IUBILATE CONLEGAE

STUDIES IN MEMORY OF ABDEL AZIZ SADEK

Part I

Varia Aegyptiaca Vol. 10, Nos. 2-3 August-December 1995

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Part I

edited by

Charles C. Van Siclen III

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Charles C. Van Siclen III, *Editor*

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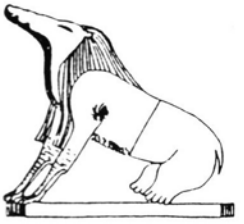

Editorial

This issue of *Varia Aegyptiaca* is the first of several devoted to the memory of my late friend Azzouz (Abdel Aziz Sadek). It was originally conceived as a volume in his honor which he might live to see, but such was not the case. The article included herein were written for the most part in 1995. The delay in publication is due to problems of the editor. My sincerest apologies are offered to the authors who have waited so long to see their works in print. Although nominally 1996, the remaining issues dedicated to Azzouz will appear in 1998.

It is intended that the two delayed issues of *Varia*, 8/3 and 9/3, will be finished in 1998 as well. There will be no issue dated 1997, but volume 12, 1998 is in the planning stages. It is to be hoped that regular publication can be resumed.

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Varia Aegyptiaca 10/2-3 (1995)

The Discovery of the Pyramidion of the Satellite Pyramid of Khufu [G1D][1]

by Zahi Hawass
with an Appendix by Josef Dorner

A Satellite Pyramid of Khufu was found at the southeast corner of the Great Pyramid.[2] We never expected to find a pyramid in that location because the site had been excavated fully by Petrie in 1881,[3] and another clearance had been done in 1940 (Pl. 1).[4] The Satellite Pyramid has a T-shaped style similar to the subsidiary pyramid of Khafra located at the south side of the second pyramid at Giza (Pl. 2).[5] The superstructure of this pyramid consists only of about three courses of limestone, located on one side of the burial chamber of this pyramid. Nothing has been found in the burial charnber except two large stones, a medium sized one, and a small one. Also, a hole was cut in the ground. The ceiling of the burial chamber seems to be vaulted over the south and north walls (Pl. 3).[6]

There are boat pits located on the south of the subsidiary pyramids G1A and G1B. The boat pit to the south of G1B is also located on the immediate east of G1D, the newly discovered pyramid (Pl. 4). One may suggest that this boat belonged to the Satellite Pyramid because of the location of the boat pit near this pyramid. The problem with this idea is that G1A has a boat pit on the south, and this boat pit is located on the south of G1B and nothing has been found on the south of G1C. We did excavate the southern side of G1C to the solid rock and found nothing. One may also suggest that the boat pit located on the north side of the subsidiary pyramid GlA belonged to it and not to the main pyramid of Khufu because this period in Khufu's reign was experimental and

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[1] Abdel Aziz Sadek, known as Azzouz, was one of the nicest men to know. He was very kind and warm. I don't think that he ever upset any person, and he almost never was upset with any other person. Only once an Egyptian colleague upset him. This individual had no capabilities and never accomplished anything in his life, but he hurt Azzouz. Azzouz came to me to complain, but he did that with honor, dignity, and pride, and he did not say a word against the other. I told Azzouz, "Do not be upset, because history will recognize you, and if after a long life you will die, all of us will write articles in your memory; but this person will be neglected."

I first met Azzouz in 1970 with the late Mohamrned Morsi, and the three of us became close. We used to meet occasionally and always discussed our work and our future as Egyptian archaeologists. Always I heard pleasant words from him. He and his wife were planning to visit my new Satellite Pyramid and its pyramidion, but instead I visited him in the hospital. He had been in pain for a very long time but never talked about it. Now I picture the friendly smile of Azzouz that we lost. He will always be remembered. He is always in our hearts.

It is to the late Abdel Aziz Sadek that I dedicate this article.

[2] Z. Hawass, "The Discovery of the Satellite Pyramid of Khufu, G1D" in *Studies in Honor of William Kelly Simpson*, ed. by Peter Der Manuelian (Museum of Fine Arts, Boston: 1996), pp. 379-98.

[3] W. F. Petrie, *The Pyramids and Temples of Gizeh, with an Update by Z. Hawass*; Histories, Mysteries of Man (London: 1970).

[4] This photo was taken on February 24, 1940, by Hasaballa El-Tieb during the excavation at the east of the Great Pyramid by Hakiem Abou-Sief and Selim Hassan.

[5] U. Hölscher, *Das Grabdenkmal des Königs Chephren* (Leipzig: 1912), p. 34-35, pl. XIII. V. Maragioglio and C. A. Rinaldi, *L Architettura delle pirimidi menfite, V: "Le pirimidi di Zedefra e di Chefren"* (Rapallo: 1966), p, 88, G, A. Reisner, A *History of the Giza Necropolis,* I (Cambridge MA: 1942), p. 131-132.

[6] Hawass, "Satellite Pyramid."

thus a boat pit was made for each pyramid. The problem with this theory is that the boat pit in the north side of Pyramid G1C is so large that it cannot fit with the small size of the pyramid. The ancient Egyptians preferred symmetry. Also, it is located to the north of the causeway of Khufu, which breaks its connection with G1A Furthermore, the boat pit located north of the causeway is similar in size to the two boat pits that flanked the upper temple of Khufu. Therefore this boat pit must be one of the architectural components of the Pyramid Complex of Khufu.

It also has been suggested that the trial passage was intended to be the substructure of the Satellite Pyramid of Khufu. It was abandoned because of the enlargement of the upper temple.[7] Then the Satellite Pyramid was moved and built in the southeast corner of Khufu's pyramid. The problem here is that the interior of the trial passage is exactly like the interior of the Great Pyramid, though shorter, and the substructure of the new Satellite Pyramid has a T shape. I do not think that this is significant because Khufu's reign initiated the development of the Old Kingdom architectural components of the Pyramid Complex and was an experimental period. Then it seems that the small area available for the Satellite Pyramid and the limited time in which to build it made it necessary to have a T-shaped style, not a trial passage. It seems that the new Satellite Pyramid was constructed in a hurried manner.

The function of the Satellite Pyramid is not known and has been debated at length among scholars. The most frequently cited possible functions of the Satellite Pyramid are: a dummy tomb connected with the *sed* festival,[8] burials for the king's *ka*,[9] symbolic burials for the king as the King of Upper and Lower Egypt,[10] burials of placentas,[11] tombs for the viscera,[12] solar symbols,[13] temporary storage for the body,[14] and tombs for crowns.[15]

The southern tomb of the Pyramid Complex of Djoser is a prototype of the Old Kingdom Satellite Pyramids. The reliefs on the panels in Djoser's southern tomb represent the king wearing

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[7] Petrie and Hawass, *The Pramids and Temples of Gizeh;* M. Lehner, *The Pyramid Tomb of Hetep-heres and the Satellite Pramid of Khufu* (Mainz am Rhein: 1985), p. 45 ff. Maragioglio and Rinaldi, *L'Architettura,* IV, p. 68-70. H. Vyse, *Operations Carried on at the Pramids of Gizeh,* Vol. I (London: 1840), p. 89.

[8] J. P. Lauer, *Histoire monumentale des Pyramides d'Égypte, I. Les Pyramides à degrés (IIIe dynastie)* (Cairo: 1962), p. 134. For discussion of the *ḥb sd* function see J. Brinks, Die *Entwicklung der Königlichen Grabanlagen des Alten Reichs* (Hildesheim: 1979), p. 76-94. Lehner, *Pyramid Tomb*, p. 35 ff.

[9] H. Goedicke, *Re-used Blocks from the Pramid of Amenemhet I at Lisht* (New York: 1971), p. 9. H. Ricke, *Bemerkungen zur ägyptischen Baukunst des Alten Reich,* II BÄBA 5 (Zurich and Cairo: 1950), p. 106, Lehner, *Pyramid Tomb,* p. 36.

[10] Ricke, *Bemerkungen,* II, p. 127-135.

[11] Brinks, *Entwicklung,* p. 76-79.

[12] Lauer, *Histoire monumentale*, I, p. 134.

[13] C. M. Firth, "Excavations of the Department of Antiquities at Saqqara October 1928 to March 1929" *ASAE* 29 (1929), p. 67-70.

[14] J. P. Lauer, "Le Temple haut de la pyramide du roi Ouserkaf à Saqqarah," ASAE 53 (1955), p. 130.

[15] Lehner, *Pyramid Tomb,* p. 35 ff.

the white crown and running holding the flail. These scenes in the southern tomb can be interpreted as representations of the *sed* festival.[16]

Therefore I propose a new theory on the function of the Satellite Pyramid: that it was used as a changing room for the ritual of the *sed* festival.

There is a very interesting sequence of the wall reliefs on the Pyramid Complexes of the Old Kingdom. The first scene shows the king in his palace with his officials and courtiers. Alternatively he is seated in his chapel. He wears the crown of Upper and Lower Egypt. He wears his robe and carries the flail to show his power over the Two Lands.[17] The second scene shows the king wearing the skirt and holding the flail and dancing or doing the ritual of the *sed* festival, The last scene in the sequence of the wall reliefs always occurs in the offering room and shows the king receiving offerings and divinity.[18] He is accepted by all the gods and becomes equal to them because he has accomplished what the gods required him to do on earth and now he is rewarded by becoming a god.

The king's duty is to build a tomb for himself and temples for the worship of the gods, to unify Upper and Lower Egypt, to give offerings to the gods, and to smite the enemies of Egypt.

The scenes of the *sed* festival occur on the walls of the southern tomb, which is a prototype of the Satellite Pyramid. The scenes also occur in the wall reliefs of the Pyramid Complexes from Dynasties IV to VI of the Old Kingdom. Therefore it is proper to suggest that there is a connection between the *sed* festival and the Satellite Pyramid.

The *sed* festival is a subject of debate among scholars. It held important meaning for the reign of the living king, as is known since the reign of Narmer in Dynasty I. The wall reliefs of Khufu's Pyramid Complex and other Old Kingdom Pyramid Complexes illustrate the activity of the king during this festival and picture the king as the primary figure.[19]

The Egyptian term for this ceremony is *hb sd*, which is translated incorrectly in Greek as a regnal jubilee that the king celebrated every thirty years after his accession in order to renew his power and strength.[20] The *sed* festival is not a regnal jubilee because it was celebrated at irregular intervals, there being no fixed years for its celebration.[21]

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16 K. Martin, "Sedfest (*ḥb sd*)," *LÄ* V(1984), p. 782-790. W. Kaiser, "Die Kleine Hebseddarstellung im Sonnenheiligium des Neuserre," in *Festschrift Ricke* BÄBA 12 (1971), p. 87-105.

17 L. Borchardt, *Das Grabdenkmal des Königs Sahu-Re*, II (Leipzig: 1913), pls. 15-45. G. Jéquier, *Le Monument funéraire de Pepi II*, II (Cairo: 1938), pls. 37, 42, 45.

18 Borchardt, *Sahu-Re, II*, pl. 23.

19 Goedicke, *Re-used Blocks*, p. 29-30. W.S. Smith, *A History of Egyptian Sculpture and Painting in the Old Kingdom* (Boston and London: 1946), p. 15. G.A. Reisner, A *History of the Giza Necropolis, II: The Tomb of Heterpheres, Mother of Cheops* (Carnbridge MA: 1955), figs. 5-6. J. P. Lauer, "Note complimentaire sur le temple funéraire de Khéops," *ASAE* 49 (1947), p. 111-123.

20 C. J. Bleeker, *Egyptian Festivals: Enactments of Religious Renewal* (Leiden: 1967), p. 114.

21 H. Bonnet, *Reallexikon der ägyptischen Religionsgeschichte* (Berlin: 1952), p. 158.

The scenes of the *sed* festival that are depicted on the reliefs of the Old Kingdom illustrate three types of rituals involved in this festival: the donning of the *sed* robe, the king sitting on his throne in his chapel wearing his crown, and finally the cultic dance, when the king took off his robe and danced in his short kilt.[22] The rituals differ because there was one for Upper Egypt and another for Lower Egypt; however, the robe is a very distinctive feature that always occurs in any scene depicting the ritual activity of the *sed* festival.

The relationship of the *sed* festival to other festivals and to the king's duties can be interpreted through the wall reliefs. It is related to the Libyan defeats, the victory and glory of the king, his coronation, his appearance in front of the gods, and also the strength of the unification of Upper and Lower Egypt.

Bleeker, in the conclusion of his study, explained that this festival "marked a critical phase in the king's relationship to the gods."[23] He pointed out that it was a ritual which made a highly dramatic impact. It was not a sacred drama, but it had a magical aspect. It also renewed the office of the king as the high priest. And finally the king's glory was shown when he wore the *sed* robe.[24]

Other scholars have commented on the function of the *sed* festival. Brinks believed that it confirmed the king as the ruler by the renewed presentation of the scepter, as well as the bow and arrow.[25] Bonnet described it as an overwhelming presentation of royal power.[26] Hornung stated that the *sed* festival was intended to guarantee the royal power.[27] Arnold suggested that the *sed* festival was a renewal rite for the life and strength of the king.[28]

I believe that the *sed* festival is the celebration by the king when he has finished all that the gods asked him to do. The rituals showed that he had completed them all, and now he was happy celebrating.

The wall reliefs depict the powers that are renewed through the festival and which entitle the king to carry out the festival. The king celebrates a good government, as is documented by scenes of the estates that produced offerings for the cult as well as scenes of victories over enemies. Such scenes are repeated throughout the Pyramid Complex. The king appears on a throne with his *sed* festival robe to represent his role as ruler. This scene appears in various places in the upper and sometimes the lower temple. The king is received by the gods as a divine equal.

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[22] Bleeker, *Egyptian Festivals*, p. 101-106. Martin, "Sedfest" p. 782-790.

[23] Bleeker, *Egyptian Festivals*, p. 120.

[24] *Ibid.*, p. 122.

[25] Brinks, *Entwicklung*, p. 159.

[26] Bonnet, *Reallexikon*, p. 159.

[27] E. Hornung and E. Staehelin, *Studien zum Sedfest* (Genf/Basel: 1974), p. 20-25.

[28] D. Arnold, "Rituale und Pyramidentempel," *MDAIK* 33 (1977), p. 10-14.

This appears in many places in the complex. The king appears celebrating a dance. He is shown taking off his robe and wearing only a skirt and dancing joyfully because he has accomplished what the gods required of him.

The function of the Satellite Pyramid is that the king used the burial chamber of this pyramid as a changing room. He took his robe off and left his crown in the burial chamber. He wore the skirt and held the flail. Then he emerged through the entrance to go outside to perform the *sed* festival, to announce to the gods that he had finished all tbat they had asked him to do.

Therefore the function of the Satellite Pyramid during the Old Kingdom was as a changing room for the *sed* festival rituals.

The Discovery of the Pyramidion

On the south side of the Satellite Pyramid was found a large limestone block which had three sloping sides. We knew that there must be a missing part on the north to make it square (Pl. 5). This block was the base of the pyramidion.

We never expected to find the missing part of the pyramidion at all, but my assistant Alla el-Din Shaat found it by accident in 1993, a year after the discovery of the Satellite Pyramid itself. The pyramidion was lying on the north side of the pyramid (Pl. 4; see Pls. 7-10 for different sides of the pyramidion).[29]

Miss Nivien Mohamed Mustafa, the architect of the Giza Pyramid, did the restoration of the Satellite Pyramid.[30] She also moved the limestone block found lying on the south side of the pyramid and put it in front of the north side of the pyramid about four meters from the pyramid entrance (Pl. 6). The block and the restored missing part were joined and put above a stone to show how a pyramidion topped a pyramid.

The Rites of the Pyramidion

In Abou-sir we found some very important scenes depicted on blocks from the causeway of Sahure that shed light on the rites around the pyramidion.[31]

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[29] Alla el-Din Shaat, Inspector of the Pyramids, assisted me in the excavation east of the Pyramid of Khufu; as did a number of other colleagues, such as Mr. Abdel Hamied Cotb, the architect of tbe Giza Inspectorate, and Miss Nivien Mohamed Mustafa.

This is the third Old Kingdom pyramidion known to us. The first was discovered by my friend Rainer Stadelmann around the Red Pyramid of Senefru at Dahshur. This pyramidion was reconstructed and it now tops a base in front of the pyramid. Another pyramidion was found around the subsidiary pyramid of Menkaure's pyramid. The satellite pyramidion of Khufu could be the oldest one with angles complete.

I would like to thank Kate McCormick for typing this paper.

[30] See Hawass, "Satellite Pyramid."

[31] The Giza Department of Antiquities of the Supreme Council of Antiquities decided to open the site of Abou-sir to the public for the first time. Therefore we started a restoration program for the funerary temple of Sahure and the causeway. The work was done under the supervision of Mr. Yahia Aied, Director of Saqqara, the architect of Saqqara, and Reis Abdou el-Metal. We also decided to clear and remove the sand around the north side of the causeway, where it had risen to a level of 50 feet. Therefore we had to use a bulldozer. Mohamed Mouslehy, who is the driver,

The first block shows workmen dragging the pyramidion. Above it is written the word *bnbnt* ("pyramidion") as well as the word *ḏ^{C}m*, which means "electrum" (Pl. 11).

This is followed by another unique scene showing five ladies in a dance position, the right arm extended upwards and forward and the left hand resting on the chest. The right leg is raised in a dancing position. All of the dancers are performing the same motion. They are wearing a short decorated skirt and a collar with straps connecting it to the skirt. In front of them is one of the workmen holding the tools with which the pyramid was built. Under this register another four ladies are dancing, raising their hands up (Pl. 12). In front of the dancers is written the following hieroglyphic inscription: *ib3 in hnr*, which means "dance by group or harem".[32]

These are two unique scenes that have never occurred before in the program of the wall reliefs of the Old Kingdom. They have no parallel. Borchardt never expected to find something like this. After he uncovered over 10,000 square meters of wall reliefs, he neglected to excavate to the north of the causeway because he thought that he would merely have found repeated subjects; so he left it to us to be discovered.[33]

These scenes tell us for the first time that the pyramidion was cased with elcctrum (Pl. 11). Also the sequence of the two scenes shows that the workmen were dragging the pyramidion to put it above the pyramid. It proves that the pyramidion was the last architectural component that was placed on the pyramid. It also meant that the pyramid was finished, and the king witnessed that moment.

The second scene indicates that the country celebrated. They danced and sang because the pyramid was finished. The king and the people were happy because the national project was accomplished. The whole country had to be united under the leadership of the king to build his tomb.

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started to work and remove the sand. During his work he found one block with a very unique scene on it. He stopped his work and took a photograph of it and brought it to me. I would like to thank him.

I am only going to discuss two blocks, and the rest will be published separately.

There is a scene found within the complex of Djed-kare Isesi of the king standing holding a staff. In front of him is a broken inscription reading, "following the *bnbnt* to the pyramid of Isesi." (This inscription has not been published.)

See also H. Goedicke, *Königsliche Dokumente aus dem Alten Reich* (Wiesbaden: 1967), p. 78-80, for the name of Mycerinus placed on the *bnbnt*. This shows the importance of the pyramidion. It also supports my theory that the pyramidion was the last architectural component that was added to the pyramid, followed by a national celebration.

The pyramidion in the relief from Sahure's pyramid complex is not shown on the scene; only the workmen and the rope are shown. The hieroglyphic word *bnbnt* that is written above this scene can explain what is missing behind the workmen; that is, the pyramidion.

[32] For *ib3*, see Faulkner, *Dictionary*, p. 15; also *WB* I, p. 62. The word *ḫnr*, usually translated as "harem," an isolated quarter for women, has recently been reinterpreted as "musical troupe." This seems to be rather narrow and does not express the nuance of constraint that the original translation implies. (See *WB* III, p. 295-298.) However, it seems that in this case the word *ḫnr* does indeed mean "musical troupe." This would be one of the earliest instances of this usage in the Old Kingdom. (See D. Nord, "The Term 'Ḫnr,' 'Harem' or 'Musical Performer?'" in W.K. Simpson and W. Davis, eds., *Studies in Honor of Dows Dunham* (Boston, 1981), p, 137-145.

[33] Borchardt, *Sahu-Re*, II.

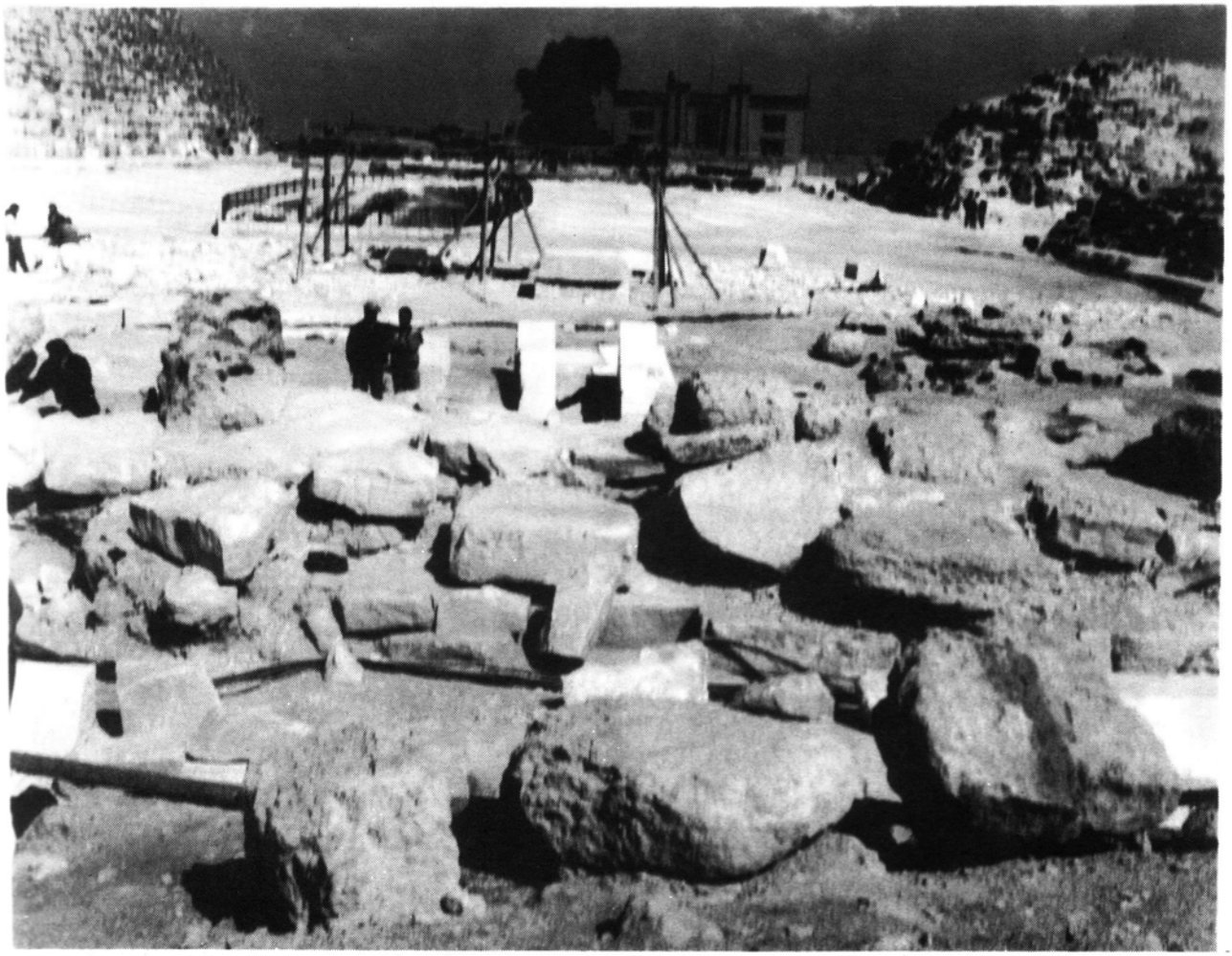
Pl. 1. Clearance southeast of the Great Pyramid, 1940.

Pl. 4. North side of the satellite pyramid.

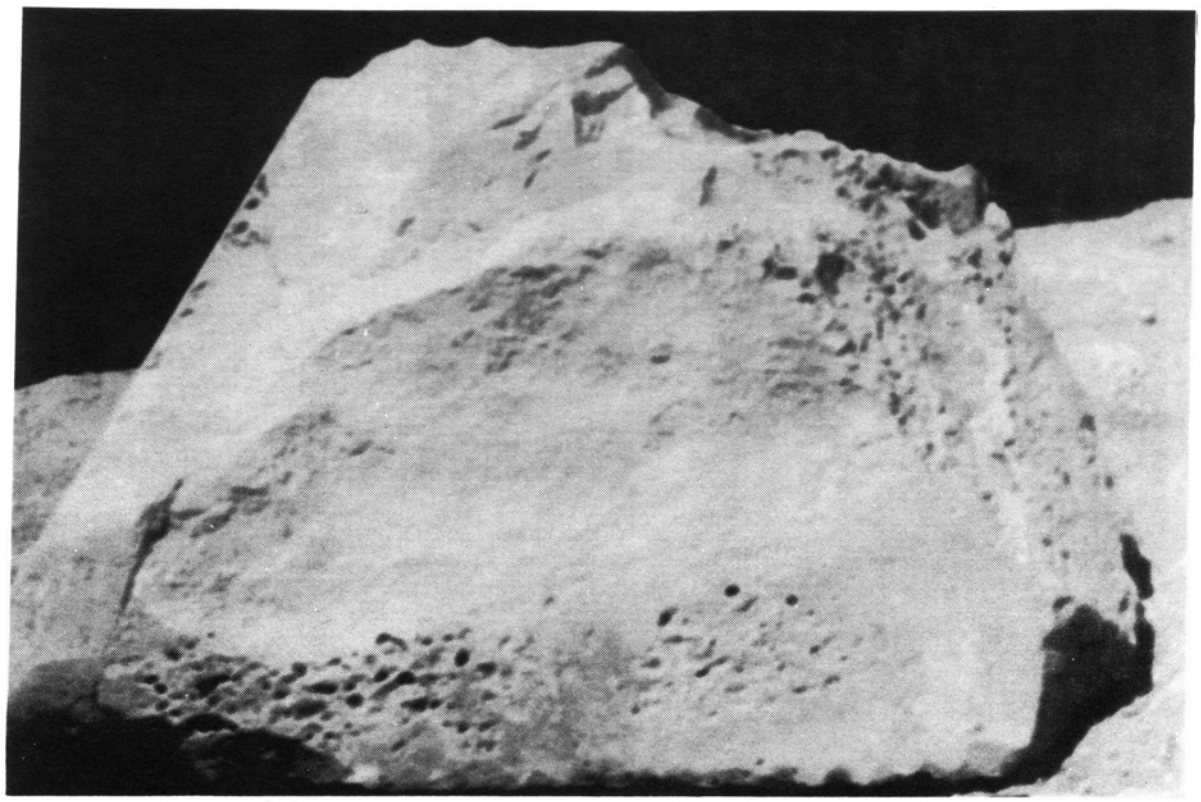
Pl. 3. Interior of the satellite pyramid substructure, looking west.

Pl. 2. View of satellite pyramid substructure, looking south.

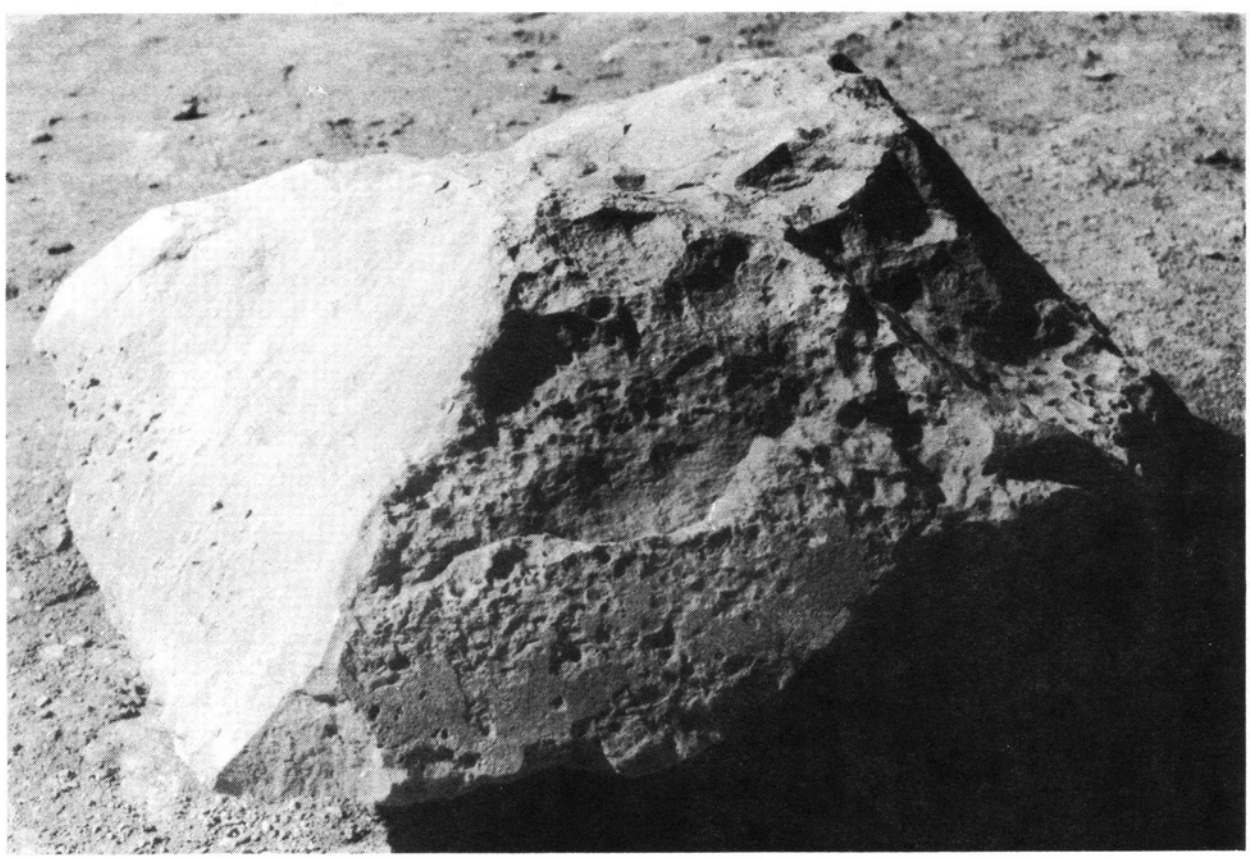
Pl. 5. The base of the pyramidion.



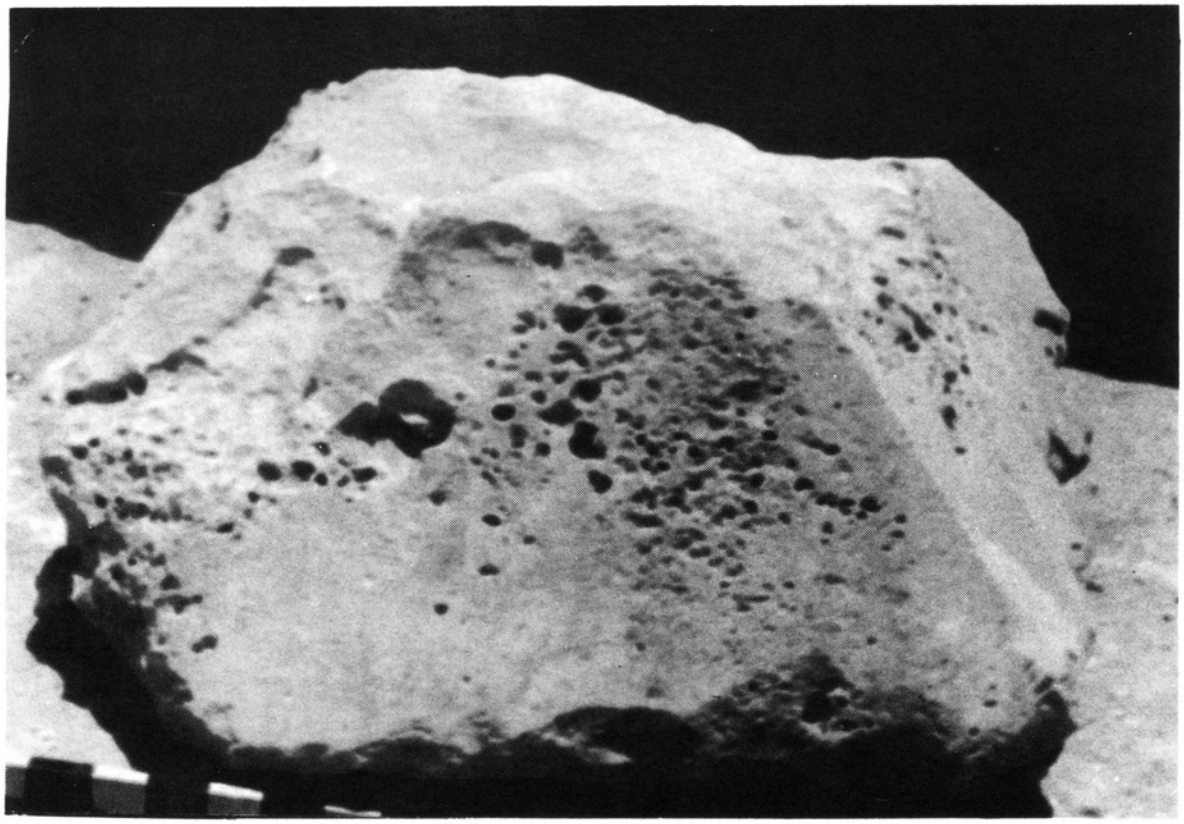
Pl. 6. The satellite pyramid restored.



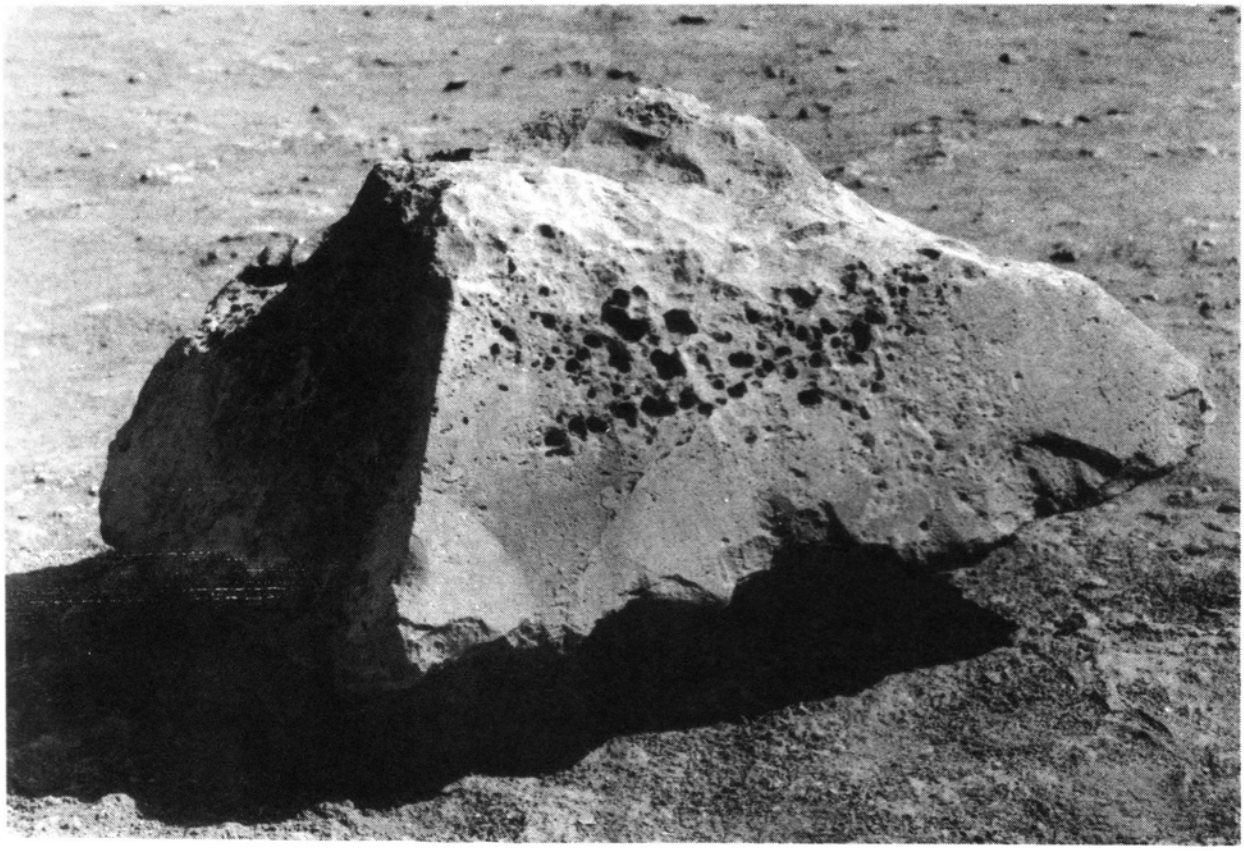
Pl. 7. Side of the pyramidion of the satellite pyramid.



Pl. 8. Side of the pyramidion of the satellite pyramid.

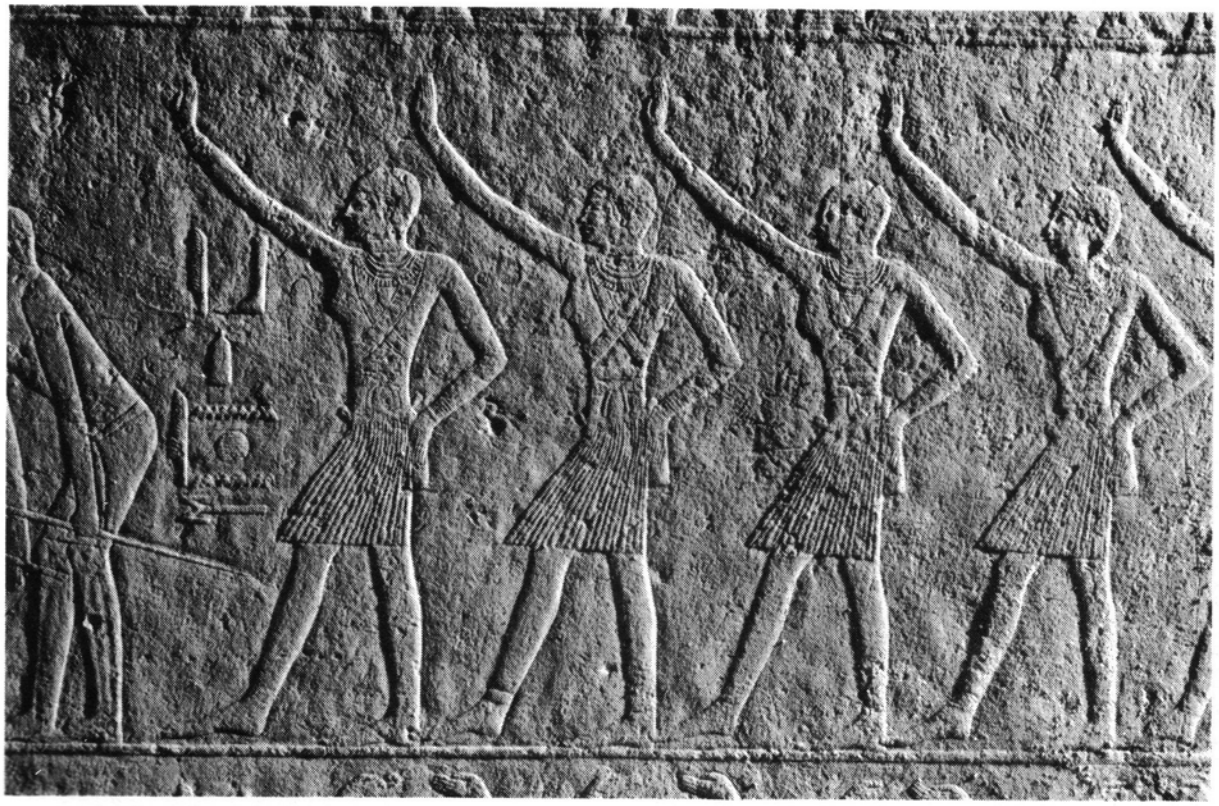


Pl. 9. Side of the pyramidion of the satellite pyramid.



Pl. 10. Side of the pyramidion of the satellite pyramid.

Pl. 11. Scene from the causeway of the pyramid of Sahure.



Pl. 12. Scene from the causeway of the pyramid of Sahure.

Appendix by Josef Dorner[34]

The top of this pyramidion is missing and a great part of the face damaged. The horizontal edges are broken away all along the base. Of the sloping edges only two are partly preserved, in the southeast 25 cm and in the southwest 50 cm. (These directions refer only to the present position.)

The lower side, only slightly damaged, is not flat but divided along the diagonals in four planes, each of them sloping from one of the horizontal edges towards the center. This protruding part was inserted into the second stone course and therefore remained rough.

Since neither the top nor any of the corners is preserved and the base is completely destroyed, we had to choose an indirect method to obtain measurements: a large aluminum ruler was placed with its flat side against the lower plane and gradually shifted until its edge was in line with the upper face. Thus on each side the line of the original base was reconstructed, and at 130 mm distance a parallel was drawn on the preserved part of the face (Fig. 1).

These four parallels with points A', B', C', D' are the base of a smaller pyramid, which is similar to the pyramidion and can be measured. The position of the missing top and of the destroyed corners C' and D' had to be found by extending the edges. This caused some inaccuracy in the lengths, approximately 2 mm for the horizontal and 4 mm for the sloping ones.

From the base only the four sides could be measured but not the diagonals. In order to gain the fifth element necessary to define its shape and as a control, the angles in B' and D' were determined by auxiliary triangles. The distances measured (in mm) and the angles derived from them are given in Fig. 2.

With these data the diagonal A'C' can be calculated twice:

A'B'C': d = 1351
A'C'D': d = 1357
mean : d = 1354

Taking the means as being close to the truth the figure is defined, and we receive for the adjusted angles:

$\alpha A' = 90.01°$; $\alpha B' = 89.93°$; $\alpha C' = 89.95°$; $\alpha D' = 90.11°$

The base has almost exactly a rectangular shape. In neglecting the little difference in the length of the corresponding sides we get:

A'B' = C'D' = 962 and B'C' = D'A' = 953

The sloping edges in the north (C'T and D'T) are completely destroyed and those in the south only partly preserved. Extending them until they intersect (T), we found:

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[34] Josef Dorner was kind enough to study the pyramidion and give the following valuable report. Miss Nivien Mohamed Mustafa and Dr. Peter Janosi helped Dr. Dorner in this study of the pyramidion. I would like to thank them all for their valuable work.–Z. Hawass.

$A'T = 911$ and $B'T = 916$

On the western face the angle included by the base and the southwestern edge was derived by an auxiliary triangle ($\alpha B' = 58.13°$) and from it the length of the sloping edge in the northwest was derived (Fig. 3):

$C'T = 909$

By these data the pyramid above the reference plane is defined and we are able to calculate all its elements (cf. Fig, 4):

in the triangle A'B'T'			in the triangle B'C'T'		
P'T	=	777	Q'T		778
P'A'	=	476	Q'B'	= P'M' =	484
P'B'	= Q'M' =	486	Q'C		469

The height:

$$M'T = \sqrt{A'T^2 - A'P'^2 - B'Q} = 607$$
$$M'T = \sqrt{B'T^2 - B'P'^2 - B'Q'^2} = 607$$

The sloping edge in the northeast:

$$D'T = \sqrt{M'T^2 + C'Q'^2 + A'P^2} = 903$$

Enlarging with the factor k the corresponding elements of the pyramidion are found:

$$k = \frac{TP}{TP'} = \frac{TP' + 130}{TP'} = 1167$$

$$k = \frac{TQ}{TQ'} = \frac{TQ' + 130}{TQ'} = 1167$$

The shape of the upper part:

height MT = 709 mm

base

S:	AB = 1123 mm	SE:	AT = 1063 mm
W:	BC = 1112 mm	SW:	BT = 1069 mm
N:	CD = 1123 mm	NW:	CT = 1060 mm
E:	DA = 1112 mm	NE:	DT = 1054 mm
mean	1118 mm		

The horizontal distance:

from top to base:			slope:	
S:	PM =	565 mm	S:	51.45° = 51°27'
W:	QM=	567 mm	W:	51.35° = 51°21'
N:	BC-PM =	547 mm	N:	52.35° = 52°21'
E:	AB-QM =	556 mm	E:	51.90° = 51°53'
mean	=	559 mm	mean	51.76° = 51°45'

The top of the pyramidion is not exactly above the center of the base but shifted 11 mm towards the corner D. The faces therefore differ considerably in their slope.

The Lower Part

The underside of the pyramidion is not flat but formed as a low and inverted pyramid. Its base lines are common with the upper one. In order to obtain its height we measured in the vertical plane, dissecting it from east to west, getting the following distances (Fig. 5):

$AE_1 = 800$; $E_1E_1 = 58$
$AE_2 = 1000$; $E_2E_2 = 110$
$AB = 1123$

Deriving from the triangle F_1F_2K:

$$\text{tg } 2\alpha = \frac{E_2E_2 - E_1E_1}{AE_2 - AE_1} \; ; \; \alpha = 7.3^\circ$$

We find the height:

$$JH = \frac{AB \cdot \text{tg}\alpha}{2} = 72 \text{ mm}$$

This height is 3 mm less than 4 fingers, which might have been intended.

A Block from the Third Course

Some interesting observations could also be obtained from a large block, which represents little more than half of the entire third stone layer of the pyramid (counting from the top). Its three faces are partly destroyed especially at the sloping edges and along the base. The upper side, better preserved, has been hollowed out in order to receive the protruding underside of the second course, which had a shape as described for the pyramidion. The underside of the block is flat.

In D, 320 mm distance from corner B, the last preserved point of this edge (cf. Fig. 6), we placed a long ruler parallel to AB and measured from it the vertical distances to E (14 mm) and F (15 mm). Enlarging the mean by 912 : 320, we obtain the depth of the point M below the horizontal edges with 41 mm. The slope of the triangle ABM is 2.6°, much less than the slope observed at the protruding underside of the pyramidion.

In the same section the slope of the faces was derived from two auxiliary triangles (all data in mm given in Fig. 7):

$\alpha_1 = 52.33^\circ$ $\alpha_2 = 52.47^\circ$ mean α: $= 52.40^\circ$

Assuming an error of ± 2 mm in the sides, the expected error in the angles is about ± 3°. The difference between α_1 and α_2 is therefore not significant.

The height of the block was measured three times:

near G:	559 mm
between J and K:	560 mm
near H:	558 mm
mean:	559 mm

Extending the sloping face and the underside of the block with two rulers we found four points of the original base lines and measured their distances from the upper edges. The results vary considerably, between 702 and 709 with a mean of 706 mm, because the faces are not plane and the underside is rough.

The slope (52.40°) and the height (559) give the recess of the faces (430) and adding the latter twice to thc length of the upper edge (1824) we receive the length of the base: GH = JK = 2685 mm.

Reconstruction

The possibility of determining accurately the original dimensions of these two blocks is restricted because both are heavily damaged. Only a few lengths, which could be measured directly, are accurate to ± 2 mm. The others are uncertain to 3 or 4 mm. It is therefore likely that the masons' work was more accurate than it appears from our results.

The mean slope of the pyramidion coincides almost exactly with that of the king's and the three queen's pyramids in the funerary complex of Cheops (51°50'),[35] and there is no doubt that the same slope was also employed for the new Satellite Pyramid. This slope is equal to a pattern of 28 : 22, a *seked* of 5 palms 2 fingers, and a proportion between height and base of 7 : 11.

In the search for the intended size of the pyramidion two possibilities must be considered:

a base of 60 ft[36] (1125) with a height of 38 2/11 ft (716)
or a height of 38 ft (713) with a base of 59 5/7 ft (1120).

The second pair differs only little from our results and is therefore much more likely.

From the third course downwards the casing blocks had flat, horizontal bases. The tbree uppermost layers, however, were linked by a peculiar construction and represent a special unit. Its base with a length of 143 ft (2681) was certainly chosen deliberately, because it corresponds to a height of exactly 91 ft (1706). Such pairs, both elements with integers, exist only in levels 7 ft from each other-

For the height of the third course we received 3 mm less than 30 ft (562). The difference is probably due to the missing edges of the base, on which the block was resting. We observed that the faces are not exactly plane, especially the section C-D, which is distinctly convex. Along the

---

35 Maragioglio and Rinaldi, *L'Architettura,* IV, p. 18, 80, 86, and 92.

36 21 ft = 18.75 mm, corresponding to a cubit of 525 mm.

upper edges the masons did not edge away enough from the block. Tbe preserved edge is 27 mm longer than 95 6/7 ft (1797) and the faces therefore more than 0.5° too steep.

Assuming that the third course rested 91 ft below the top in the height, which corresponds with the length of the base (143 ft.), the second course would have been 23 ft (431) high and the slope of its faces only 50°, due to the faulty length of AB. In Fig. 7, the deviations from the intended shape are shown in scale 1 : 1.

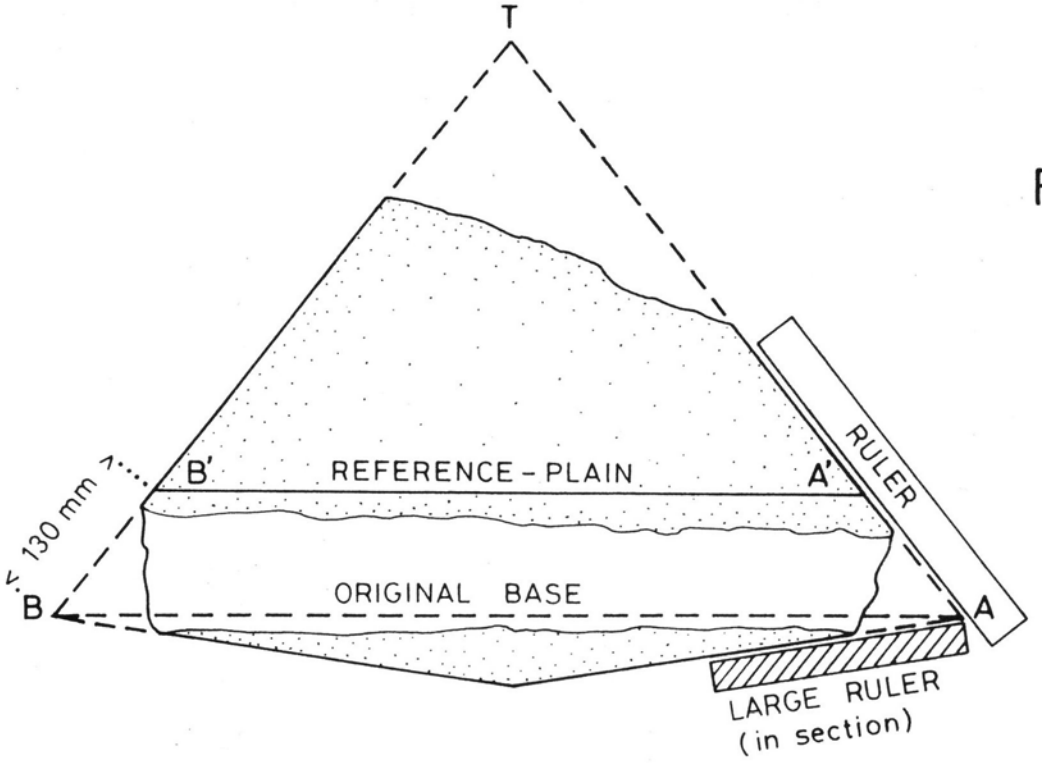

T
B'
REFERENCE – PLAIN
A'
RULER
130 mm
B
ORIGINAL BASE
A
LARGE RULER
(in section)

FIG. 1

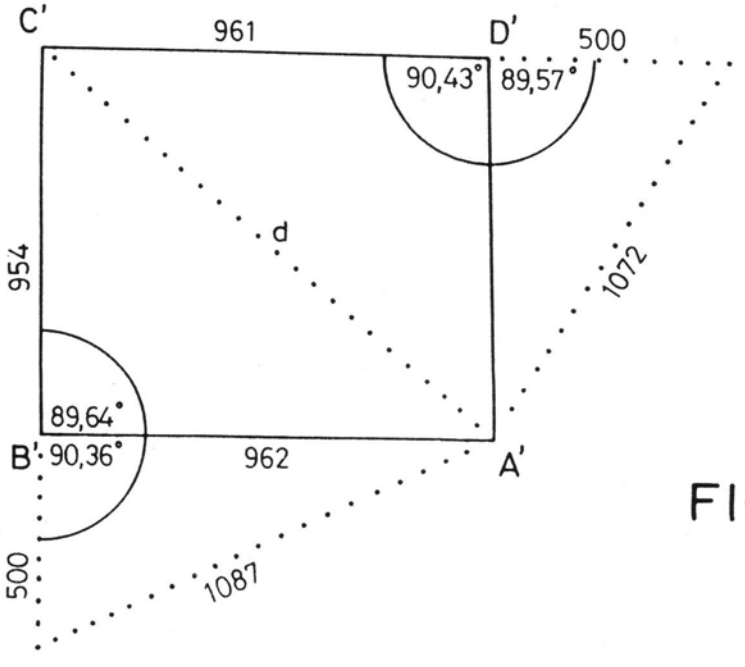

C'
961
D'
500
90,43°
89,57°
d
954
1072
89,64°
B'
90,36°
962
A'
500
1087

FIG. 2

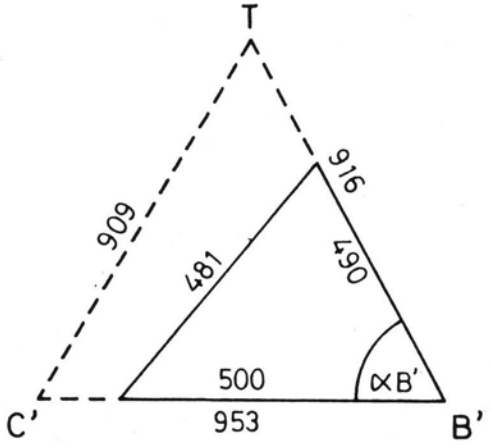


FIG. 3

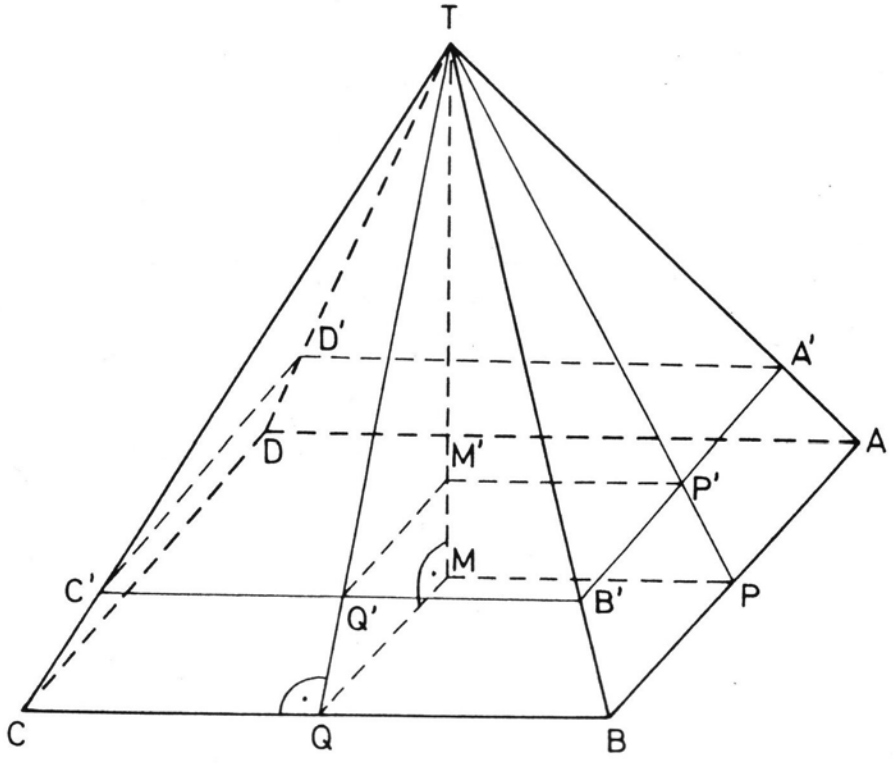


FIG. 4

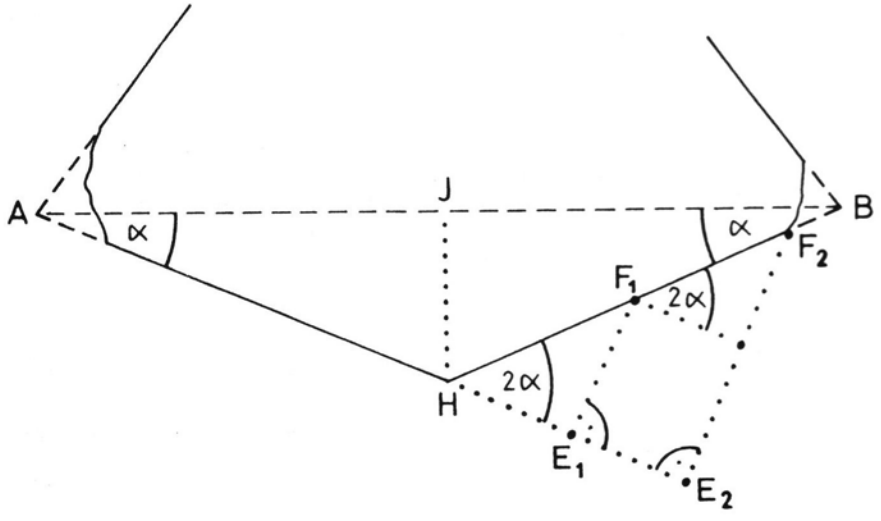
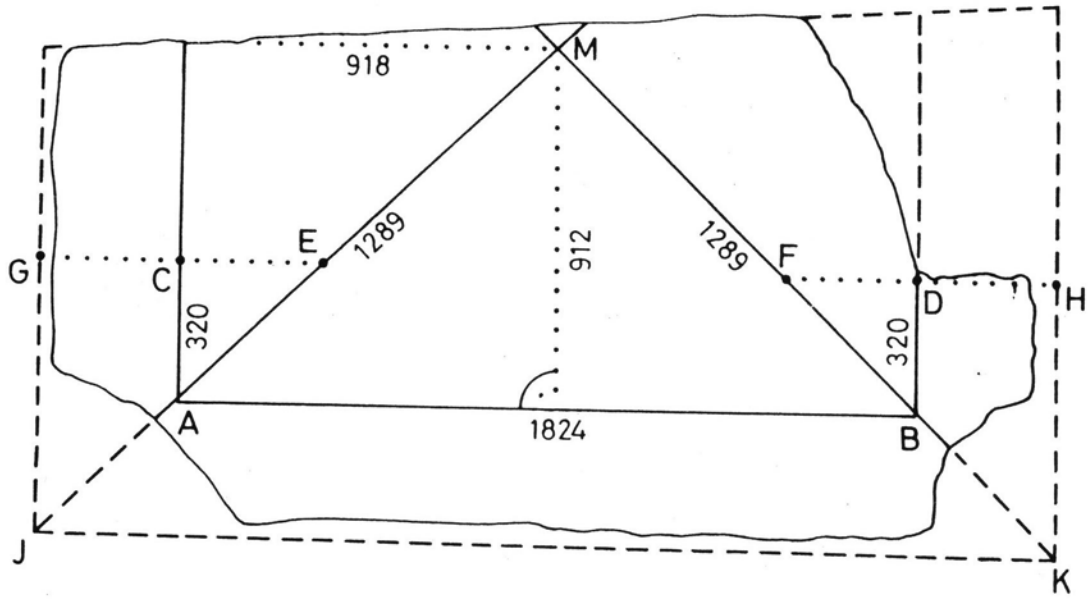


FIG. 5

FIG. 6


M
918
G
C
E
1289
912
1289
F
D
H
320
320
A
1824
B
J
K

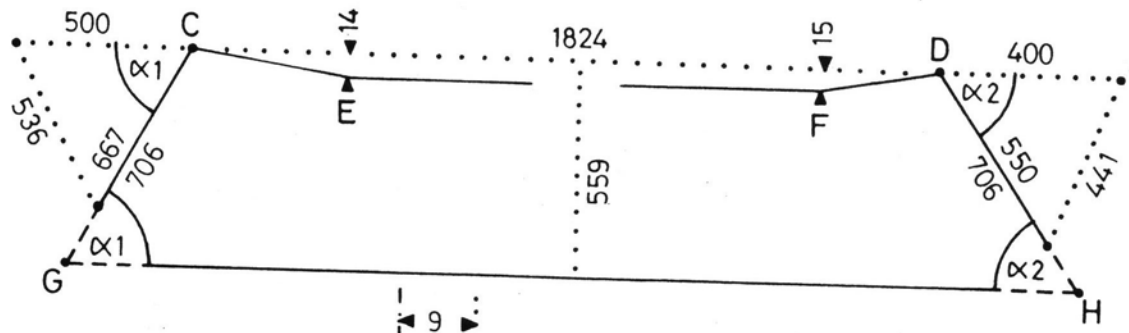
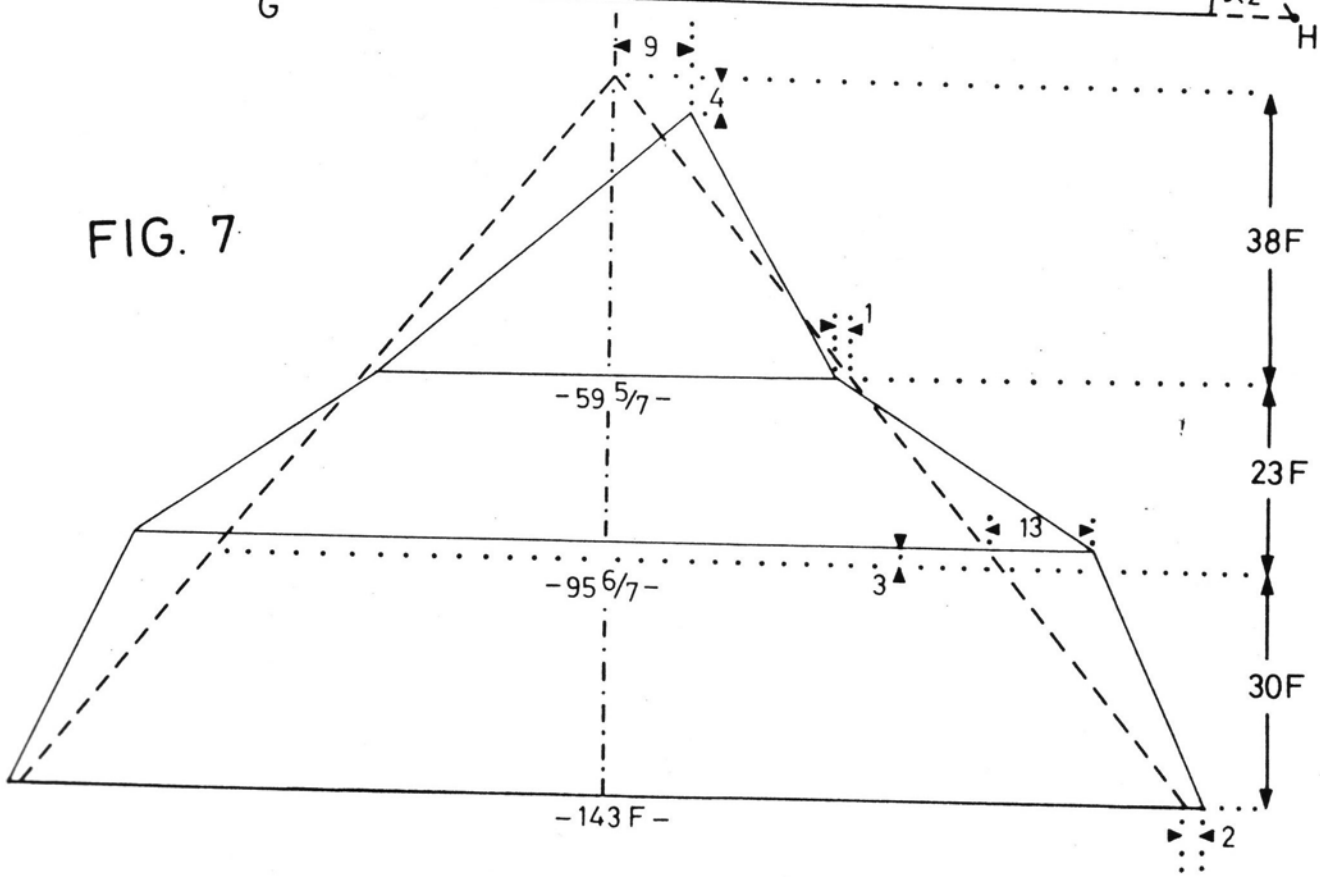

500
C
14
1824
15
D
400
α1
α2
536
667
706
E
F
559
706
550
441
G
α1
α2
H

FIG. 7


9
4
38F
1
-59 5/7-
23F
13
-95 6/7-
3
30F
-143 F-
2

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