Chamber, and at level 35. Blocks of this size are so large that they occupy the space of two tiers. Nevertheless, this general statement is always cited, whereas the precise detailed reports on the variation of the heights are rarely, if ever, taken into consideration.

Because of the difficulty of raising such large stones to great heights, their detailed report poses a serious threat to the accepted carving and hoisting theory.

Stage 3: Khafra north-west, a view of the trench (Khafra)

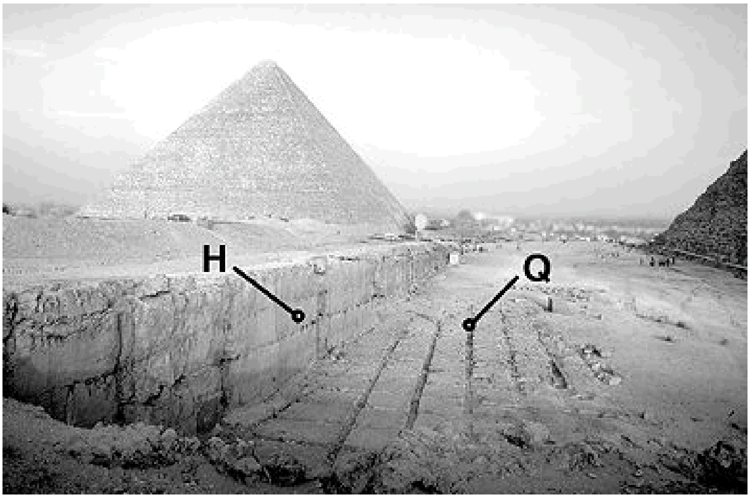


Figure 3a: Stage 3, standing above the trench on the west side of Khafra Pyramid. On the far left, Khufu Pyramid. (1988)

There is a remains of quarrying activity (label Q) in a trench on the north-west side of the Khafra Pyramid (Fig. 3a). Egyptologists use it as evidence to support the traditional carving and hoisting theory. For example, French Egyptologist Goyon states that the blocks were easy to cut because advantage was taken of natural divisions in the bedrock [120]. Occasionally, a stratum (lift line) can be observed in very large

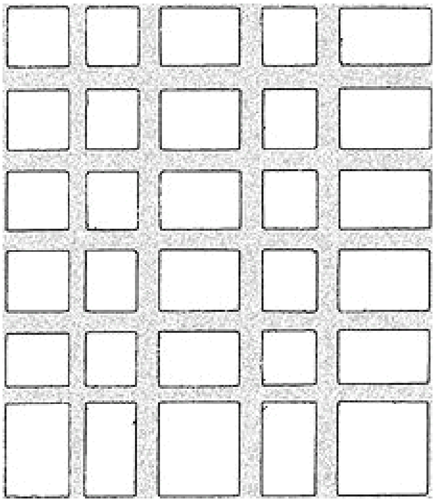


Figure 3b: sketch of the quarry remains (Q), adapted from Goyon [121]

pyramid blocks. When one does appear, however, it is not as high as the divisions of strata found on the Giza plateau. The divisions of strata in the bedrock near the pyramid of Khafra are about 4.5 meters (5 yards) apart (label H), three to four times greater than the heights of the pyramid blocks.

Goyon provides also an interesting sketch of the quarry Q (Fig. 3b) [121]. The most striking element is that the blocks are of different sizes. Apart from one fracture crossing obliquely at the end of the quarry, the outcrop is homogeneous and it does not make sense to have cut blocks of different dimensions.

The northern vertical face of this quarry bears hieroglyphic inscriptions (label H) with a large cartouche containing the name of the New Kingdom pharaoh, Ramses II (1298-1235 BC) (Fig. 4), who demolished numerous monuments to obtain ready-made blocks for his own constructions or hew blocks for his buildings or restored temples, the remains of which are seen here under (Q). But, why are they not all of the same size? Any logical explanation on this issue would focus on the fact that Ramses' architect deliberately followed an architectural plan by hewing blocks with different sizes. From Goyon's sketch it can be deduced easily that the architect wanted blocks having five to seven different dimensions.

My own research on the dimensions of the Khafra pyramid blocks emphasized that " … almost all 2000 blocks I photographed in Khafra's pyramid conform to ten uniform lengths. The various lengths are set in different patterns throughout the twenty-two steps - [photography taken at three sites located on the right of Stage 3, just in front of the west side of the pyramid, where the steps are clear from any stone debris] - That only ten dimensions exist indicates that all twenty-two steps were produced with molds of only five sizes, because some blocks were packed with their lengths perpendicular to the plane of the pyramid face… " [122]. Khafra's architect, like all Egyptian builders, from the IIIrd Dynasty onward, followed a precise architectural plan, then all blocks were dimensioned according to a clever master plan of patterns that eliminated the formation of aligned vertical joints, detrimental to the stability of the structure. Staggering the various block heights (see in Stage 2) and sizes produces tremendous stability. This type of structural design was used from the beginning of the Egyptian civilization. It explains how the Great Pyramids remained unscathed by the earthquake of 1301 that devastated Cairo

Stage 4: Khafra north-west, hieroglyphs, cartouche of Ramses II

On the rock above is an inscription in honor of Ramses II architect Mey, chief architect in the temple called "Ramses shines in the Great House of the Prince" and son of Bek-en-Amun, chief architect of Thebes. It is assumed that during the reign of Ramses II, Mey either systematically demolished the temple of Khafra or restored it. The discussion is still open. He also took parts of the facing of the pyramid to obtain materials for building a temple at Heliopolis. Ramses II and other pharaohs took a number of ready-made blocks from various pyramids, but they were incapable of producing a monument or any combination of monuments equivalent in volume to the Great Pyramid. This holds true even though Ramses II used enormous wealth and manpower endlessly to rob ready-made blocks from existing monuments over his sixty-five year reign.

Figure 4: Stage 4, at the quarry remains (Q), inscription in honour of Mey, with the cartouche of pharaoh Ramses II. (1988)

Stage 5: Khafra north-west, in the trench, natural bedrock

To form a level base on the incline of the Giza plateau, five steps on the west side of the pyramid of Khafra were shaped in situ from natural bedrock (Fig. 5a). There are no individual blocks in these bedrock steps, and therefore, shaping them did not involve the arduous labor required to cut perfectly fitting blocks.

Above these natural steps, and at a place that has been covered by sand and protected against differential weathering, the pyramid stones bear the traditional density pattern encountered in Stage 1 (Fig. 5b). The natural steps show no sign of weathering (Fig. 5c) and therefore it can be concluded that this pattern does not come from weathering but from the manufacturing process itself. If the pyramid blocks were natural limestone, the unnatural density pattern could be explained only if two adjacent strata of different quality had

Figure 5a: Stage 5, Khafra west, floor of the levelled plateau. View on the natural steps (arrows) (1988).

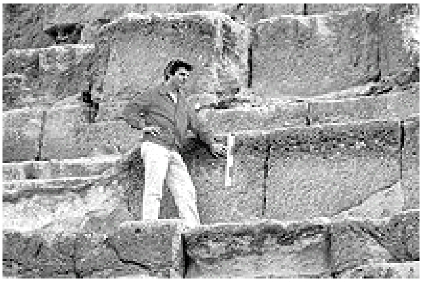


Figure 5b: Pyramid blocks on 6th step with density pattern (1988).

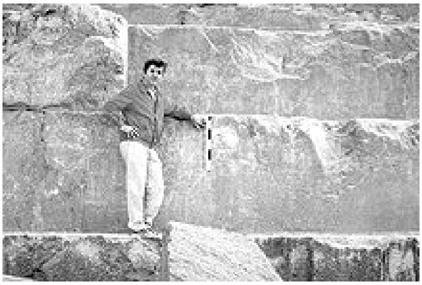


Figure 5c: Unweathered natural steps (1988).

been included in the cut, the lower of a better quality than the upper (see the geological explanation on the burrows, in Stage 18). That the pyramid blocks were cast explains why the rough top layer is always about the same size, regardless of the height of a block. So far, to our knowledge, quarries exhibiting this unusual feature have not been identified and used to the degree that is visible in the pyramids (see the nature of the bedrock in the known quarries at Stages 13-14-15-16).

Stage 6: Khafra south, inclined bed rock and pyramid stones

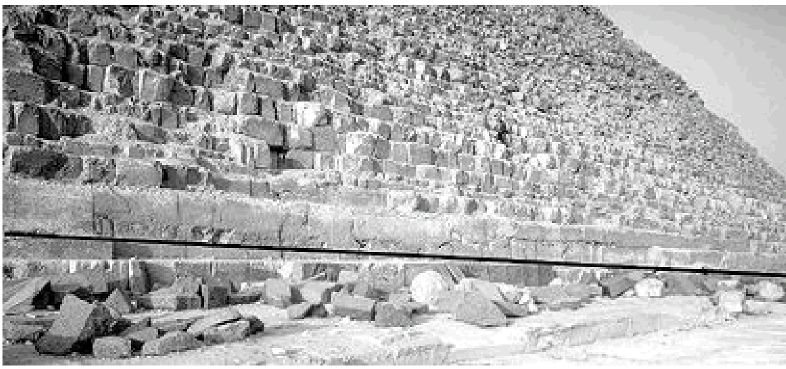


Figure 6a: Stage 6, middle of the south side of Khafra Pyramid. Inclined bedrock, thick line (1984).

To study the transition between the homogeneous natural bedrock steps and the individual pyramid limestone blocks, a good place to stay is near the middle of the south side of the base of the pyramid. Above are about 2 million individual blocks. At the base, on the inclined bedrock (marked with the thick line, inclination 3°), the individual blocks automatically correct the inclined level to produce a perfect horizontal base. The bedrock is quite homogeneous in density. The nummulites in the bedrock steps are oriented horizontally, characteristic of natural sedimentary layering.

Figure 6b: pyramid blocks above inclined bedrock (doted line) (1984).

On the other hand, the shells in the pyramid blocks lying just above the bedrock, are jumbled, not horizontally oriented. This feature distinguished agglomerated limestone from carved limestone.

Stages 7 and 8: East Side of Pyramids

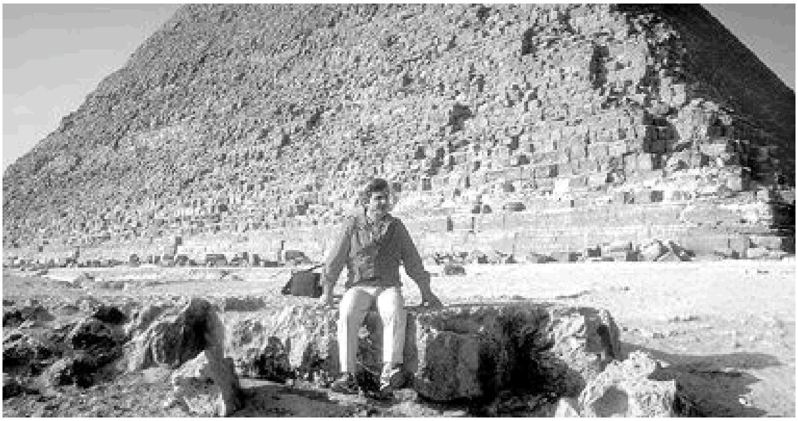


Figure 7: Stage 8, Khafra Pyramid, east, with enormous corner stone and blocks (1988).

It is worthy of note that the first row on the east side of Khafra's pyramid is made of enormous individual blocks (Fig. 7). When looking at the first and second stairs of the three great pyramids (Khufu, Khafra and Menkure) one notices that the blocks have been subject to intensive repair or restoration work. They bear marks and lines, which have sometimes been taken for natural bedding (horizontal and vertical). The Egyptians used to flank the pyramids with subsidiary buildings. The Mortuary Temples seemed to have been separated from the east face of the Pyramid (at Khufu and Khafra) by a paved alleyway. In later pyramids, for example Menkure and those from the Vth and VIth Dynasties, the Mortuary Temple is contiguous and the first rows of the pyramid are part of the temple walls. In other words, the architecture of the east sides of the pyramids may have been altered and changed.

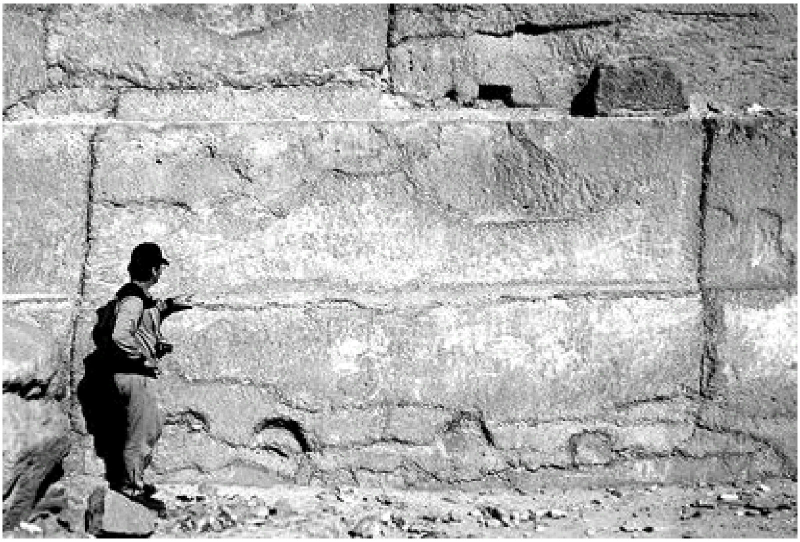


Figure 8a: Stage 7, south end of the east side of Khafra Pyramid. Blocks with demolition mark (1984).

In Fig. 8a, the author examines the mark left by repair or demolition work. This mark runs horizontally through the middle of a series of adjacent blocks. The curved angle joint at the left of the picture suggests that the stones were cast against bare neighboring stones to produce a close fit. A close fit is the main characteristic of all large blocks constituting this east side and all temples at Giza, which will be visited at the following Stages. The bottom of the block bears imprints

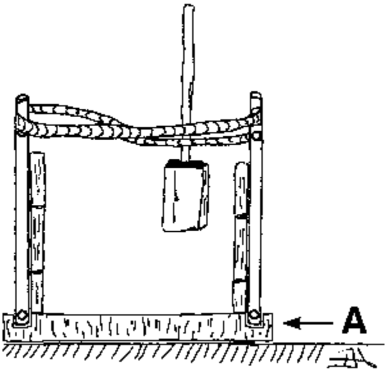


Figure 8b: mold with crossing pieces of wood (A) for casting or packing wet limestone material.

of holes patched with mortar. This feature suggests the use of a mold (Fig. 8b) by which the side planks are maintained in position by several pieces of wood running across the mold (A). Before complete hardening of the stone, the pieces of wood were taken out of the structure and the resulting holes patched with quick mortar.

Stage 9: Khafra east, Mortuary Temple, enormous blocks

I closely examined blocks in the Mortuary Temple, Valley Temple, and the Temple of the Sphinx in Khafra's complex, and the Mortuary Temple in Menkure's complex. These walls were originally covered with granite ashlars or with a coating, an imitation of granite, which has now disappeared.

Figure 9: Stage 9, Mortuary Temple, Khafra Pyramid east. Block with strata, on right hand when looking east, to the valley. Notice the close vertical fit between the blocks and the thin mortar separating each block (1984).

Walls protected from weathering are smooth and light gray. Large areas of blocks composing the walls that have been attacked by weather display the same density variations as in the pyramid blocks. The blocks in the temples in Khafra's complex are gigantic. They stand approximately 2 to 3 meters (6 to 10 feet) high and weigh up to 200-300 tons apiece (10 truck loads, or the equivalent weight of 150 cars). The weathered faces of the largest of these blocks exhibit two or three wavy irregular strata (Fig. 9). These are smaller than the divisions of strata in the Giza plateau. The geologists I encountered from Ain Shams University in 1984 opined that the strata proves that the stones are natural. They were unaware that most types of concrete can also exhibit strata, known as lift lines.

Like those visible in the largest pyramid blocks, these lift lines can be explained by the method used to produce the blocks. If the large temple blocks were natural, they would have to have been quarried from close by, because their great size would make them almost impossible to move by primitive means. To cast blocks of such enormous size might require three days. After the workers quit for the day, the unfinished block hardened. As it set, a surface (lift line) formed. The process was repeated daily until the block was complete. The lift lines are visible now that the outer surface has been destroyed by weathering (at the end of the scaled arrow). In addition, the strata in the bedrock are horizontal, whereas the wavy lift lines are characteristic of material dumped, packed or rammed into a mold.

Stage 10: Menkure, north, carved granite casing (Mykerinos)

The pyramid of Menkure has an exceptional history. Most of its casing blocks, now disappeared, were limestone. Those appearing on the lower quarter of the pyramid are made of carved granite (Fig. 10). Some of the blocks are irregularly shaped, typical of carved blocks. The Menkure pyramid probably fell victim to the New Kingdom pharaoh, Ramses II, who routinely used pyramid casing blocks to build or restore temples dedicated to his god, Amun.

Maybe, the pyramid of Menkure was stripped starting at the bottom, but only one-third was denuded. A subsequent ruler restored the pyramid with carved syenite granite from Aswan, a material which was commonly carved during the New Kingdom. Far from supporting the traditional theory of construction, the carved blocks contribute to my theorem. Their appearance clearly demonstrates the difference between carved and agglomerated blocks.

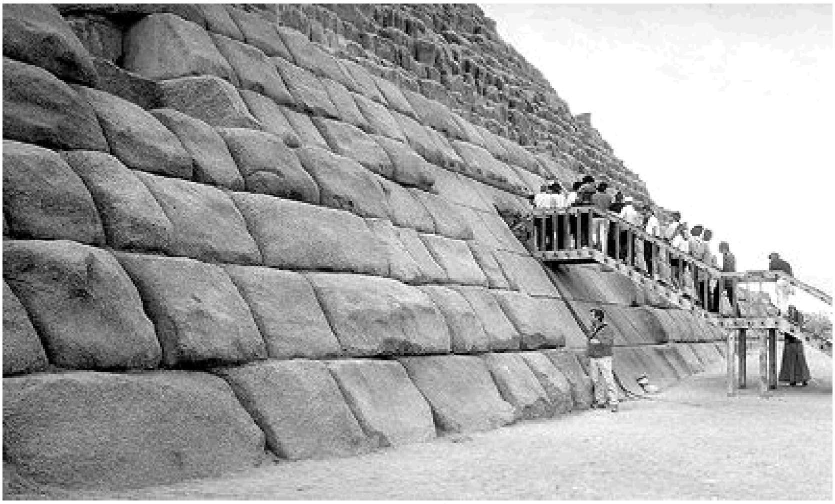


Figure 10: Stage 10, north side of Menkure Pyramid, entrance and casing with carved granite (1988).

Stage 11: Menkure east, toolmarks on Mortuary Temple blocks

Edwards states in his book *The Pyramids of Egypt [123]:*

" … Menkure must have intended to follow the example of Khafra by constructing his Mortuary Temple of limestone faced with ashlars of granite. Reiner's excavations, however have shown that this plan was never realized (…) Only the foundations of the Valley Building were made of stone; the superstructure was composed almost entirely of crude brick. (…) In the Mortuary Temple the foundations and the inner core of some of its walls were composed of limestone blocks (…) but crude brick was again the material used for completing the greater part of the building… "

The blocks were overlaid with a plaster imitating gra-

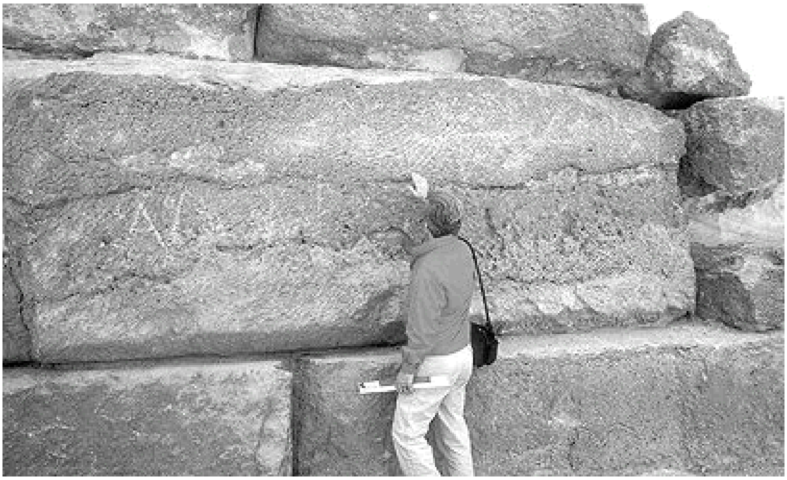


Figure 11a: Stage 11, Mortuary Temple, Menkure Pyramid, east, on the right hand when facing the valley. Blocks with toolmarks

Figure 11b: visible toolmarks (1988).

nite or with a white plaster, inside and outside. The unweathered side (north) of the Menkure Mortuary Temple blocks shows visible toolmarks (Fig. 11a, 11b). These toolmarks are also observed on the blocks of other temples and have been taken as proof against the agglomerated stone theory. They are not! As mentioned above, the blocks were not bare, but recovered with a decorative coating. It is traditional in all civilizations to proceed in the same way when applying a decorative coating or plaster, or stucco, upon a smooth stone or brick surface. The stone surface must be roughened in order to achieve good mechanical adhesion between the plaster and the stone surface. In the author's mind, these toolmarks were specially worked on the agglomerated stone because Menkure' architect did not have the time or the budget to face the ashlars with massive granite stones. Remains of colored plaster (coating) are often visible on pyramid blocks, essentially those located on the east sides (see at Stages 7- 8 the restoration of the steps adjacent to the Mortuary Temple).

The worked bottom edge of the block in Figure 11a

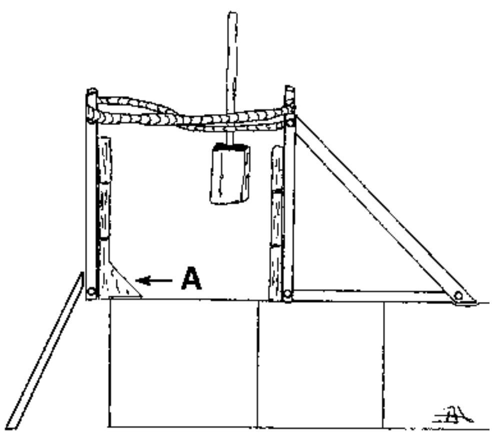


Figure 11c: Another mold type for casting or packing wet limestone material

suggests the use of another type of mold (Fig. 11c) by which the side planks are maintained in position by a special piece of wood running lengthwise (A), the planks being also fixed to the ground with a pole.

Stage 12: Menkure stepped satellite pyramids, close fit, stone with vertical bedding for mold

The route now leads to the southwest of the Menkure pyramid. To its south stand three small pyramids belonging to near relatives of King Menkure. Those of interest are the stepped pyramids, made of gigantic blocks. A place of curiosity is the north side of the third one located at the extreme west (the dot, left in Fig. 12a).

In 1991, I noticed there a cavity of particular interest. It

Figure 12a: Stage 12, west end of Menkure satellite pyramids (1991)

shows how the huge horizontal ashlars are lying flat over one each other, with a superb close fit highlighted by a 1 mm (0.04 inches) thin white line (Fig. 12b). In the carving and hoisting scenario, this thin white coat would have been entirely destroyed during the dragging, adjusting and pushing of the upper block against the one situated below. On the opposite, in the agglomerated stone system, this thin layer would have been spread over the finished packed material. Today's concrete blocks are often covered with a thin layer of impervious coating to prevent or restrain the evaporation of water. Geopolymeric hardening also requires water for the reaction to happen and evaporation may not occur during

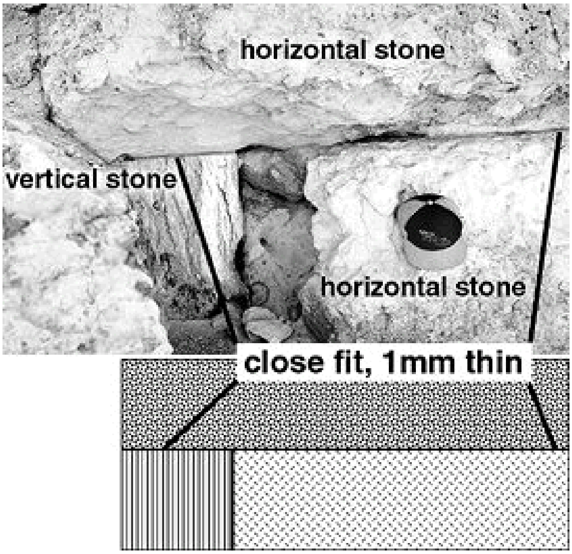


Figure 12b: Large blocks with 1mm (0.04 inches) thin white close fit and vertical bedding on narrow stone, left (1991).

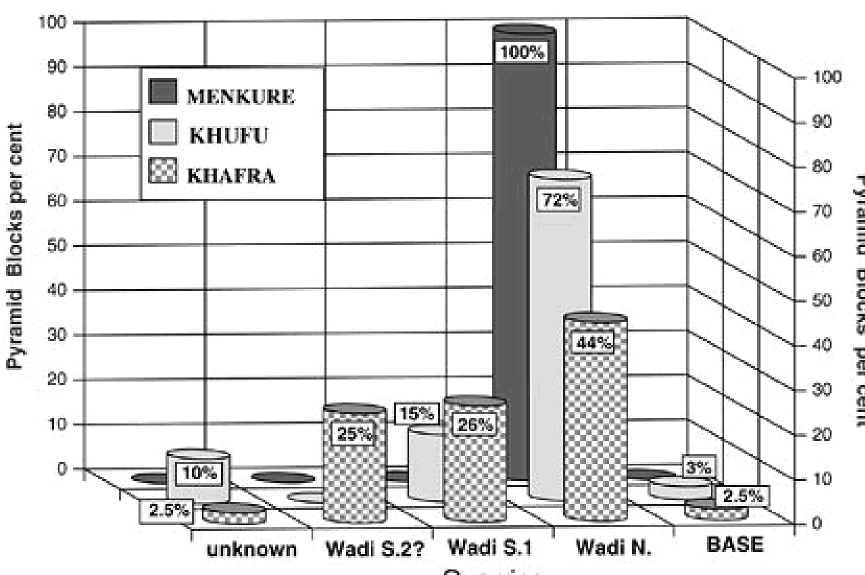
the preliminary phase of hardening. The following ashlar would have been cast later (after hardening) and packed above this white coat, providing close fit with its underlying neighbor, leaving the white layer visible in this cavity.

The same spot provides a more intriguing element. In Fig. 12b, the small and narrow block on the left bears nummulitic beds with a vertical orientation. If this stone was cast, the nummulitic bed orientation would be jumbled, perhaps horizontal, but of course not vertical. This is probably natural limestone hewn in the nearby quarry attributed to Menkure. It is not heavy, weighing only 0.5 to 1 ton maximum. In comparison, the majority of the step pyramids blocks are gigantic, in the 5 to 20 tons range.

This light block could easily have been moved in and laid with its narrow side on the horizontal level. It constituted the first solid element, on which the other parts of the mold (wood planks, crude bricks) were anchored. Neighboring stones were rammed against it, providing close fit and stability. Similar narrow blocks with vertical bedding are present in all pyramids and may easily be detected laying between two larger stones. Yet their number is very small with regard to the main population of the pyramid blocks. They were probably used as stable mold parts as well as a level reference.

THE QUARRIES: Stages 13 to 16, in the wadi.

The basic geological knowledge reported at the beginning of this circuit sets out that the stone material was extracted from quarries located at the edges of the wadi. In 1993, the German geochemist Klemm published analytical data on the origin of the core stones for the three pyramids, Khufu, Khafra and Menkure [124]. The chart summarizes the results of Klemm's study performed on 72 core block samples for Khufu , 77 for Khafra and 22 for Menkure. They are statistically representative of the material representing each



Origin of the core stones for Khufu, Khafra and Menkure pyramids. Adapted from Klemm [124] pyramid.

1 - Only up to 3% (0% for Menkure) of the analyzed blocks are attributed to the hard Mokattam Formation named here ***Base.*** It is reasonable to admit that these stones were added later to the site and were carved, during subsequent repair works carried out either by Ramses II or his successors.

2 - Up to 100 % (100% Menkure, 72% Khufu, 44% Khafra) are attributed to the quarries located at the north edge of the wadi, some in the vicinity of Khent Kawes, named here ***Wadi N.*** (Stages 13, 14, 15).

3 - Up to 26% (0% Menkure, 15% Khufu, 26% Khafra) are attributed to a quarry located at the south edge of the wadi at the place called Hitan el Gurab and named here ***Wadi S.1***.

4 - For Khafra, 25% are attributed to a quarry not recognized by Klemm; yet, from the analytical data, it could be located in the vicinity of the latter, at the south edge of the wadi, named here ***Wadi S.2.***

5 - up to 10% (0% Menkure, 10% Khufu, 2.5% Khafra) are attributed to an unknown quarry, which is not located in the vicinity of the pyramids (the Base).

Klemm's results confirm the basic geological statement, namely that the pyramid builders did not quarry the hard Mokattam limestone located in the direct vicinity of the pyramids, but preferred to excavate soft marly outcrops located at the edges of the wadi (down the hill).

Stage 13: Menkure east, Causeway and quarries

Menkure' Causeway leading from the Valley Building to the Mortuary Temple consists of an embankment of nummulitic limestone blocks upon which was built a crude brick corridor overlaid, both inside and outside, with white plaster and roofed with wooden logs. As for other ashlars, this site was covered with sand during centuries. The blocks

Figure 13: Stage 13, Menkure Causeway (1984).

show a weak differential weathering pattern (Fig. 13). The nummulite shells are jumbled and the blocks bear the same typical top layer. To the north of the causeway are quarry sites, probably for Khafra's pyramid, filled with debris and sand.

Stages 14 and 15: wadi north, quarries, Khent Kawes

A large basin quarry is located between stages 14 and

Figure 14a: Stage 14, west side of the quarry (1984)

15 (Fig. 14a, 14b). The basin is presently filled of stone rubble and debris. According to Lehner, [125] the quarry had a width (E-W) of 230 m, a length (N-S) of 400 m and was 30 m deep.

His volume calculation gives 2,760,000 m3 of stone to be compared with the estimated 2,590,000 m3 of stone for the Khufu pyramid. This depth of 30 m means that the ground of the quarry, when cleaned away from debris, would be at 15-20 meters above sea-level, that is below or at the same level as the Nile flood.

A queen of the Vth Dynasty (after Menkure), who may

Figure 14b: east side of the quarry, Khent-Kawes (1984).

have been married to Pharaoh Shepseskaf (whose tomb is the huge Mastabat Fara'un in Saqqarah), built on an open space lying between the quarries a tomb which was essentially similar to the Mastabat Fara'un. Its superstructure was in the form of a sarcophagus mounted on a high, square podium (Fig. 14b, 14c).

In Fig. 14c, the visible trench (line and dot), running W-E towards the bottom of the wadi and the Nile Valley, could be the remains of the water canals that brought the Nile water into the basin for the disaggregation of the limestone chipped down from the quarry edges.

At Stage 15, for a spectacular water soaking

Figure 14c: east side of the quarry basin, Khent-Kawes, W-E canal (line and dot (1988).

disintegration experimentation (within 5-10 hours), sampling can be made in the vicinity of the geological separation (line and dot in Fig. 15). The selected sample should contain nummulites (disk like shells) 1-3 cm in diameter (0,5 to 1 inch). Limestone with smaller nummulites needs more soaking time, preferably alternate soaking and drying cycles. An easy

Figure 15: Stage 15, middle of the east quarry side, sampling site (line and dot) (1991)

access to the sampling site is provided when descending the Khafra Causeway, between the Mortuary Temple and the Sphinx.

Stage 16: Maadi Formation, quarries, gypsum bed

This Stage is not mandatory. Those visitors interested in the mineralogy of this outcrop should take a look at the beautiful layers of gypsum crystals and clay that alternate with the limestone beds (Fig. 16a). When heated and calcined, gypsum (dot in Fig. 16b), clay and limestone materials, provide some of the reactive geopolymeric reactants, which are necessary to catalyze the hardening of the agglomerated limestone blocks.

Figure 16a: Stage 16, knoll of the Maadi formation with gypsum and clay beds (1984).

Figure 16b: gypsum bed (1984).

Stage 17: Khafra Valley Temple and Sphinx Temple granite blocks used as mold.

The Khafra Valley Temple remained buried under the desert sand until the 19th Century and was completely excavated only in 1910. It was not described by the French Napoleonic Expedition in 1799-1802. The walls of the Khafra Valley Temple and of the adjacent Sphinx Temple are formed of huge parallelepipeds of limestone with irregular surfaces

Figure 17a: Stage 17, Khafra Valley Temple South, concrete-like enormous blocks (line and dot) (1984)

(line and dot on Fig. 17a). Yet, as for the other temples on the Giza Plateau (see at Stages 9 and 11), the walls were originally faced with granite cladding, still intact on the inside of the Khafra Valley Temple (Fig. 17b).

What strikes the casual observer is the irregular shape of the granite blocks. Their outside surface is smooth and level whereas they show a rather irregular belly feature in

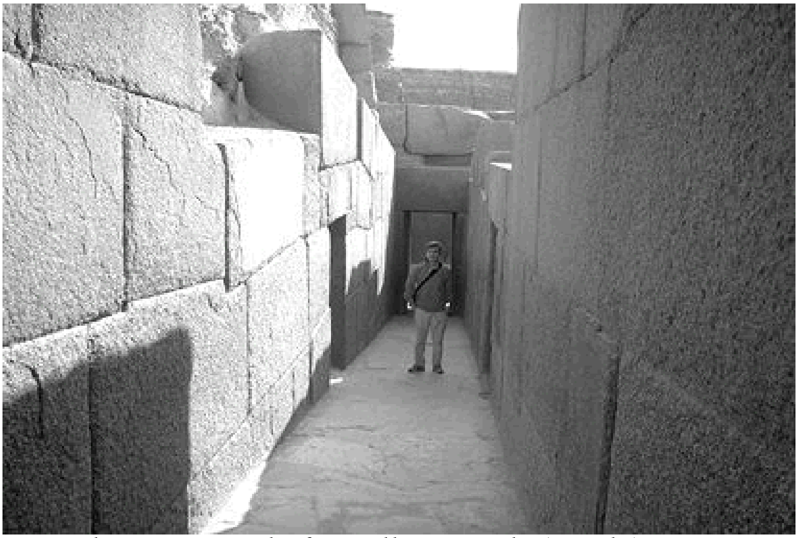


Figure 17b: Stage 17, Khafra Valley Temple (inside), casing made of small granite blocks with fine flat exterior surface and irregular belly shape in contact with the limestone core (1988).

Figure 17c: Stage 17, Khafra Valley Temple (south side), limestone surface represents the negative face of the granite claddings (1984).

contact with the limestone core. On the outside, with the exception of the East Temple Entrance, these granite ashlars were stripped away during Antiquity. The bare limestone with it impressive irregular surface remained unweathered because it was buried under the desert sand. It seems that the limestone surface represents the negative face of the granite claddings (Fig. 17c). To match such granite ashlars to the limestone blocks may have required some masonry work on their surfaces and edges. Some experts claim that the limestone core was worked and sculpted in order to provide close match with the irregular granite surface. Other experts state that, on the contrary, the carving and sculpting had to be performed on the granite ashlars themselves to make them match the huge irregular limestone blocks. On both temples (Khafra and Sphinx) these cladding works have also left marks, which may be seen running through adjacent blocks. Some geologists have taken these work marks for genuine sedimentary stratification layers [126].

There is a more practical explanation directly connected with the limestone agglomeration technology. The granite ashlars were the exterior molds for the huge limestone concrete blocks. What we see now is the imprint of the molds. We know several examples of concrete walls and structures built with a similar technique in modern and ancient times. The ancient Romans had a special word for this, namely *opus caementicium*. It implies the casting of concrete like mixes in shuttering made of natural stone or baked brick. Generally the outside face of the natural stone (limestone, marble, and sandstone) is worked out and smooth. The natural irregular stone is actually cut or split in two parts, providing two stone blocks, each one with a smooth plane face (the split). The backside of the stone remains rough and may have any dimension. A spectacular example of this technique is provided by the Roman Coliseum in Rome (Italy) with its travertine cladding and its brick-concrete core.

Stage 18: The Sphinx, water sensitive limestone

Excursionists who undertake this Circuit should take

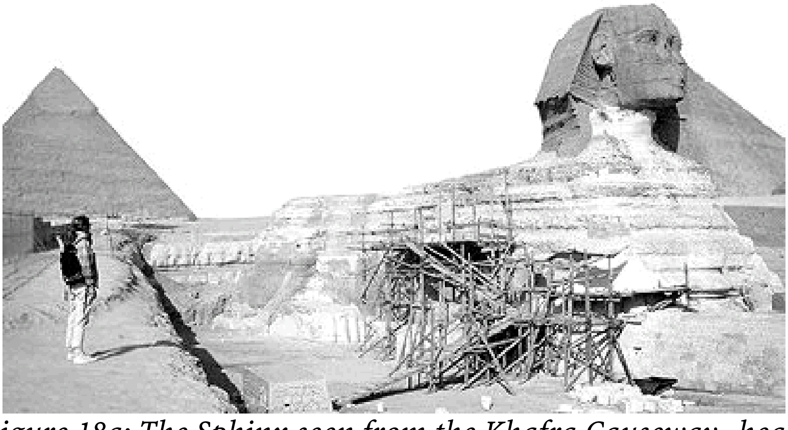


Figure 18a: The Sphinx seen from the Khafra Causeway, head made of hard grey Mokattam Formation, body resulting from quarrying the soft marly yellowish limestone (1988).

advantage of our knowledge. They will understand why the head of the Sphinx (cut in a local protuberance of the dark hard Mokattam Formation) brilliantly withstood 4,500 years of harsh weathering conditions.

On the other hand, the body of the Sphinx, which has been subject to intensive restoration work during the last decades (Fig. 18a) and during Antiquity, was for thousand years covered with sand and therefore protected against weathering. Yet, it underwent severe degradation. The Sphinx body is the remains of stone excavation in the softer marly layers. The differential weathering caused by water has sculpted 7 sequences of projected and recessed layers. It is assumed that the quarried stone material was used in the making of the Khafra Valley Temple as well as for the Sphinx Temple. The limestone of the Sphinx body is widespread in the pharaonic quarries at Stages 14, 15, 16. The inclined soft-marly limestone bed is sandwiched between two hard-grey limestone layers. For certain experts, the strikingly obvious degradation would have resulted from "erosion due to rain and flooding", i.e. disaggregation through water soaking. In order to explain what causes the degradation of the rock, L. Gauri made a thorough petrographic and chemical analysis of the six layers featured in Fig. 18b. He measured the content of the water soluble salts and of the non-carbonate clastic materials (clays, silt and sand) - elements which are sensitive to water. They either become soluble (the salts) or expand when wet (the clay and the silt). I called them water-sensitive parts in Fig. 18a. The amount of water-sensitive parts, expressed as weight percent of stone, is strikingly very high [127]. A similar analysis of the equivalent layers constituting the quarry sites of Stages 14-16, has not been carried out so far. However, it is reasonable to assume that these limestones do contain the same range of water-sensitive parts.

Today, civil engineers often use the ASTM D4843 Code

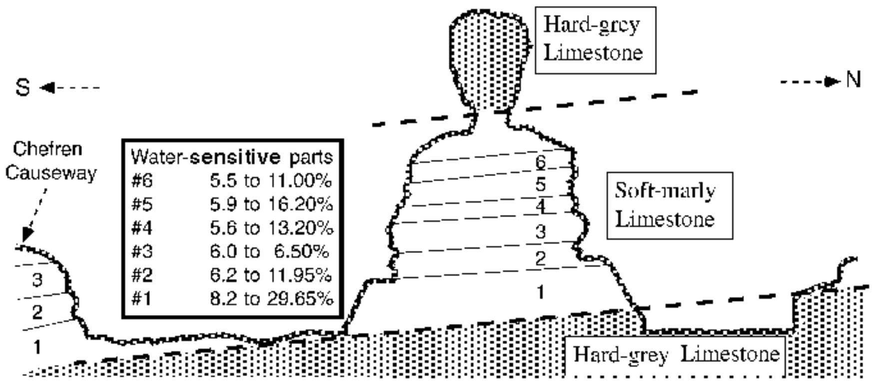


Figure 18b: North-South vertical profile of the front of the Sphinx. Layers #1 to #6 analysed by L. Gauri [127] and amount of water-sensitive parts (salt + clastic material) for each layer.

to evaluate the water disaggregating long-term behavior of building materials. A procedure adapted from ASTM D4843 requires that the stone be soaked for 24 hours in water, then dried out at 60°C (140°F) for 23 hours, followed by a 1 hour rest at room temperature. If, after this first cycle, the stone or the concrete remains intact, it is subjected to a second and more cycles, until it disintegrates. The 60°C (140°F) drying temperature is relevant for temperatures reached during summer time in the quarries at Giza (in the sun).

Modern Geopolymeric concretes do not disintegrate even after more than 300 cycles. As for the soft natural marly limestone of the Sphinx body, I expect that only 1 to 3 cycles would be necessary.

The ancient Egyptians could have installed soaking/reaction ponds at the bottom of the quarries. These ponds would have been flooded then followed by a drying period and flooded again, in order to achieve the appropriate disaggregation. Chunks that do not disintegrate easily (dependent on the water-sensitive parts amount) would be packed into the muddy limestone matrix.

Stage 19: return to Khufu Pyramid, east; geologists demonstration favors natural stone blocks

In the previous stages, the excursionists will have visited and observed the two different limestone outcrops of the Mokattam Formation : a hard grey superior bed on which the pyramids are founded, and a soft yellowish (with clay beds) where the pyramids core materials were extracted.

Notwithstanding this basic and visible geological knowledge on the two different outcrops within very close range of the monuments, two American geologist teams, Folk and Campbell on the one hand, Harrell and Penrod on the other hand, violently challenged the casting and packing theory. They never mentioned noticing any difference between the pyramid blocks and the hard Mokattam Formation that constitutes the surrounding plateau.

Immediately upon arriving at the site in January 1990,

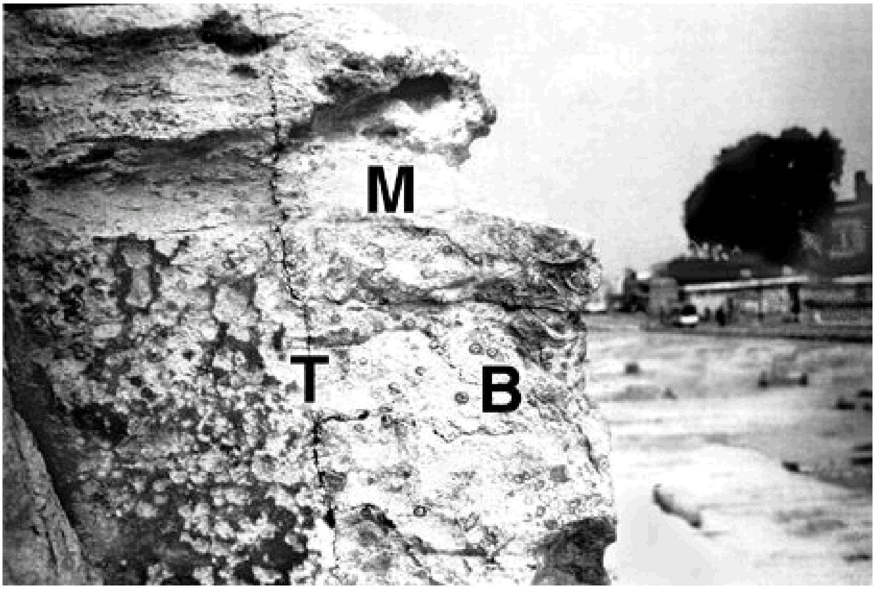


Figure 19a: Block discussed by Folk and Campbell in Ref. 92,101, with vertical tectonic fracture T, burrow B and marly bed M. Notice the tree and the building on the right (1991) and compare with the sketch.

Folk and Campbell observed features that they interpreted to indicate that the blocks are natural. In an article published in *Journal of Geological Education* , they state:

> " Within the first minute at Khufu pyramid, we knew that the pyramids were built of real limestone blocks, not of concrete [agglomerated stone]… ". [128]

For a reason which is not explained in their papers, Folk and Campbell went directly to the North East corner of the Khufu pyramid, and found there natural limestone, an outcrop of the Mokattam Formation.

A major part of their preliminary geological study was carried out precisely on this location (see in Fig. 19a and the sketch in Fig. 19b). They deliberately ignored the elementary fact that the pyramid was built on a leveled plateau, which left some natural bedrock as part of the monument.

In 1983, Lehner had mentioned that this natural bedrock

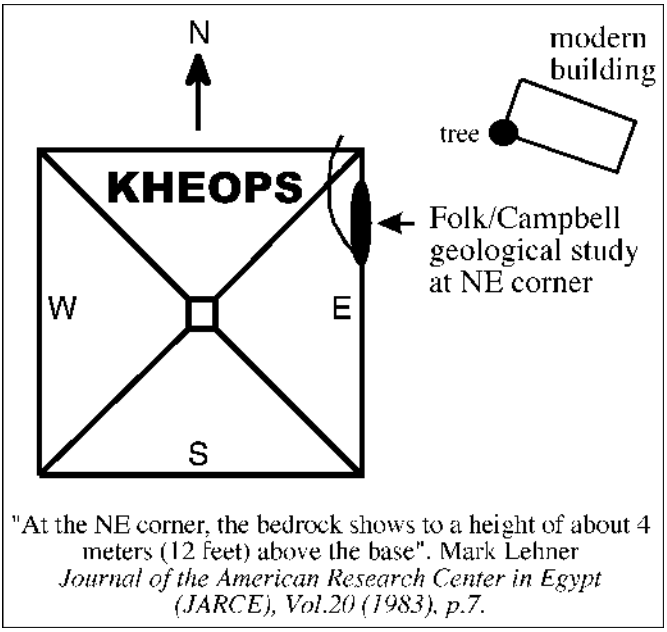


Figure 19b: Sketch published in Ref. 133 by J. Davidovits in relation with Folk/Campbell geological study

shows to a height of 4 meters above the base, at the North-East corner [129]. Nevertheless, Folk and Campbell based all their demonstration against the agglomerated limestone theory, on superficial investigation. They identified real stones where previous studies showed them to be located, thus proving on one hand their expertise in geology and on the other hand their scientific misconduct. They used this N.E. corner natural stone to demonstrate that

> " … they are tectonic fractures in many pyramid blocks, filled with calcite [the vertical tectonic fracture T in the photo]… These fractures generally are only about 1 mm wide, and run in a more or less straight path all across a single block. (…) These are obvious tectonic fractures formed when the block was flexed millions of years ago, and demonstrate that the pyramid core stones were quarried blocks, not poured geopolymer… ".

They also used these natural blocks to demonstrate that specific weaker parts of pyramid blocks were caused by the presence of burrows (label B in the picture), stating that there are " … numerous burrows and tubes formed by animals when the sediment had a muddy consistency on the Eocene sea floor. Similar burrows are readily seen in nearby outcropping limestones. Burrowing and churning of the soft sediment by sea-floor organisms produces inhomogeneities in sediment composition, texture, and porosity, which control to a great extent the processes of hardening into rock as the pore spaces are filled with a secondary geological cement, in this case calcite. When the rock is weathered, the inhomogeneities are strikingly brought out as generally irregular, elongated, discolored features on the rock surface. Consequently, the inhomogeneities in the rock result in its differential weathering… "

Other natural limestone blocks located on the lower two coarse on the East face of Khufu's pyramid, were given as proof for the explanation of density changes and lift lines presence in pyramid blocks. Taking the marly layer labeled M as example, they stated that all layers were

> " … without doubt in the writers' minds, merely geological stratification produced in the ancient Eocene seas. The stratification in the pyramids blocks is caused by changes in particle size, porosity, percentage of geological cement, mineralogy, and thickness of individual laminations and layers… " [130]

From 1990 onwards and with arrogance, Folk and Campbell presented several papers at geological congresses and stated:

> " … we feel it is the duty of professional geologist to expose this egregiously absurd archeological theory before it becomes part of entrenched pseudoscience… " [131].

In response to another of their papers also published in 1991 but in a different technical journal, *Concrete International* [132], I published in 1992 in the same journal, the sketch focusing on the N-E corner of Khufu pyramid (Fig. 19b) and the obvious occurrence of natural stones [133]. Yet, and despite this important rebuttal from my side, Folk and Campbell never publicly admitted their error.

The second American geologist team, Harrell and Penrod, who published on ancient Egyptian limestone quarries, also ignored the presence of the two different outcrops. They relied only on the generic denomination of the Giza Pyramids bedrock, namely the name Mokattam Formation. Mokattam is the name of a Cairo suburb in the vicinity of the Citadel, made of hard limestone. The quarry at Gebel Mokattam supplies squared stones for the Cairo monuments. In a paper also published in *Journal of Geological Education* in 1993, they state:

> " … Our objection to the geopolymeric process

> [agglomerated stone process] has to do with disaggregating limestone by soaking it in water - it does not work! We soaked the Mokattam limestones whose composition is given in Table 1 for seven weeks and after this time the samples were just as hard and solid as the day we first immersed them… " [134].

For their demonstration, Harrell and Penrod deliberately took hard Mokattam limestone instead of the soft material. In addition, the soaked sample did not come from the Giza Pyramids site at all. These ancient Egyptian quarries specialists ironically collected this piece of hard limestone from the modern quarry behind the Citadel on Gebel Mokattam, Cairo, 20 km (15 miles) east of the Giza Pyramids, on the other side of the Nile. Other individuals who published statements against the cast and packing theory, made the same mistake as Harrell and Penrod. For example, Moores soaked in water for a long period of time a chunk of limestone, which he had removed from the hard Mokattam Formation, near the Khufu Pyramid base [135].

An Introduction to the Study of the Pyramids Mysteries of the Ancient World

Popular books about the mysteries of the pyramids and other ancient feats of engineering demonstrate the ongoing quest for a solution. Few Egyptologists take part in this quest. They are willing to accept standard, inadequate explanations of the enigmatic artifacts and are mostly satisfied with logistic studies on the pyramids.

The standard carving and hoisting theory is speculative, with no scientific merit, from every perspective, engineering logistics, geochemistry and geology, Egyptology and other history, feasibility and common sense. Every so often we read about another clever lifting device being proposed as a solution to the riddle of pyramid construction. Interesting in and of themselves, such devices and methods are inapplicable if they do not answer the questions raised here. Geologists Folk and Campbell claim the use of enormous metal (copper?) saws to hew the enormous close fitting blocks of the temples [92,103]. Such tools have not been found by archaeology and therefore, demonstrations of simple, effective methods of pounding with dolerite stone balls or otherwise tooling stone also arise.

From an engineering perspective, when applying the agglomerated stone method, we understand how gigantic blocks were placed at great heights to build the Great Pyramids using the technology of the Pyramid Age. We understand how the tiers of the Great Pyramids were made level and their faces absolutely flat, each meeting to form perfect summits. We understand how 200 ton blocks were placed in temples. We understand how casing blocks were applied with great precision in the Great Pyramids without even slightly chipping the corners.

We can dismiss from our minds the scenario of numerous thousands of workers crowded onto the work site at Giza shoulder to shoulder, with many struggling to raise enormous blocks to great heights, as shown in Stage 2.

Stage 3 raises the issue of structural stability connected with a pre-established architectural master plan . The quarry remains, with their 5-7 different block sizes, poses more problems. Anyone attempting to transfer this technique to the erection of the pyramids, and explain the preparation and use of 2,000,000 blocks based on the carving and hoisting hypothesis, would be unable to do so. Blocks could never have been cut, stored, and selected on the scale required. With the agglomerated stone scenario, any dimension required could be determined quickly by the architect because it would be relative to the length of the block in the tier directly below. It is simple to determine the length and height needed and change accordingly the dimensions of molds.

Stages 7 and 8 emphasize the issue of repair and restoration works carried out on the east sides of the pyramids, to connect the pyramid with the adjacent Mortuary Temple. These works left marks still visible today. This could explain the presence of carved blocks.

Stages 11 and 17 highlight other types of toolmarks, those engraved on several temples blocks. The masons used their tools, stone picks or copper chisels, to roughen the surface for a safe cohesion of the decorative facing, granite ashlar or granite imitation coating.

In Stage 12 we have discussed the presence of small and narrow natural hewn blocks, with verticular bedding, and their use as a solid anchor for molds and level reference.
In Stages 14 to 16, the quarries, we did not see any remains of the inclined solid ramps that must have connected the bottom of the quarry with the top of the plateau, for the transport of the hewn blocks on sledges. Traditionally, during Antiquity, quarry men hewed their blocks in outcrops located on a height, to take advantage of the incline descending natural ramp. This is not the case at Giza. Why?

In the agglomerated-stone scenario, the limestone extracted in the quarries (Stages 14 to 16 and Stage 18) should be easily disaggregated in water. The numerous studies dedicated to the severe degradation of the Sphinx body focused on water erosion, and on the exceptional high content in water-sensitive elements. These studies demonstrate the ease with which parts of this outcrop disintegrates in the contact of water. The high amount of clay and silt is of the highly reactive kaolinitic type [100], recommended by my scientific and technological experiments. The disaggregated muddy (kaolinitic) limestone paste would bind together the remaining limestone chunks that would not disintegrate. Water is a requisite. This implies that water was abundant and had an easy access to the bottom of the quarries, during the annual flood of the Nile (see in the general Circuit Map for details).

My expertise in material sciences has driven my research to discover the uniqueness of the geological formation at Giza. In contrast, those world limestone expert geologists, who should have known about this exceptional property of the Pyramids environment, had only one preoccupation in mind, namely to hide it. Notes [116] to [135] provide additional information on this issue.

Notes – References

Chapter 1

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2. L. T. Dolphin et al., Electromagnetic Sounder Experiments at the Pyramids of Giza, Report prepared for the Office of International Programs, National Science Foundation, Washington D.C., NSF Grant No. GF-38767, by SRI International Memlo Park, CA, USA, and Ain Shams University, Cairo, Egypt,. The report states on page 70:

> " *... the stones were highly sensitive to local relative humidity, but also that the rocks were sufficiently porous so that small samples equilibrated with the environment in a few days time. Evidently the rock samples lying around the surface at Giza, selected for our Giza laboratory tests, were slightly drier than either the bedrock or the large building blocks in which the in situ measurements were made, and this accounted for the lower losses in the samples even when measurements were made under Giza ambient environmental conditions. The relative humidity at Giza is moderately high because of a prevalent, almost year-round onshore flow of marine air from the Mediterranean; therefore, the interior of the pyramids must be still more humid to account for the discrepancy between the sample and in situ data. One of the team members, Robert Bollen, after noting the constant 83 percent humidity in Belzoni's chamber (temperature, 85˚F) decided to measure the humidity level in Mycerinus's pyramid where no tourists are presently permitted. He found the humidity in the Third Pyramid to be also 83 percent. Before the*

Mycerinus pyramid humidity measurement, the team had assumed the 83 percent humidity level in Belzoni's chamber was a result of the daily influx of tourists. However, apparently the interior of the pyramids and the bedrock are naturally very damp — 83 percent relative humidity represents probably equilibrium between the rock and the noncirculating air of interior chambers. "

At the time of the opening of the Great Pyramid by Caliph Al Mamun in AD 820 after it had been sealed for many centuries, the interior chambers were found mysteriously encrusted with salt as much as one-half inch thick *consistent with rock that is by nature damp and porous.*

*) Note:

It is conceivable that a major weather change in Egypt could result in sufficient drying of the pyramids over the course of a few decades (or centuries) so as to decrease the RF losses sufficiently to permit successful probing of the interiors by this radio-wave technique. Artificially drying the pyramids would be novel but is clearly not practical. The pyramid of Chephren (Khafra) weighing as it does about 100 billion pounds contains about 100 million gallons of water. A simple calculation shows that this represents 8.8 percent by weight of water, or 18.3 percent by volume of water with the density of water = 1, density of pyramid stone = 2.08 (see in note 82 below).

3. Plinius, Natural History, Book XXXI, Sect. 70, To remedy unfit water.

4. G. Hyvert, The statues of Rapa Nui, UNESCO Report nr 2868/RMO/CLP, Paris 1973.

5. G. E. Brown in L. T. Dolphin report, see note 2 above. Page 72 states:

" *Further details concerning the mineralogy of two samples of Giza limestone are given in Appendix C. In this appendix typical Chephren (Khafra) building block limestone of good local-Giza* *quality is designated as 'G2', and a sample of very porous, stained limestone from a faulted area in the bedrock of the ruck-cut tombs near the northeast corner of Chephren's pyramid is designated as 'G1' "*. Appendix C, page 121, states: *" … G1 is an essentially pure calcite microcrystalline allochemical limestone, casts of gastropods and fragmented brachiopods … up to several mm in diameter… G2 was found to be a non-fossiliferous microcrystalline limestone containing roughly 3% or less of dolomite, quartz, and clay minerals… "*. On page 122, concerning G2 and the difficulty in assigning the X-Ray d-spacings reflections to accurate minerals, one reads: *" …It should be emphasized that the assignments in Table 1 are tentative due to the weakness and number of extra reflections that are present. However, the presence of clay fraction [that is of alumino-siliceous minerals] in G2 is unequivocal.* "

6. D. D. Klemm, R. Klemm, B. Wagner and D. Wildung , 2nd International Congress of Egyptologists, Grenoble, France, Session 14, 1979.

7. Jollois and Devilliers, Description de l'Egypte, Edition Panckoucke, Paris 1822-1828, Vol. II, Chapt. IX, Section II, page 153.

8. M. E. Lehner, J.P. Allen and K. L Gauri, ARCE Sphinx Project, a preliminary report, Newsletter of the American Research Center in Egypt, nr 112, Fall 1980, pp. 3-34.

9. H. Haas, J. Devine, R. Wenke, M. Lehner, W. Wolfli and G. Bonani, Radiocarbon Chronology and the Historical Calendar in Egypt, Chronologies in the Near East, Aurenche O., Evin J. and Hours P. eds., British Archaeological Report, International Series nr. 379, Part II, pp. 585-606, 1987. For example, on page 592, one reads:

" *… Table 4 illustrates the range and average of dates for the Khufu Pyramid. An attempt has been made to determine the spread of age dates from samples from the lower levels of the monuments, as compared to samples from the apex. The spread is nearly 100 years, but the trend is reversed, the youngest dates are from the bottom samples…* " In Table 4, individual value

for the top platform dates 3101 BC and for the lowest 2nd course (bottom of the pyramid) 2853 BC , or a spread of 350 years, whereas mean values reduce the range to 100 years. The bottom of Khufu's Pyramid was finished between 100 to 350 years after the completion of the top platform. This is opposite to what should be expected with traditional construction theories.

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13. J. P. Adam, l'Archéologie devant l'imposture, Ed. Robert Laffont, Paris, 1975, page 135.
14. See in note 6.
15. R. Klemm and D. Klemm, The Munich Pyramid Project: Origin, Determination of the Stone Material of the Royal Monuments of the Old Kingdom Between Abu Roash and Meidum, 5th International Congress of Egyptology, Cairo 1988, Abstracts, pp. 158-159.
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19. M. Jomard, Description de l'Egypte, Vol. VII, pp. 67-73.;
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22. Nestor l'Hote, cited by G. Perrot and C. Chipiez in Histoire de l'Art dans l'Antiquité, Paris 1882, Vol. I, page 676.

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27. D. D. Klemm and R. Klemm, The archaeological map of Gebel el Silsila, 2nd International Congress of Egyptologists, Grenoble 1979, Session 05.

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www.geopolymer.org . The Library provides several downloadable papers (in pdf. Acrobat Reader format).

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- The Sunday Star Toronto, Sept. 5, 1982: World's top Egyptologists meeting in Toronto " … Pyramids How were they built? French scholar J.P. Lauer answers the question on the basis of 50 years of Study. French chemist Joseph Davidovits presents his theory … — it took fewer than 1,500 workers with man-made limestone… "
- The Toronto Star, Sept. 7, 1982: Two choices on how Pyramids went up " … Now Two Frenchmen believe they each have the answer, they are poles apart (J. Davidovits and J.P. Lauer)… "
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- Both papers as electronic file, Making Cements with Plant Extracts, Internet WEB page, Geopolymer Institute, Library, see note 32.

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Chapter 10

47. Manetho, édit. W. G. Waddel, Loeb Classical Library, Harvard University Press, Cambridge, Massachusetts, 1997

48. Manetho, Aegyptiaca, Fr. 11, Syncellus, p. 104., AFRIKANOU : ΑΦΡΙΚΑΝΟΥ (Τρίτη δυναστεία) β´ Τόσορθος, ἔτη κθ´, <ἐφ ´οὗ Ιμούθης>. οὗτος Ασκληπιὸς <παρὰ τοῖς> Αἰγυπτίοις κατὰ τὴν ἰατρικὴν νενόμισται, καὶ τὴν διὰ ξεστῶν λίθων οἰκοδομίαν εὕρατο· ἀλλὰ καὶ γραφῆς ἐπεμελήθη.

Dynasty III. Fr. 11 (from Syncellus). The account of Africanus. (the third dynasty) 2. Tosorthros, for 29 years. In his reign lived Imuthès who because of his medical skill has the reputation of Asclepios among Egyptians, and who was the inventor of the art of building with *xeston lithon*. He also devoted attention to writing.

- Fr. 12 (a). Syncellus, p.106. KATA EUSEBION. ΚΑΤΑ ΕΥΣΕΒΙΟΝ. · (Τρίτη δυναστεία) β´ Μεθ' ὃν Σέσορθος ..., ὃς Ασκληπιὸς παρὰ Αἰγυπτίοις ἐκλήθη διὰ τὴν ἰατρικήν. οὗτος καὶ τὴν διὰ ξεστῶν λίθων οἰκοδομὴν εὕρατο · ἀλλὰ καὶ γραφῆς ἐπεμελήθη.

Fr. 12 (a). .... He was also the inventor of the art of building with *xeston lithon*....

- (b) Eusebius, Chronica I. (Armenian version), p. 96 : (tertia dynastia). Deinde Sosorthus..., qui ob medicinam artem Aesculapius ab Aegyptiis vocitatus est. Is etiam sectis lapidibus aedificiorum struendum auctor fuit : libris praeterea scribendis curam impendit.

- (b) (the third dynasty) Next came Sosorthus... : he was styled Aesculapius by the Egypstians because of this medical skill. He was also the inventor of building with hewn stone; and in addition he devoted care to the writng of books.

In Ancient Greek: *xeston lithon* means " polished " stone, but also has the notion of: scrapes (to rasp stone), small pieces, shreds. The author of the latin translation wanted to express the notion of small pieces of stone with the Latin expression *lapis sectilis*, which does not mean hewn stone, but rather designates a very thin sheet of stone (*opus sectile*) such as slate. If Eusebius' intention had been to translate *xeston lithon* into carved stone, he would have written *saxum quadratum* or *lapis quadratus*. It is therefore logical to claim that *xeston lithon* meant the stone made with scrapes (small aggregates), i.e. agglomerated stone.

49. There are two natural limestone stratas that alternate on the Saqqarah plateau. One is a Sand-Limestone (in German *Kalksandstein*) comprising up to 30 percent sand and 60 per cent limestone and 10 percent clay. The second is a clay-limestone (in German *kalkige Mergel*) comprising 20 to 60 percent clay and 40 to 80 per cent limestone. It is assumed that the major clayish ingredient is of the reactive kaolinitic type. Analytical data on these limestones are scarce. These limestones are very sensitive to climatic erosion and should be very easily disaggregated with water, yielding the muddy limestone paste suitable for the fabrication of limestone bricks (some information is provided by D. D. Klemm on page 72-73 of his book (see in note 93 below). The cross section of a limestone material taken from Zoser's pyramid (Farbtafel 2.5) is very similar to what would be expected from a rammed muddy limestone material.

Chapter 11

50. J. Davidovits, Pyramid Man-Made Stone, Myths of Facts, III). The Famine Stele Provides the Hieroglyphic Names of Chemicals and Minerals involved in the Construction, 5th International Congress of Egyptology, Cairo 1988, Abstracts, pp. 57-58. Paper as downloadable electronic file, Internet WEB page, Geopolymer Institute, Library, see note 32.

51. Famine Stele list of authors:

- H. Barguet. La Stele de la Famine à Sehel, Institut Français d'Archéologie Orientale, Bibl. d'Etude, 24, Cairo. 1953.

- H. Brugsch, Die biblischen sieben Jahre der Hungersnoth, Leipzig 1891.
- M. Lichtheim, Ancient Egyptian Literature, A Book of Readings, Vol.III, University of California Press, Berkeley 1973.
- J. de Morgan, In Catalogue des Monuments et Inscriptions de l'Egypte Antique, 1 série, Tome 1, Ed. Adolphe Holzhausen, Vienne, Austria; pp. 78-83, 1894.
- W. Pleyte, Schenkingsoorkonde van Sehele; Letterkunde, 3 Reeks, Deel VIII; Royal Academy of Sciences, Amsterdam, Netherlands, 1891.
- K. Sethe, Dodekaschoinos; Ed: J.C. Hinrisch, Leipzig; pp.19-26, 1901.
- S. Aufere, Remarques sur les termes servant à désigner l'émeraude, le béryl, l'olivine, Revue d'Egyptologie, Paris 1984, 35, pp. 23-30.

52. J. R. Harris, Lexicographical Studies in Ancient Egyptian Minerals, Akademie-Verlag, Berlin, *aat* and *rwdt*, p. 21-24 (1961) On page 21-22;, for *aat*:

> *"… Now it is evident that aat does in fact cover a very wide range of materials, largely minerals, but also including other substances, and it is difficult to see what it was that led the Egyptians to class them together…. That the common quality of all aat is hardness as Varille suggests is most unlikely, since although the semi-precious stones and the few monumental stones classed as aat were undoubtedly hard, many of the other minerals mentioned among aat are friable and even powdery. … Alternatively, the conception of aat may be based on the form in which the material was obtained, or the use to which it was destined to be put. Thus, aat were brought from the mountains, and probably therefore mined, and were generally in small lumps as opposed to the larger blocks of building stones inr. In addition, nearly all the examples of the use of aat are for sculpture, vessels, inlay, and other quasi-artistic purposes, and this may perhaps be significant… "*

53. Bekhen stone, Couyat-Montet, Les Inscriptions du Ouadi-Hammamat; cited in J. Jéquier, Manuel d'Archéologie Egyptienne; Editions August Picard, Paris, 1924; note page 21.

54. A. Gardiner, Egyptian Grammar, Griffith Institute, Ashmolean Museum, Oxford, U.K., 3rd Edition, 1994, p. 528 (Sign list W 9).

55. cited in J. F. Champollion, Principes Généraux de l'Ecriture Sacrée Egyptienne, Paris, 1822-1836. See Also the new edition by Institut d'Orient, Paris 1984, page 348.

Chapter 11b

56. G. Maspero, TSBA 5, pp. 559-560, (1877)

57. Fl. Petrie, A History of Egypt I, London (1895). On page 140 lines 8-9 are translated:

> " *… I know what belongs to it, the sinking waters, the weightings done for the reckoning of accounts, how to produce the form of issuing forth and coming in, so that a member go to its place…* "

58. E. Naville, The XIth dynasty temple at Deir el-Bahari I, London 1907. . On page 40 lines 8-9 are translated:

> " *… I knew … how to represent the forms of going forth and returning, so that each limb may be in its proper place…* "

59. H. Madsen, Sphinx 12 (1909). On page 248 lines 8-9 are translated:

> " *Je savais les règles de la peinture (?) et les poids des justes calculs … jusqu'à ce que le membre est à sa place…* "

60. H. Sottas, RT 36, (1914). . On page 157 lines 8-9 are translated:

> " *…Je connais les formules de l'irrigation, les comptes de fournitures des exemples de calcul, les prélèvements et livraisons en entrées et sorties, de telle manière que la chair vient à sa place…* "

61. M. A. Murray, Ancient Egypt (1925). On page 33 lines 8-9 are translated:

> " *I know the things which belong to the sinking of waters, the weighing of exact calculation, the cutting of that which enters*

and the coming out, it enters in order that a limb may come to its place… "

62. M. Baud, Le métier d'Iritisen, Chronique d'Egypte, Bruxelles, Tome XXV, pp. 21-34, (1938).

63. W. St. Smith, A history of Egyptian Sculpture and Painting in the Old Kingdom, p. 356, (1946).

64. J. A. Wilson, The Artist of the Egyptian Old Kingdom. Journal of Near Eastern Studies, VI, Chicago, P. 245, (1947).

65. H. E. Winlock, The rise and fall of the Middle Kingdom in Thebes, New York, 1947. On page 47 lines 8-9 are translated:

" … I knew … how to produce the forms of going forth and returning… "

66. W. Wolf, Dies Kunst Ägypten, Stuttgart, p. 395 (1957).

67. A. Badawy, The Stela of Irtysen, Chronique d'Egypte, Bruxelles, Tome XXXVI, pp. 269-276, (1961).

68. W. Schenkel, Memphis-Herakleopolis-Theben, ÄgAb 12, Wisbaden Germany, 1965. On page 247 lines 8-9 are translated:

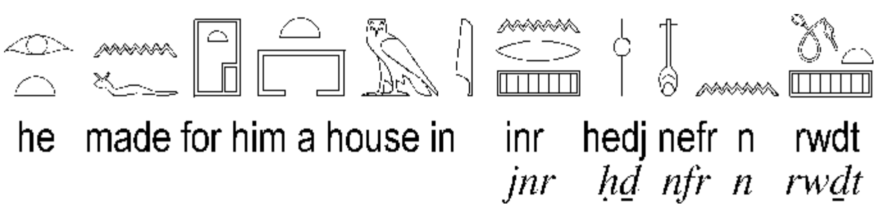
" … Ich kenne die Regeln des Reliefs: die Erhebungen die richtig sind; das Herausheben und Eindringenlassen, indem es (das Relief) heraus — und hereingeht, so dass ein Körper an seinen (richtigen) Platz kommt… "

69. W. Barta, Das Selbstzeugnis eines altägyptischen Künstlers (Stele Louvre C 14), Münchner Ägyptologische Studien, Verlag Bruno Hessling, Berlin, (1970).

70. Hieroglyphic word for " sculptor ". In lines 5-6, the word for sculptor is *gnwty*, which literally means the maker of the annals. There is no mention of carving or sculpting with chisel. Another important word is the adjective *nfr n.* The Old Kingdom word for limestone is *inr (hdj*) whereas, during the New Kingdom, limestone is very often written *inr (hdj) nfr n X* and generally translated by Egyptologists, 'the beautiful white limestone from X'. Same for sandstone *inr rwdt* and *inr nfr n rwdt*, or granite *inr maat* and *inr nfr n maat*. The adjective *nfr n*, is only found in texts dating to the New Kingdom when stone was carved, not in earlier texts from Old and Middle Kingdom. The adjective *nfr* means ‘beautiful’, ‘happy’, ‘good’. Yet according to A. Gardiner, *ibid*, § 351, page 266, when added with the preposition *n, nfr n* has the signification of “ 'finished' 'brought to an end ” and has a meaning of a negative word; “ … *nfr n* always denies an occurrence… ”.

71. For another linguist, A. Loprieno, Ancient Egyptian, a Linguistic Introduction, Cambridge University Press, 1995, pages 90 and 129.

> *“ … (page 90).. Especially in the Old Kingdom, the substantivized particle of other verbs, the most important of which is nfr “ to be complete ”, is used in grammaticalized negative patterns: nfr n X “ it is complete to X ” > “ it does not happen, that X ”… (page 129) … .A last observation pertains to a semantically interesting peculiarity of the verb nfr, whose basic meaning is “ to be complete ” and which is mostly in the positive sense of “ to be good ”, but which is also integrated into the negative system of Egyptian because of the opposite connotation “ to be finished ” it can acquire in specific contexts… ”*



Text from Seti I Mortuary Temple at Qurna, New Kingdom.

In the Figure, instead of translating *inr hdj nfr n rwdt* into “ beautiful white sandstone ” it would be more correct to write “ white finished (compact) sandstone ”, i.e. a good solid sandstone block ready for carving. On the other hand, *inr* alone would designate stone in general, which is not finished, that is even loose, broken, or pebbles, from which a stone slurry could be made for casting a statue, to make a finished stone. Using the negative system, *inr (hdj) nfr n* could also be translated into “ stone that is not broken (loose) ”, meaning a compact stone.

72. Many years ago, Daressy came to a similar conclusion, translating *inr hdj* as ‘calcaire’ (limestone) and *inr hdj nfr n* as ‘calcaire compact’ (compact limestone in opposition to loose limestone). This was rejected by Egyptologists and J. R. Harris, *ibid*, limestone *inr hd nfr n*, .p. 71, note 6.: “ Daressy, Rec. Trav. 10, p.143, translates inr hd as ‘calcaire’, and inr hd nfr as ‘calcaire compact’, though without justification. ”

Chapter 12

73. Herodotus, Historiae, Book II, sect. 124. The discussion of Herodotus text is based on the Greek text as well as on the French translation published by Société d’Edition “ Les Belles Lettres ”, 1930 (1972).

74. Diodorus Sicilus, Historical Library, Book I, chapt. 63, sect. 8.

Chapter 13

75. De Rozière, Description d l’Egypte, Vol. 26, pp. 227-249

Chapter 14

76. see note 34

77. K. Mendelson, L’Énigme des Pyramides, Taillendier, Paris, page 102-103.

78. R. Stadelman and H. Sourouzian, Die Pyramiden des Snofru in Dahschur, Mit. des Deutschen Archäologischen Intituts, Abteilung Kairo, Vol. 38, pp. 379-393, 1982.

79. Edwards, ibid, Pyramid plugs, pages 127-128.

80. M. Jomard, ibid., see note 42; Cecile, Description de l’Egypte, Tome V, XIII, 2.

81. G. Dormion and J-P. Goidin, les Nouveaux Mystères de la Grande Pyramide, Albin Michel Ed., Paris, 1987, pp. 104-112.

82. L. T. Dolphin, ibid , see note 2. In the report, the Note on page 66 states:

“ One particular sample of ‘typical’ Chephren (Khafra) building-blocks limestone was heated and vacuum-dried for several days, then vacuum-impregnated with water. The initial dry weight of the sample (400mg) increased by 7.6 percent (to 433gm) after water impregnation. Let to stand in the laboratory for several days at 55 percent relative humidity, the sample dried out to 404 gm. Measured density of the sample was 2.08, which is relatively low for limestone… ”.

Chapter 15

83. A. Lucas, Journal Egypt. Archaeol. 10, pp.128-132, (1924) (cited in note 84 below).
84. D.D. Klemm and R. Klemm, Mortar Evolution in the Old Kingdom of Egypt, Archaeometry '90, Birkhäuser Verlag, Basel, Switzerland, pp. 445-454 (1990).
85. I.E.S. Edwards, *ibid*, Pyramids of the Vth and VIth Dynasties, p. 189.

Chapter 16

86. Arman, in L.A.E., page 84, cited by J.A. Wilson, Vie et Mort d’une civilisation, page 83.

Chapter 17

87. Erman in L.A.E., page 84, and also in J.A. Wilson, “ L’Egypte, Vie et Mort d’une Civilisation ”, Arthaud Ed. Paris, p. 135
88. G. Maspero, Histoire Ancienne des peuples de l’Orient classique, Volume II, Librarie Hachette, Paris 1897, p. 312
89. G. Maspero, *ibid*, page 92.
90. M. Dolinska, Red and Blue Figures of Amun, Abstract of Papers, 66-67, E.A.O. Press, Fifth International Congress of Egyptology, Cairo, Egypt, Oct. 29-Nov. 3, (1988).
91. G.Maspero, *ibid*, page 237.
92. Translated first by Golenischeff, cited by G.Maspero, *ibid*, page 253; see also A.H. Gardiner, Journal Egypt. Archaeology, 32 (1946), page 43.

93. R. Klemm and D.D. Klemm, Steine und Steinbrüche im Alten Ägypten, Springer Verlag Berlin Heidelberg 1993.

Chapter 18

94. E.Jomard,“ Description de l’Egypte ”, Volume I, page 181.
95. J. H. Breasted, Ancient Records of Egypt, Amenhotep III Dedication Stela, page 369, Chicago (1929).
96. Plinius, Natural History, Book XXXVI, sect. 58.
97. Jollois and Devilliers, Description de l’Egypte, Volume II, Chap.IX, Section II, page 153.
98. H. Bowman, F.H. Stross, F. Asaro, R.L. Hay, R.F. Heizer and H.V. Michel, The Northern Colossus of Memnon: New Slants, Archaeometry 26, 2, pp. 218-229 , (1984).
99. R. Klemm and D.D. Klemm, Steine und Steinbrüche im Alten Ägypten, *ibid*, pages 300-303, Figures 351-354.
100. W. J. Young, Technical Examination of Nine Tell El-Armana Objects, Property of Mr. William Monsoor, Report, Boston Museum of Fine Arts, April 14, 1949.
101. The reports mentioned here and in the following notes, are internal reports, not published in journals or magazines. Copy of the reports are available and since 1998 may be consulted in the Internet at www.armana.com . Few published general papers dealing with the Mansoor Collection are:

- F.H. Stross, Authentification of Antique Stone Objects by Physical and Chemical Methods, Analytical Chemistry, Vol. 32, n°3, 17, (1960).
- E. R. Monsoor, Je Cherche un Homme …, 1971
- S. Hochfield, The Mansoor Collection: an insoluble controversy?, ARTnews (USA), summer 1975, 50-57, (1975).

102. Z. Iskandar and Z. Mustafa, Examination of Sculpture Pieces of El-Armana Type, Report, November 28, (1950).
103. R. Protsch, Expertise of the Mansoor Collection, January 12,1976.
104. Cited in ARTnews, see in note101 above

105. R. L. Hay, Report on two sculptures from El-Armana, Feb. 10, 1975.
106. P. Blanc, Report Mansoor Arman Collection, May 31, 1986.

Chapter 19

107. Herodotus, Historiae, Book IV, sect. 36-42.
108. see note 9 above.
109. M. J. Aitken, Physics and Archaeology, Clarendon Press, Oxford, 1974, p. 42;

See also:

- F. W. Shotton, An example of hard-water error in radiocarbon dating of vegetable matter, Nature, 1972, pp. 460-61;
- E. S. Deevey, M. S. Gross, G.E. Hutchinson and H. L. Kraybill, The natural C14 contents of materials from hard-water lakes, Proc. nat. Acad. Sci., Washington, 1954, 40, pp. 285-88.

110. M. D. Coe, Breaking the Maya Code, Thames and Hudson eds. (1992) and Penguin Books (1994).

Appendix 1

111. Le Chatelier, cited in P. Munier, Technolgie des Faïences, Ed. Gauthier-Villars, Paris, p. 132, (1957) .
112. Dictionnaire Archéologique des Techniques, Edition de l'Accueil, Paris, p. 422, (1963).
113. M. De Rozière, De la Constitution Physique de l'Egypte, 7° Partie, Description de l'Egypte, *ibid*, Vol. 21, p. 199.
114. M. De Rozière, Description de l'Egypte, *ibid*.
115. J. Davidovits, Determination of the Origin of Ceramics by Analysis of the Geopolymers contained in Ceramic Pastes backed at Low Temperature, (in French), XX° Archaeometry Symposium, Paris 1980, published in Revue d'Archéométrie, 1981, Supplément 1981, pp. 53-56.

See also:

- C. Boutterin and J. Davidovits, Low-Temperature Geopolymeric Setting of Ceramics, Proc. 22nd Symposium on Archaeometry, Bradford, U.K., pp. 213-217 (1982).
- J. Davidovits and C. James, Low Temperature Geopolymeric Setting of Ceramics (L.T.G.S.) (IV), Dolomite Presence is Proof of LTGS in Cyprus Amphorae, , 1984 Symposium on Archaeometry, Smithonian Institution, Washington D.C., pp. 24-25 (1984).
- J. Davidovits, French Patent 2.490.626 (Process for the fabrication of building items, with various lateritic soils..).
- J. Davidovits and C. Boutterin, French Patent 2.528.822 (Process for the fabrication of building items, with lateritic soils and clays).

Appendix 2

116. T. Aigner, Facies and origin of nummulitic buildups: an example from the Giza Pyramids Plateau (Middle Eocene, Egypt). N. Jb. Geol. Paläont. Abh. 166, 347-68 (1983). Cited in M. Lehner (see following note 117 page 113-114):

> *" … According to Aigner's model, the Pyramids Plateau began as a bank of nummulites seen to exceed 30 m in thickness in the northern escarpment. A shoal and reefal facies was laid over the southern slope of the nummulites bank. A " back bank " facies was, in turn, laid over the shoal reef, forming a series of limestone/ marl beds which 'lense out' over the shoal reef to the N. In practical terms, this left the very hard and brittle limestone of the nummulites bank to the NNW part of the Pyramids Plateau, and the softer thickly bedded layers to the lower SSE area of the plateau… "*

117. M. Lehner, The Development of the Giza Necropolis: The Khufu Project, Mitteilungen des Deutschen Institutes, Abteilung Kairo (MDAIK), 41, pp. 109-143, 1985. In page 118:

> *" … According to Aigner's depositional model of the plateau, the*

pyramid was based on the harder, more massive nummulites bank which swells up along the N-NW part of the formation… "

118. M. Lehner *ibid*, p. 129.

" … As far as we know, no large quarry sufficient to the bulk of the Khufu Pyramid exists to the West, North, or East of this pyramid… The large Central quarry is to the S of the pyramids. In exploiting this the builders took advantage of the thickly bedded softer limestones of the south part of the Mokattam Formation, while founding the pyramid on the hard nummulites bank to the north. The natural slope of the formation already provided an inclined plane from the quarry [upwards] to the pyramid… "

119. D. H. Campbell and R. L. Folk, The Great Pyramid Debate, The Ancient Egyptian Pyramids - Concrete or Rocks, Concrete International, Vol. 13, No. 8, pp. 28-39. (1991)

See also, the rebuttal by

- M. Morris, The Great Pyramid Debate: The Cast-in-Place Theory of Pyramid Construction, Concrete International, Vol. 13, No. 8, pp. 29-44. (1991)

120. G. Goyon, see in note 20 above, and on pages 105-110 of note 94 below.

121. G. Goyon, Le Secret des bâtisseurs des grandes Pyramides Kheops, Pygmalion ed., Paris, 1990, Fig. 29 bis on page 107.

122. J. Davidovits' measurement of blocks length on photographs taken in 1988.

123. I.E.S. Edwards, *ibid*, Mykerinus' pyramid, page 157-158.

124. R. Klemm and D.D. Klemm, Steine und Steinbrüche im Alten Ägypten, Springer Verlag Berlin Heidelberg 1993… Klemm's analysis are shown in diagrams plotting the rare elements magnesium (Mg) against strontium (Sr), Figures 212a, 213, 214, 215 a,b, involving 74 samples for Khufu, 80 for Khafra and 32 for Menkure.

125. M. Lehner, *ibid*, p. 121 quarry.

126. R.L. Folk and D.H. Campbell, Are the Pyramids built of poured concrete blocks, Journal of Geological Education, Vol.

40, pp. 25-34 (1992):

"... *One of the trenchant observations is that in a row of temple or pyramid stones, adjacent blocks often show the same vertical sequence of textural variations and stratification brought out by differential weathering; e.g. recessed zone may appear near the middle of a row of blocks... The true geological explanation is that the Egyptian quarried blocks from the same series of beds and placed them next to each other, retaining to a major extent the stratigraphic continuity in the construction...* " This statement illustrates Folk/Campbell's ignorance of the local stratigraphy .

127. L. Gauri, Geological Study of the Sphinx, Newsletter American Research Center in Egypt, No 127, pp. 24-43, 1984.

Bed	water soluble salts %	clastic materials %	water-sensitive parts %
6ii	1.258	4.226	5.484
6i	1.529	9.464	10.993
5ii	1.901	3.996	5.897
5i	4.775	11.447	16.222
4ii	0.737	4.920	5.657
4i	5.043	8.140	13.183
3ii	3.389	2.630	6.019
3i	1.269	5.230	6.499
2ii	2.640	3.650	6.250
2i	2.630	9.310	11.940
1ii	1.663	6.580	8.243
1i	3.517	26.130	29.647

Table 1 (page 36) provides the water soluble salts (sulfates, nitrates, chlorides of potassium, sodium, calcium and magnesium). Table 2 (page 37) provides the non-carbonate clastic materials (sand, silt, clays). Sand does not necessarily means quartz sand, rather silt or limonite of bigger grain size than silt. For each of the six beds, Gauri gives the lowest and the highest value. The designation 'i' in each bed refers to the highest value (generally the bottom marly portion of the bed) and 'ii' for the lowest value (generally the upper more calcareous portion). The following table provides a summary of these analysis.

The values are expressed as weight percent. The water-sensitive parts are obtained by adding water-soluble salts and clastic materials.

The clay fraction in all beds if of the kaolinitic type (which is very reactive in any post reagglomeration process). According to Gauri, page 39:

> " ... *The kaolinite occurs in all the studied samples but illite and Montmorillonite have been identified in the upper limestone of the Akhet Member [the hard-gray limestone of the head] and in Bed 3 of the Setepet Member [the soft-marly limestone of the body]...* "

128. R.L. Folk and D.H. Campbell , *ibid*. There are several statements made by Folk/Campbell in this paper that demonstrate their lack of knowledge on the geological uniqueness of the Giza Plateau. They came to the site with only one preconceived idea, namely to look after natural stone:

> " ... *A fundamental and obvious objection to the geopolymer theory is that, had the Egyptians wanted to make " permastone ", why would they have gone to the excessive labor of crushing limestone and glueing it back together when it would have been much easier to use the abundant, nearby, loose desert quartz sand that would have surely made a more homogeneous concrete...* "

See also rebuttal by

- M. Morris, Geopolymeric Pyramids - A rebuttal to R.L. Folk and D.H. Campbell, Journal of Geological Education, Vol. 40, pp. 35-46 and 344-346 (1992):

129. M. Lehner, Some Observations on the Layout of the Khufu and Khafre Pyramids, J. American Research Center in Egypt, Vol. 20, p. 7 (1983)

130. R.L. Folk and D.H. Campbell , *ibid*.

131. R.L. Folk and D.H. Campbell , *ibid*. In this paper there are several similar statements, for example:

" …We believe that had Davidovits had any understanding of basic geologic principles and understood the implications of simple geological evidence at Giza, he would have realized that this geopolymer theory had no basis in fact…. We have also shown how geologic commonsense can destroy archaeological quackery, but not, unfortunately, before it has enjoyed widespread publicity among the gullible and sensation-minded…. The geopolymer theory is defunct; we still remain in awe of the enigma of Egyptian skill and engineering… "

132. see note 119 above.

133. J. Davidovits, J., Great Pyramid debate, Concrete International, Vol. 14, No. 2, pp. 17-18, (1992)

134. J.A. Harrell and B.E. Penrod., The Great Pyramid Debate - Evidence from the Lauer Sample, Journal of Geological Education, Vol. 41, pp. 358-363 (1993). In the cited Table 1, Harrell provides location of the samples, namely: Gebel Mokattam (the suburb of Cairo behind the Citadel), Tura, Masara and Lauer. There is no mention of any Giza sample.

See also the rebuttals:

- M. Morris, How Not to Analyze Pyramid Stone, Journal of Geological Education, Vol. 41, pp. 364-369 (1993).
- R.G McKinney, Comments on the Work of Harrell and Penrod, Journal of Geological Education, Vol. 41, pp. 369 (1993). McKinney, a geologist concludes with the following statement:

" … Finally, I am not a " geologist sympathetic to the geopolymer theory " as Harrell suggests. I was asked to participate in this project by Marshall Payn, President of the Epigraphic Society of America, and financier of R.L. Folk's trip to Egypt. He wanted an impartial observer with no knowledge of the theory to render an

opinion on the results of the visit. I have since read Davidovits' book and do think his approach to the problem of pyramid construction is the most analytical I have read, but this has nothing to do with thin-section analysis… "

135. B. Moore, Great Pyramid Debate, Concrete International, Vol. 14, No. 2, pp. 82-84, (1992). Moore, an employee of Black & Decker (drilling tools) states:

" … In October 1987 I was a member of the National Geographic sponsored team that non-destructively revealed the entombed second wooden ship of Khufu. I designed and operated the drilling system that obtained air samples and photographs of the pit interior [hard Mokattam Formation]… I have had a chunk of nummulitic limestone, that I personally detached from the Giza plateau, soaking in water for five months now, and it exhibits no change in hardness… "