EXAMINING THE GRAND GALLERY IN THE PYRAMID OF KHUFU AND ITS FEATURES

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ABSTRACT

The explanation of the symmetrical features on the west and east sides of the grand gallery in the pyramid of Khufu has always been an intricate puzzle for researchers. The existence of such peculiar features is generally related to the function of parking the granite plugs, but only three or four granite blocks were presumably used to plug the ascending corridor, while a much larger number of slots and niches are found in the gallery. Previous interpretations of niches, slots, cuttings and grooves are unsatisfactory, and the present investigation focuses on important, formerly neglected aspects. The analysis of numerical patterns in the design of the grand gallery provides crucial evidence, and a new interpretation of the features in the gallery is, therefore, proposed, by considering the numerous variables implied in the problem.

The grand gallery in the pyramid of Khufu, with its astonishing corbelled ceiling made of huge limestone blocks, has no parallel in internal passages of pyramid tombs. Its smaller scale prototype, though, can be identified, as indicated by Lehner (1997: 104), in the ascending corridor of the Bent Pyramid's satellite (cenotaph). The purpose of the gallery is generally related to the parking, before their release, of the three blocks in red granite that still today block the ascending corridor. However, previous interpretations of the functions of the peculiar features on the west and east sides of the monument are unsatisfactory. The present paper proposes a new explanation. As will be argued, the grand gallery was not created simply as a 'parking garage' for the granite plugs: it fulfilled also a primary symbolic purpose that can also be identified in other monuments at Giza.

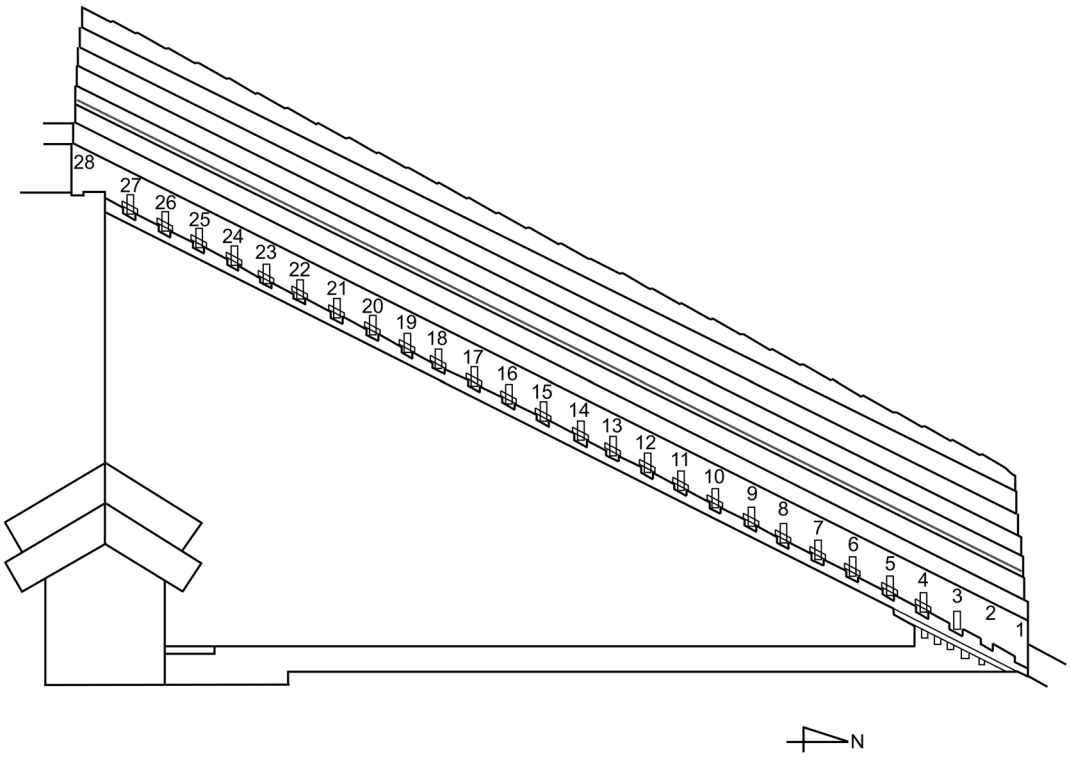

Figure 1. Plan of the grand gallery and its features. Diagram by the author.

Slots, niches and trapezoidal cuttings along the two ramp benches and side walls of the gallery are marked in figure 1 with numbers from 1 to 28. These numbers will be used to identify the symmetric features in the gallery. For example, the notation 'Nos. 1-2' identifies the two northernmost pairs of elements. The features are here described in the order of creation suggested by Lehner (1998):[1]

- The side walls of the gallery were built after the ramp benches, since the blocks of the first course rest upon the ramp benches;
- 27 slots (Nos. 1-27), or rectangular holes, were cut at regular intervals on the upper surface of each ramp bench; another pair of slots is carved against the south wall, on the great step (No. 28), for a total of 28 pairs of slots. The holes are 14 cm wide, 18 cm deep, and their mean length alternates regularly between 52.1 cm (one cubit) and 59.2 cm (Petrie, 1883: 72).[2] As illustrated by Maragioglio & Rinaldi (1965: pl. 6, fig. 5), the northern face of the notches is sloping, making a right angle with the bottom, which is crudely chiseled;
- 25 niches (Nos. 3-27), 32 cm wide and 60 cm high (mean measures), were cut above the slots on each side wall, with the exception of the two northernmost slots (Nos. 1-2) and the

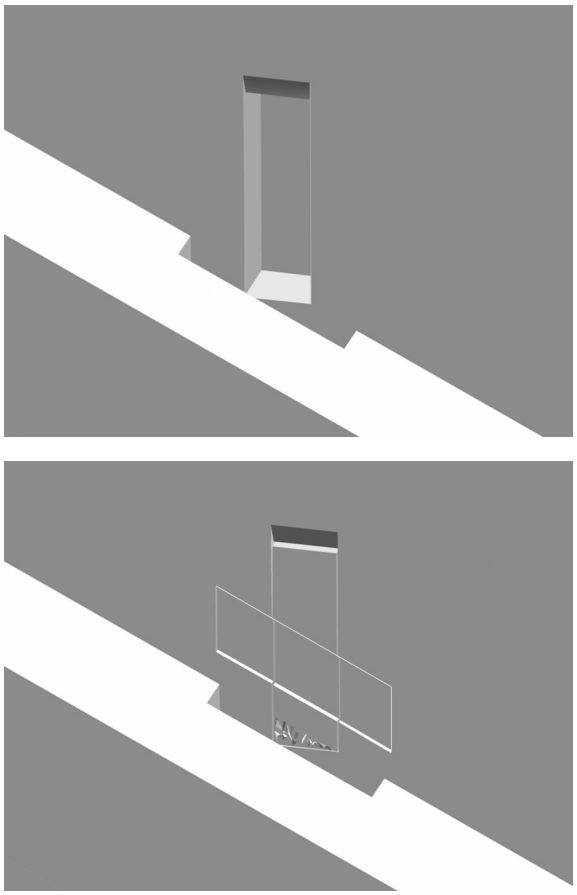

Figure 2. Slot and niche (top); niche closed with patch, and trapezoidal cutting (bottom). Diagram by the author.

slot on the great step (No. 28). It is generally recognised that the niches were later closed by limestone patches, but, according to a French team headed by Bardot & Darmon (2006: 82-91), some patches of the central niches are 'fake': the niches were carved only superficially. The 'real niches' are about 20 cm deep.[3] Their outer top is bevelled; top and bottom are horizontal; the bottom north corner is at the same level as the top of the slot, while the bottom south corner extends down into the slot for 10-13 cm (see figure 2, top), suggesting that a niche was created after the corresponding slot was completed;

- The niches were closed by limestone patches, whose bottom has the same slope as the ramp benches, and were filled below the stones with limestone fragments and mortar (figure 2, bottom). Traces of red colour are found on some patches of the northern niches (Bardot & Darmon, 2006: fig. 58). It seems a mineral pigment, probably ferruginous, visible also on some parts of the walls in the gallery;
- 24 trapezoidal cuttings (Nos. 4-27), 2-3 cm deep, 20 cm high and 55-70 cm long, were made across the patches, or the superficial niches, and on the adjacent wall (see figure 2, bottom), with the exception of the northernmost niche (No. 3). Their base lies 10 cm above the upper surface of the ramp benches; their top and bottom sides are roughly parallel to the slope of the ramp benches;
- On both sides of the gallery, a continuous groove, 15 cm high and two cm deep, was cut 13 cm above the base of the third corbel. The lower edge of the groove is situated at the half of the vertical height of the gallery, *i.e.* 4.35 m above the floor, and is less roughly chiseled than the upper edge (*cf.* Petrie, 1883: 73-74). It is impossible to deduce, by comparison with the other features, when the grooves were created, but they were probably initially intended at a lower height. In fact, two short lines parallel to the slope of the gallery were noticed by Borchardt (1932: 12) along the northern part of the first western corbel, 2.62 m (five cubits) and 2.67 m above the gallery floor.

Previous Explanations of the Features in the Grand Gallery

It is generally conceded that the three granite plugs that obstruct the lower part of the ascending corridor were parked, at the moment of the burial of the royal body, on the floor of the grand gallery. Borchardt (1932), advancing the very doubtful argument that the passage of the burial procession over the granite plugs would have compromised the ceremonial decorum,[4] suggested that the slots served as sockets for vertical beams supporting a ceiling of planks inserted into the grooves of the third corbel. The space created by the trapezoidal cuttings would have served to wind the beams with ropes. The granite plugs would have been stored upon the planks, allowing the procession to pass underneath, but how blocks weighing several tons would have been lowered down to the gallery floor is inexplicable, and Borchardt's proposal was not accepted by most scholars.

Borchardt's idea of a wooden framework was, however, proposed again by Lauer (1971: 138-41, fig. 35b), who indicated another function for such structure. Lauer based his arguments on the hypothesis that initially the king's chamber was not planned, and the queen's chamber was intended for the burial of the king. In his view, at this stage the grand gallery was closed at its upper end, and the niches were sockets for cross beams keeping back the plug blocks, parked on the floor between the ramp benches. With the building of the king's chamber as burial chamber, slots, cuttings and grooves would have been created for the construction of a wooden platform similar to the one proposed by Borchardt, with the purpose to clear the gallery from most plug blocks. Only three or four plugs would have been left at the bottom of the gallery. As Lehner (1998: 108) observed, Lauer's theory is invalidated by important arguments indicating a single plan for the chambers (Maragioglio & Rinaldi, 1965: 148-54; Stadelmann, 1990: 117-42; 1991). Also, the space between consecutive niches (1.45 m at the top of the ramp benches) is insufficient to contain the plugs in the lower part of the ascending corridor, which are 1.60-1.75 m long, and there is room for a block only 50 cm long in front of the great step (*cf.* Lehner, 1998: 105-106).[5] If, as Lauer proposed as explanation, not each and every plug was held by a cross beam, the reason for the systemic regularity of the niches would be denied.

While in Lauer's hypothesis the niches served for cross beams, slots and cuttings for a wooden framework, Goyon (1963) suggested a single function for these features. In his theory, the niches were sockets for cross beams retain-

ing the plugs, but dangerous clearences would have suggested the creation of more stable devices: a wooden mortise receiving the ends of cross beams would have been embedded in slots and trapezoidal cuttings. However, as argued by other researchers, there is no reason to believe that thick wooden cross beams, deeply inserted into the niches, could be unstable, and the cuttings are 10 cm above the top of the ramp benches, not at the same level as illustrated by Goyon (1963: fig. 73). Furthermore, even assuming that the builders initially intended to plug the whole ascending corridor, Goyon's interpretation does not account for the existence of the slots on the great step and the two northernmost pairs of slots.

The presence of features at the two ends of the gallery led Maragioglio & Rinaldi (1965: 120) to rule out the hypothesis that niches and slots were in connection with an eventual retaining system for the plug blocks. They found no reasonable explanation for the presence of the niches, but assumed that a wooden structure comparable to the panellings in the eastern galleries of the Netjerykhet pyramid was installed. Planks would have been lodged into the grooves, secured by vertical beams inserted into the slots, and ornamental wooden panels or reed mats would have been tied in correspondance to each beam. The hypothetical scaffolding would have fulfilled a merely decorative purpose, but it seems, however, unreasonable that a high corbelled ceiling with huge stones was conceived to be covered by a wooden roof.

An important question was pointed out by Lehner (1998: 106): contrarily to the hypotheses formulated by Borchardt, Goyon and Lauer, a niche was created after the corresponding slot was completed, and probably slots and niches functioned *together*. Lehner (1998: 106-7, fig. 2) suggested that slots and niches served for a series of slightly sloping wooden steps, upon which the granite plugs were placed. Although the argument, previously advanced by Wheeler (1935: 168-169, 177), that the builders intended to restrain the blocks at intervals seems reasonable, there are several problems with this interpretation. Lehner (1998: 107) admitted that his model does not explain the function of the slots on the great step and the northernmost slots, where there are no niches, nor the regular alternation between long and short slots. The assumption that not all the 28 pairs of slots existed at this stage, and some were added when the niches were plugged for an initially unexpected function, is contradicted by the regular distance between slots, which was evidently planned originally. Lehner recognised also that the slots were probably sockets for vertical objects and they "do not seem appropriate for nearly horizontal struts". Furthermore, simple artifices, as sand on the floor or chocks, would have more efficiently restrained the blocks, if necessary. To explain the second stage, Lehner assumed that the niches were closed because of a radical change in the function attributed to the features in the gallery: the slots would have been then used for vertical uprights belonging to the framework proposed by Borchardt. A wooden platform, with planks embedded in the grooves, would have improved the stability of the grand gallery, in consideration of structural difficulties the builders encountered after its completion. However, traces of structural problems are in the roof of the king's chamber and not in the grand gallery, and without a satisfactory explanation for the function of the features in the gallery at the first stage, the reasons for the changes cannot be plausibly conjectured. Furthermore, the grooves are only two cm deep, and each side of the boards would have been inserted for less than one cm. It is unclear how such an unsecure scaffold would have improved the stability of the gallery.

More recently, Bardot & Darmon (2006: 95-98, 125-129) re-proposed the assumption that the niches were sockets for transversal beams retaining the granite blocks. They argued that 'fake' niches in the central part of the gallery were made as disguise, to keep the number of plugs secret. They assumed that further granite blocks parked on the gallery floor were used to plug the horizontal corridor to the queen's chamber and even the antechamber and the king's chamber, and that the niches were closed with patches after the burial. This hypothesis seems to me unreasonable: for which reason had the niches to be disguised by adding trapezoidal cuttings after the burial of the king? Furthermore, the model proposed by Bardot & Darmon (2006: 125-129, fig. 87a-87g), in which consecutive niches are sockets for cross beams, is contradicted by the fact that, as mentioned before, the space between consecutive niches is insufficient for the length of a plug. There is evidence of a system of portcullises in the ante-

chamber to seal the King's Chamber,[6] while it seems unreasonable that for this purpose granite blocks weighing several tons were moved from the gallery floor. The function of the slots remains also obscure in the reconstruction of Bardot & Darmon.

None of the explanations previously proposed for the features in the gallery seems satisfactory. There are, however, important aspects that have been neglected. One of these concerns the force exerted by a granite block on the gallery floor.

Estimation of the Force Exerted by a Granite Plug

An object on a sloping surface is subject to two forces: a motive force F, due to gravity force, and a resistive force H, due to static friction. The mean slope of the grand gallery and the ascending corridor together, from the plug blocks to the great step, is 26°12'50" (Petrie, 1883: 65), and the equality of the forces F and H occurs when an object of weight *w* placed on the floor of the gallery has a coefficient of static friction μ of about 0.5.[7] The approximate weight of a granite plug in the lower part of the ascending corridor is about five tons,[8] and a coefficient of static friction of 0.45 would correspond to a force F - H of about 170 kg (1,670 N) for each block. One should consider, however, that the estimated coefficient of static friction of granite on stone varies usually from 0.5 to 0.7. The value depends on the roughness of the surfaces and on humidity conditions: dry surfaces imply higher coefficients. A coefficient lower than 0.5 seems, however, hardly obtainable, at least in dry conditions. It is not excluded, therefore, that the plug blocks had even to be pushed down along the floor of the gallery. An evidence of this indetermination is provided by the Bent Pyramid's satellite, in which, despite the steeper slope of 32°30', only two plug blocks out of four slid down to close the lower part of the ascending corridor. As suggested by Fakhry (1959: 94, fig. 56), a prop, inserted into a cavity of the floor to hold back the plugs, was presumably pulled away from the lower end of the ascending corridor by means of a long rope, but the two upper blocks moved only a short distance to stay in the position in which they are today. The force F - H of a granite block on the floor of the grand gallery was hence presumably low, if not negative. This important aspect was not highlighted in previous analyses.

A further important question concerns the identification of numerical patterns in dimensions and architectural elements of the grand gallery and, more generally, in the design of Old Kingdom pyramids.

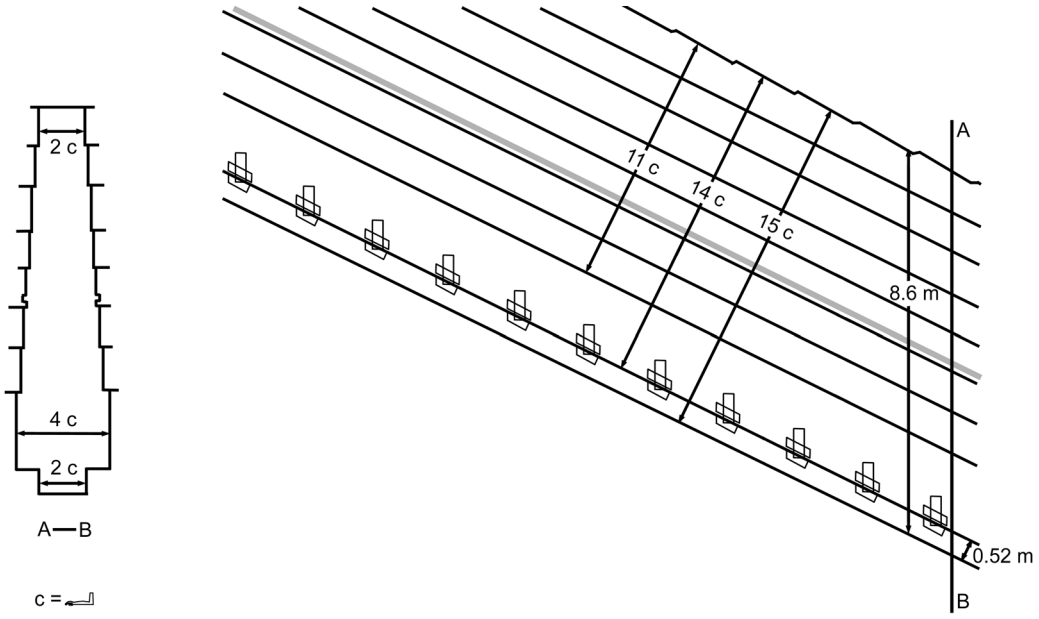

Figure 3. Measurements of the grand gallery. Diagram by the author.

Numerical Patterns: Recurrent Numbers in Architectural Dimensions

Before considering briefly the architectural design of the grand gallery, it is worth to observe that the gallery ceiling is constructed in a saw-toothed line, since each of its blocks is set at a greater inclination than the ones of the gallery floor. Thanks to this system, the lateral forces of the ceiling are transmitted by intervals to the walls, into which the blocks of the roof are plunged, and the combined transmission of forces to the northern part of the gallery is thus avoided (Petrie, 1883: 72; Maragioglio & Rinaldi, 1965: 38). The main measurements of the grand gallery are the following (see figure 3):

- The slope of the gallery corresponds to a *sḳd* of 14 palms;[9]
- The middle axis of grand gallery, ascending corridor, and all the three chambers, is 14 cubits east of the pyramid middle axis (Petrie, 1883: 72, 95; Stadelmann, 1991: 382);
- Projections of the seven corbels together: seven palms (one palm each);
- Distance between ramp benches, equivalent to space between the highest corbels: 2 cubits, or 14 palms (Petrie, 1883: 73-74);
- Sloping distance of the grand gallery from the north wall to the great step, whose junction with the ramp benches is exactly equidistant from the north and south sides of the pyramid: 88 = 11 x 8 cubits;[10]
- Perpendicular height from the gallery floor to the top of the gallery: about 15 cubits;[11]
- Perpendicular height from the top of the ramp benches to the top of the gallery: about 14 cubits;[12]
- Perpendicular height of the seven corbels together: about 11 cubits.

The design of the corbelled ceiling of the grand gallery is analogous in its conception to that of the niche in the queen's chamber: each of the seven corbels of the gallery projects 1/7 of cubit, or one palm, and each of the four corbels of the niche projects 1/4 of cubit, or seven fingers (see figure 4; *cf.* Petrie, 1883: 70; Maragioglio & Rinaldi, 1965: pl. 6, fig. 2). Remarkable is the fact that the perpendicular height of the grand gallery is 15 cubits, and the perpendicular height from the top of the ramp benches to the top of the ceiling is 14 cubits (see figure 3). As we will see, the combined use of 14 and 15 cubits is found also in the design of

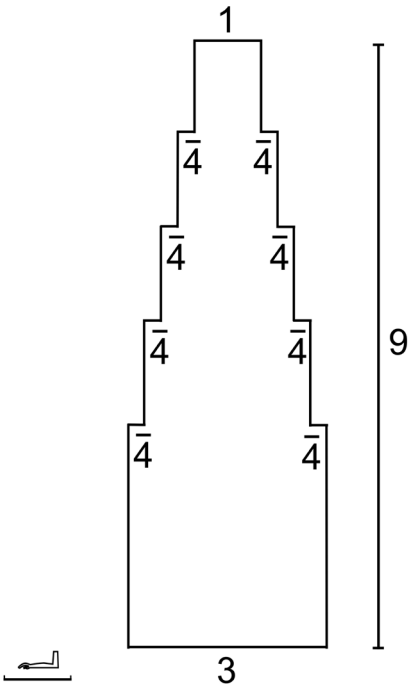

Figure 4 Measurements in cubits of the niche in the queen's chamber. Diagram by the author.

the burial chamber in the pyramid of Unas, and is presumably connected to an important numerical symbolism. The choice of 11 cubits for the perpendicular height of the seven corbels and a multiple of 11 for the sloping distance of the grand gallery from the north wall to the great step (88 cubits) can be ascribed to a wider use of multiples of 11 in the pyramid design.

Measures in cubits of Old Kingdom true pyramids, excluding subsidiary and satellite pyramids, are listed in the Appendix, from pyramid P1 to P20.[13] As one can observe, a characteristic of the pyramids of Snefru (P1-P3) and Khufu (P4) is the recurrent use of multiples of seven, nine and 11 cubits in the architectural design. Such numbers, and multiples of 15, are highlighted in bold in the Appendix, with regard to all the monuments taken into consideration. The use of multiples of seven and 11 cubits is not a mere consequence of the adoption of a *sḳd* of 5 1/2 palms (five palms, two fingers) for the inclination of the walls in the Meidum Pyramid (P3), and in the pyramid of Khufu. In fact, a *sḳd* of 5 1/2 palms was used also in later Old Kingdom pyramids, certainly in the 5th Dynasty pyramids of Neuserra at Abusir (P13) and Djedkara Isesi at Saqqara (P15). However, their dimensions are not multiples of seven and 11: both monuments have a side of base of 150 cubits, and a height of 95 1/2 cubits. On the other hand, multiples of seven, nine and 11 cubits char-

acterise the position and dimension of various architectural elements of pyramids, in particular chambers and corridors, at the beginnining of the 4th Dynasty. In addition, the level of the lower chambers above the base in the Red Pyramid, and the length of the antechamber of Khufu, is 5 1/2 cubits, *i.e.* the half of 11 cubits. The following is a list of multiples of seven, nine, 11 (or 5 1/2) cubits in pyramids from Snefru to Khufu (see the Appendix for bibliographical sources):

Bent Pyramid (P1):
- Side of base of the pyramid at the initial base-level: 360 = 9 x 40;
- Height of the pyramid in the lower part: 90 = 9 x 10;
- Horizontal distance of the bending line from the pyramid side: 63 = 9 x 7;
- Level above the pyramid base of the west corridor: ≈ 63 = 9 x 7;
- Height of the pyramid in the upper part: 110 = 11 x 10;
- Height of the lower chamber: 33 = 11 x 3.

Red Pyramid (P2):
- Length of the lower horizontal corridor: 14 = 7 x 2;
- Width of the first chamber: 7;
- Width of the second chamber: 7;
- Length of the upper horizontal corridor: 14 = 7 x 2;
- Height of the upper chamber: 28 = 7 x 4;
- Side of base of the pyramid: 418 = 11 x 38;
- Height of the pyramid: 209 = 11 x 19.
- Level above the base of the upper chamber: 22 = 11 x 2;
- Level above the base of the lower chambers: 5 1/2 = 11 : 2.

Meidum Pyramid (P3):
- Height of the pyramid: 175 = 7 x 25;
- Level above the base of the entrance: 35 = 7 x 5;
- Horizontal distance of the entrance from the north base: 28 = 7 x 4;
- Length of the corridor from second large niche to well: 7;
- Side of base of the pyramid: 275 = 11 x 25;
- Entrance, horizontal distance from the pyramid middle axis: 110 = 11 x 10;
- Length of the descending corridor: ≈ 110 = 11 x 10;
- Length of the burial chamber: 11;
- Height of the burial chamber: 11.

Pyramid of Khufu (P4):
- Height of the pyramid: 280 = 7 x 40;
- Horizontal distance of the middle of all chambers from the pyramid middle axis: 14 = 7 x 2;
- Height of the antechamber: 7;
- Length of the underground chamber: 27 = 9 x 3;
- Height of the queen's chamber up to the base of the roof: 9;
- Side of base of the pyramid: 440 = 11 x 40;
- Sloping distance of the grand gallery floor from the north wall to the great step: 88 = 11 x 8;
- Perpendicular height from the top of the ramp benches to the top of the gallery: 14 = 7 x 2;
- Length of the queen's chamber: 11;
- Height of the king's chamber: 11;
- Length of the antechamber: 5 1/2 = 11 : 2.

Multiples of 11 are identifiable already in the design of the step pyramid of Netjerikhet. In particular, the length of the longest sides of the rectangular base is 121 m, corresponding to 231 = 11 x 21 cubits.[14] In the step pyramids from the 3rd to 4th Dynasty, the *sḳd* seems to be calculated *as slope of the accretion layers*, which is the complement of the slope of the pyramid walls.[15] The mean slope of the walls in the pyramid of Netjerikhet is about 74° (Lauer, 1936: 24) and the slope of the layers is about 16°, corresponding to a ratio of 1 : 3 1/2. A ratio of 1 : 5 1/2 for the slant layers of the kernel occurs in several minor step pyramids (for the angles, Dreyer & Kaiser, 1980: 52-53):
- Seila: 14° (ratio of 1 : 4);
- Elephantine: 13° (ratio of 1 : 4 1/2);
- South Edfu: about 13° (ratio of 1 : 4 1/2);
- Ombos: 10° (ratio of 1 : 5 1/2);
- Zawyet el-Meitin: about 10° (ratio of 1 : 5 1/2);
- North Hierakonpolis, el-Kula: about 10° (ratio of 1 : 5 1/2);
- South Abydos (Sinki): about 10°? (ratio of 1 : 5 1/2).

A *sḳd* of 5 1/2 palms (five palms, two fingers) for the pyramid walls, which is found in the Meidum Pyramid (P3) and in the pyramid of Khufu (P4), was probably chosen for the properties of a corresponding triangle. In fact, in a right-angled triangle with base of 5 1/2 palms and height of seven palms, not only the length of the base equals 5 1/2 cubits divided by seven, but the slant side is obtainable, with infinitesimal error, by dividing seven cubits by 5 1/2, result 1 1/4 1/44 cubits (Miatello, 2005-6: 54). Probably, Old Kingdom architects were faced with the calculation of the hypotenuse, as is indicated also by the *sḳd* of 5 1/4 palms, characterising the slope of the pyramid of Khafra (P6), Userkaf (P9), and presumably all the pyramids from Teti (P17) to Pepi II (P20): in a right-angled triangle having height of one cubit and base of 1/2 1/4 cubits (five palms and one finger), the value of the slant side is obtainable empirically by multiplying the height by 1 1/4. This is the so-called 3-4-5 triangle.[16] In the Bent Pyramid at Saqqara (P1), the angle of 55° in the lower part of the pyramid corresponds to a triangle with base of seven units and height of 10 units,[17] slant side approximately 12 1/5. The multiplication of the values seven, 10, 12 1/5 by nine, yields 63, 90, and about 110. The sloping distance up to the bending line could thus be estimated as 110 = 11 x 10 cubits. The fact that the height of the upper part of the pyramid is also 110 cubits seems to indicate that the sloping distance of 110 cubits was known by the architects of the Bent Pyramid.

Returning to the design of the pyramid of Khufu, further multiples of seven, nine and 11 cubits, not previously highlighted, concern the design of the oblique shafts, which, as known, were not constructed to conduct air,[18] but for a mere symbolic purpose.[19] The hypothetical intersection of the upper shafts with the pyramid casing is at 154 = 7 x 22 cubits above the base, and the sloping distance up to this level is 196 = 7 x 28 cubits (see figure 5).[20]

After Khufu, multiples of seven, nine and 11 do not occur often in the architectural design (see Appendix). To such numerical patterns is ascribable the length of 27 = 9 x 3 cubits of both the burial chamber in the pyramid of Khafra (P6) and the antechamber in the pyramid of Menkaura (P7); the possible height of 126 = 7 x 18 cubits of the pyramid of Menkaura;[21] the side of the base of 140 = 7 x 20 cubits of the pyramid of Userkaf (P9). In the pyramid of

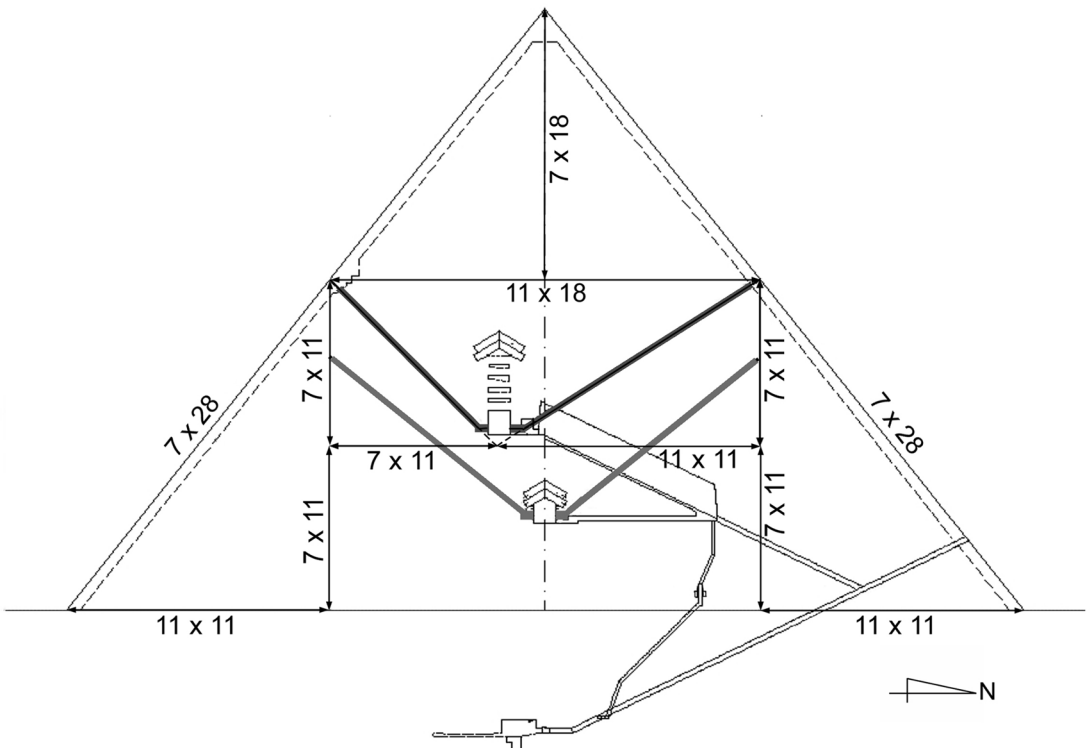

Figure 5. The design of the upper shafts in the pyramid of Khufu. Diagram by the author.

Djedkara (P15), 9 cubits is the wideness of the north chapel at the entrance of the pyramid and the height of the burial chamber. A return to the use of multiples of seven and 11 cubits seems to characterise the design of the pyramid of Unas (P16): the base length is 110 = 11 x 10 cubits and the height was possibly set at 84 = 7 x 12 cubits;[22] the total length of the horizontal corridor is 27 = 9 x 3 cubits, and the antechamber is seven cubits long. Also, the length of the burial chamber is 14 = 7 x 2 cubits in the lower section to the west wall decorated with palace-façade panelling, 15 cubits in the upper section to the gable. This combination of 14 and 15 cubits is very important: as previously indicated, it also occurs in the grand gallery of the pyramid of Khufu.

The first pyramid inscribed with the Pyramid Texts sets also dimensional canons for the chambers of later Old Kingdom pyramids: all burial chambers from the pyramid of Unas (P16) to the pyramid of Pepi II (P20) have a length of 15 cubits, width of 6 cubits, height of six cubits at the base of the gable, 9 1/2 cubits at the top of the roof. A length of 15 cubits is found already in the upper chamber of the Bent Pyramid (P1) and later in the burial chambers of the pyramids of Userkaf (P9) and Djedkara (P15). The external width of the north chapel in the pyramid of Userkaf is also 15 cubits. After Unas, the external dimensions of the pyramid are standardised: *sḳd* of 5 1/4 palms (five palms, one finger); side of base of 150 cubits, *i.e.* ten times 15; height of 100 cubits. The use of multiples of seven cubits is limited to the external width of the north chapel, which is always 14 cubits, and the antechamber is always seven cubits long. Noteworthy is also the canonical height of 9 1/2 cubits for the burial chamber. Such measure occurs for the first time in the 4th Dynasty: 9 1/2 cubits is the width of the lower chamber in the Bent Pyramid (P1), and of the burial chamber in the pyramid of Khafra (P6). It is interesting to note that the height of the pyramid of Djedkara Isesi (P15) is ten times 9 1/2 cubits,[23] and the base length is ten times 14 cubits. A remarkable pattern in the design of two pyramids at the beginning of the 5th Dynasty consists in proportioning the height of the monument to that of a large pyramid at Giza: the height of the pyramid of Userkaf at Saqqara (P9), 93 1/3 cubits, is exactly one-third of the height of the pyramid of Khufu;[24] the height of the pyramid of Sahura at Abusir (P10), 91 1/3 cubits, is exactly one-third of the height of the pyramid of Khafra.

Dimensional choices are characterised by the wide use of multiples of seven and 11 cubits in early 4th Dynasty pyramids, and standardised measurements, in particular 150 cubits for the side of the base and 15 cubits for the length of the burial chamber, in 5th and 6th Dynasty pyramids. Multiples of seven and 11 cubits, however, are not used exclusively for Old Kingdom pyramids. In papyrus Anastasi I, dated to the 19th Dynasty (BM 10247; 15, 3-4), the shaft (*jwn n fnḏ*, lit. "column of the nose") of an obelisk is 110 = 11 x 10 cubits in height, and the square base is 7 cubits: (...) *jr.w tḫn m mȝw.t ḫty ḥr rn ḥm=f ʿnḫ wḏȝ snb n mḥ 110 n jwn n fnḏ tȝy=f dby.t n mḥ 10 pȝ sn.t n pḥwy=f ḥr jr mḥ 7 ḥr wʿ.t=f nb.t* "(...) an obelisk is made anew, inscribed with the name of his majesty - life, prosperity, health - of 110 cubits for the shaft, its pedestal of 10 cubits, the base-block of its end making seven cubits on every side of it" (Fischer-Elfert, 1983: 113). Evidence that symbolic and magical properties were attributed to characteristic numerical dimensions of objects and entities is provided for by religious texts throughout two millenia.

A length that is multiple of seven and 11 cubits at the same time is attributed to the divine raft of the king's *bȝ*-soul in the Pyramid Texts (Par. 1209): *bȝ.tj ḫʿj.tj m ḫnt smḥ=k pw nj mḥ 770 spj.n n=k nṯr.w p ʿrḳ.n n=k* "You are *bȝ* and apparent at the fore of your raft of 770 cubits, that the gods of *Pe* caulked for you and the eastern gods bent into shape for you" (Allen, 2005: 160; see also Sethe, 1910: 178).

In the Amduat, seventh hour, the extent of sandbanks in the netherworld is 440 = 11 x 40 cubits, the same measure as the base length of the Khufu pyramid: *ṯs nḥȝ-ḥr m dwȝ.t mḥ 440 pw m ȝw.t=f* "The sandbank of the 'Horrible of face' in the netherworld is 440 cubits in length"; (...) *sḏȝ.w mw rn n ṯs pn mḥ 440 m ȝw.t=f mḥ 440 m sḫ.w=f* "(...) 'Bringing water' is the name of this sandbank, it is 440 cubits in length and 440 cubits in breadth" (Warburton, 2007: 230-31).

Multiples of seven cubits are frequently used in religious and magical texts to indicate the size of magical creatures, for instance in the Book of the Dead Chapter 149, centred on the 14 mounds of the netherworld: *jw ḥfȝ.w ḥr=f st.t-dswy rn=f ny-sw mḥ 70 m sjn=f* "There is a serpent on it called 'Shooter of Two Knives',

measuring 70 cubits in its circuit" (149d); *jw ḥfꜣ.w jm=f rrk rn=f ny-sw mḥ 7 m ꜣw n psḏ=f* "There is a serpent in it called Rerek, 7 cubits as length of its back" (149g). A further example is provided by the famous tale of the wax crocodile from the papyrus Westcar (Berlin Papyrus 3033, 3, 13-14): (...) *ꜥḥꜥ.n* [*ḫpr.n=f*] *m msḥ n mḥ 7 ꜥḥꜥ.n mḥ.n=f m pꜣ nḏs* [...] "(...) and it became a crocodile of 7 cubits, and it seized the commoner [...]" (see Blackman, 1988: 3).

Seven cubits is also the measure associated to the perfect proportions of the sacred eye. In the Book of the Dead, Chapter 101, the *wḏꜣt*-eye is 7 cubits, and its pupil is the half of 7 cubits: *j rꜥ m rn=k pwy n rꜥ jr swꜣ=k ḥr jr.t n.t mḥ 7 dfḏ n mḥ 3½ kꜣ=k swḏꜣ=k wsir nw ꜣḫ jḳr m js.t=k* (...) *wḏꜣ=k wḏꜣ=f* "O Ra, in this your name of Ra, if you pass by the eye of 7 cubits, pupil of 3 1/2 cubits, then you are to make the Osiris Nu well, the excellent spirit in your crew (...); (as) you are well, he is well" (see Lapp, 1997: pl. 79). Analogous is the inscription in the tomb of Paser at Thebes (TT 106, 19th Dynasty): *swꜣ.n=j ḥr dfḏ n mḥ 3½ wḏꜣ=j ḥr wḏꜣ.t n mḥ 7* "I have passed by the pupil of 3 1/2 cubits and I am well near the *wḏꜣt*-eye of 7 cubits" (Dümichen, 1869: pl. 43b).

In the Famine stela, the chief lector-priest of Imhotep reveals to Netjerykhet the different heights of the Nile, embodied by Hapy: "(...) Bounding up he copulates, as man copulates with woman, renewing his manhood with joy; he goes 28 cubits (high), he transfers to Semabehdet at 7 cubits" (*ḫpt=f mḥ 28 sjp=f r smꜣ-bḥd.t r mḥ 7* - Lichtheim, 1980: 94-100). This reference to the measurement of 28 = 7 x 4 cubits in a Ptolemaic legend is a further confirmation that the use of multiples of seven cubits was deeply-rooted in the Egyptian culture. An inscription on the enclosure wall of the temple of Edfu, making reference to the architectural plan, recites: *s.t wr.t pw nḏ ḥr-ꜣḫty s.t nḏ itf=f ḳꜣ.w=s m mḥ 105 sbḥ.t=s n mḥ 63* "It is a great place, protection of Harakhty, the place of protection of his fathers, its length is 105 cubits, its wideness is 63 cubits" (hieroglyphic transcription in Chassinat, 1932: 12). Both 105 and 63 are multiples of 7, and the measure of 63 cubits is also a multiple of nine.[25]

Even though the Egyptians tended to express the knowledge in several ways, especially with regard to the divine sphere, there is ample evidence that characteristic dimensions in cubits of objects and entities, in particular multiples of seven cubits, were identified with canons of excellence and magical attributes. The use of numerical patterns in the design of Old Kingdom pyramids is doubtless connected to such cultural aspect. A parallel phenomenon is constituted by the use of characteristic numbers in the determination of groups of elements, both in iconography and architecture.

Numerical Patterns: Recurrent Numbers of Elements in Architecture and Iconography

A symbolic significance was attributed by the Egyptians to a set of seven elements, from archaic to late periods. Religious and magical texts contain recurrent references to gods, animals, entities of all kind, in groups of seven or multiples of seven (for more examples, see Dawson, 1927). Canonical in Old Kingdom offering lists is the reference to the seven sacred oil jars. The following list shows that the numerical patterns previously highligted for architectural dimensions in the pyramids of Snefru and Khufu, with a wide use of multiples of seven, nine and 11 cubits, were also applied to architectural elements:

Bent Pyramid at Dahshur:
- No. of corbels of the roof in the lower chamber: 15 (Fakhri, 1959: 48);
- No. of corbels of the roof in the upper chamber: ?

Red Pyramid at Dahshur:
- No. of corbels of the roof in the lower chambers: 11;
- No. of corbels of the roof in the upper chamber: 14.

Meidum Pyramid:
- No. of corbels of the roof in the burial chamber: 7 (Petrie, 1892: 11).

Pyramid of Khufu at Giza:
- No. of corbels of the roof in the grand gallery: 7;
- No. of columns on the north and south side of the courtyard in the mortuary temple: 7;
- No. of columns on the west and east side of the courtyard in the mortuary temple: 14;

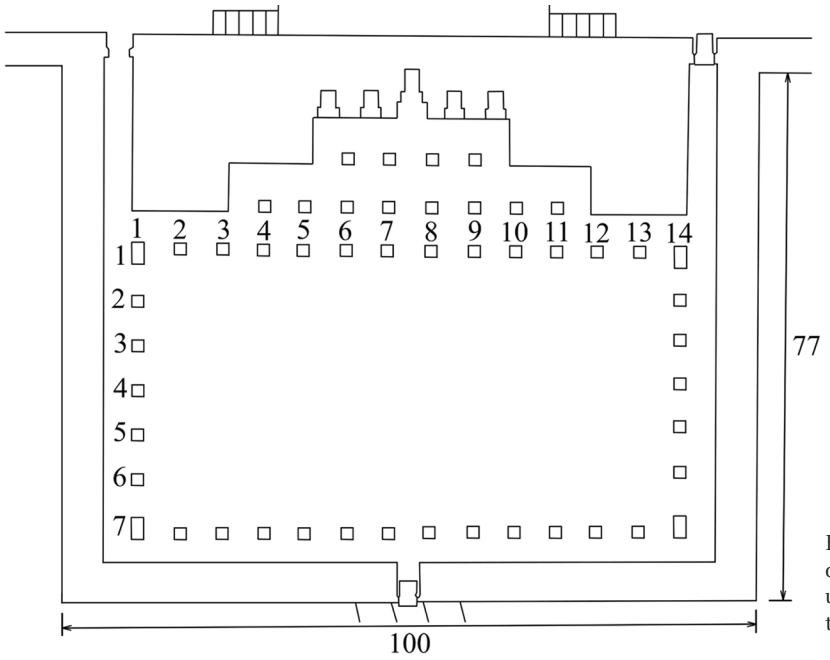

Figure 6. Rows of seven and 14 columns in the open court of the upper temple of Khufu. Diagram by the author.

- No. of slots on the west and east side of the grand gallery: 28;
- No. of beams in the roof of the King's Chamber: 9 (Petrie, 1883: 81).

Figure 6 shows the plan of the upper temple of Khufu, in accordance with the reconstrution proposed by Maragioglio & Rinaldi (1965: 60, pls. 9-10). Rows of 14 columns on the long sides, seven columns on the short ones, with columns in the corners twice as larger than the others, were lined up in the open court. The temple is 100 cubits wide, 77 = 7 x 11 cubits long from the façade to the exterior face of the temenos wall.

Noteworthy is also the use of 15 corbels for the roof of the lower chamber in the Bent Pyramid and 14 corbels for the upper chamber of the Red Pyramid. The choice of seven, nine, 11, 14/ 15 elements in the architecture of early true pyramids can be traced back to the decoration programme of the funerary complex of Netjerykhet. There, elements like hypostyle, portico, cavetto cornice, *uraeus*-frieze, *ḏd*-frieze, *ḥkr*-frieze, were proposed for the first time, and prototypes of numerical patterns can be identified.[26] For instance, the semi-circular shaped panels of blue faience tiles in underground chambers of the pyramid of Netjerikhet are composed of nine or 11 *ḏd*-pillars (Ćwiek, 2003: 73).[27]

Very important is the number and arrangement of elements in the north-south oriented rectangular enclosure wall, built with a palace-façade motif analogous to that in 1st Dynasty mastabas at Saqqara. Recesses and bastions, both decorated with pairs of niches, alternate to larger projections with a dummy door in the middle of two pairs of niches.[28] In the precinct were 196 bastions and 14 dummy gates, interpretable as gigantic false doors: four in the west and east sides, three in the north and south sides. An actual doorway was located on a projection at the south end of the eastern wall, for a total of 15 doors. This motif was executed also in the temenos wall of the mortuary complex of Sekhemkhet, and later in Middle and New Kingdom perimeter walls, for example in the pyramid complex of Senusret III at Dahshur (Arnold, 2002: 23-24, fig. 2) and in the temple of Soleb.[29] Several Middle Kingdom sarcophagi, in particular the granite sarcophagi of Senusret III and Amenemhat III at Dahshur, show the same decorative pattern on the four sides: a series of recesses and projections, on which pairs of niches and dummy doors are carved. According to the drawings published by Arnold (2002: pl. 28), though, the sarcophagus of Senusret III has 16 doors in total: three doors on each of the north and south sides, five on each of the west and east sides. In the sarcophagus of Amenemhat III, instead, the arrangement of doors in the precinct of the Netjerykhet pyramid complex is carefully reproduced: four doors on the west side, five on the eastern face, three doors on each of the other two faces, for a total of 15 doors (Arnold,

1987: 33, fig. 12). Even the door corresponding to the actual entrance is singled out on the east side, by carving it on the most projecting part of the face. In the New Kingdom, the numerical pattern of 15 doors in the precinct of the Netjerykhet pyramid complex reoccurs in the decoration of the granite sarcophagus of Pasebakhenniut I (Psusennes I, 21st Dynasty) at Tanis, usurped from Merenptah (19th Dynasty; Montet, 1951: pls. 82-88). A further example is found in the mysterious giant tomb TT33 of the librarian and priest Padi-imenipet at Asasif, from the Saite period: a rectangular stone block, or cenotaph sarcophagus, is decorated with the palace-façade pattern of three doors on the shorter faces, four on the west side, five on the east side.[30] A pair of statues of protectress gooddesses were situated at each corner, analogously, as it will be described below, to the emplacement in Tutankhamun's canopic shrine.

Although sarcophagi from the Middle Kingdom to the Late Period are decorated with 15 doors, the original pattern in the precinct of the Netjerikhet funerary complex is characterised by 14 dummy gates and one actual door. An evidence that the number 14 is fundamental in such patterns is given by the number of bastions: 196 = 14 x 14 (= 7 x 28). Moreover, the limestone basement decorated with lion heads found in a room near the colonnade of the funerary complex of Netjerykhet (Firth & Quibell, 1935: pl. 56), possibly originally used as pedestal for a statue set against a wall decorated with the palace-façade motif, shows four lion heads on the long sides and three on the short ones.[31] This is the same arrangement as the dummy gates in the temenos wall. Kees (1963: 111-12) assumed that the numerical pattern of 15 doors in total was linked to the half of the lunar month in *hebsed* celebrations.[32] As in the case of the number seven, though, multiple symbolisms were probably created in various periods. An indication can be found in the Book of the Dead, in which the 14 mounds of the netherworld of Chapter 149 become 15 in the merely visual Chapter 150. Certainly the numerical symbolism in the precinct of the mortuary complex of Netjerikhet is twofold: it involves both the number of dummy doors, 14, and the total number of doors, 15. The previously highlighted use, on a dimensional level, of the numbers 14 and 15 in the design of the grand gallery of Khufu and the burial chamber of Unas is presumably linked to such symbolism.

The numerical pattern of 15 doors is not used in Old Kingdom sarcophagi adorned with the palace-façade motif, although, as we will see, there are various references to the number 15. Table 1 shows a list of stone sarcophagi from the 4th to 6th Dynasty, usually in red or pink granite (more rarely in limestone), decorated with palace-façade patterns. In the first column is the identification number used by Donadoni Roveri (1969). It is noteworthy that all examples are from Giza, apart from three sarcophagi of the 5th and 6th Dynasty from Saqqara. The earliest are those of Kufu's sons Horbaf, Khufudjedef, Khufuankh, and Khufu's daughter Meresankh II.[33] As indicated by Donadoni Roveri (1969: 76-78), three types of palace-façade decorations can be distinguished:

1) The pattern of 'type 1' is illustrated in figure 7 with reference to the west and east side of the granite sarcophagus of Khufuankh, overseer of all the construction works of the king.[34] A palace door (*prunkscheintür*), flanked by a small niche on each side, has two jambs and the drum at the top, and is surmounted by a series of windows, in variable number. Long niches, usually three and topped by a double lotus flower, flank both sides of the door (figure 7). Projections on the walls of 1st Dynasty tombs at Saqqara have usually three niches,[35] while, as previously explained, two niches decorate recesses and projections in the temenos wall of the mortuary complex of Netjerykhet. Palace doors of 'type 1' are identified in table 1 by an abbreviated notation indicating the number of doors and niches. For example, one door in the middle of six long niches is written 1d+6n. A palace door with a single long niche on each side, executed on the north and south sides of the sarcophagus of Khufu's son Horbaf, is identified by the notation 1d+2n. The multiple arrangement of a series of doors alternated to three niches is, for instance, the feature of the sarcophagus of Menkaura, sadly lost at sea during transportation, whose numerical pat-

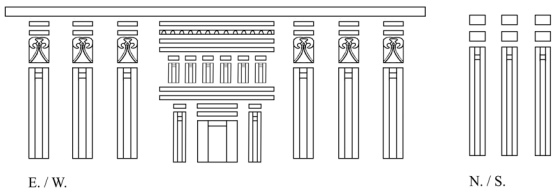

Figure 7. Palace-façade decoration of 'type 1' and 'type 2' in the sarcophagus of Khufuankh. Diagram by the author.

Dynasty	Owner	Site Inv. No.	West side East side	North side South side	Reference
4	B11 - Horbaf (Khufu's son)	Giza G 7420 CG 1788	1d+6n 1d+6n	1d+2n 1d+2n	Donadoni Roveri (1969: pl. 26/1)
4	B14 - Khufudjedef (Khufu's son)	Giza G3-S JDE 53149	1d+6n + 1d+6n 1d+6n + 1d+6n	1d+6n 1d+6n	Donadoni Roveri (1969: pls. 20/2; 23/3)
4	B15 - Khufuankh (Khufu's son)	Giza (G 7750?) CG 1790	1d+6n 1d+6n	3p 3p	Donadoni Roveri (1969: pl. 27/1)
4	B18 - Meresankh II (Khufu's daughter)	Giza G 7410-20 MFA 27.441	1d+6n 1d+6n	- - (7 gran.)	Donadoni Roveri (1969: pls. 30-31)
4	\ - Akhethetep (?) (priest of Khufu)	Giza G 7650 Brooklin 48.110	5d+18n 5d+18n	2d+9n 2d+9n	Fazzini *et al.* (1999: 47)
4	B21 - Minkhaf (Khafra's son)	Giza G 7430-40 JdE 48852	7P (7 gran.) 7P	3P 3P	Donadoni-Roveri (1969: pls. 32-33)
4	A6 - Menkaura	Giza pyramid Lost	3d+12n 3d+12n	1d+6n 1d+6n	Perring (1840: pl. 12)
4	B25 - Kaemnefret (Menkaura's butler)	Giza mastaba 3 RPM 3177	14p 14p	5p 5p	Junker (1951: pl. 10)
4	B22 - Meresankh III (Menkaura's wife)	Giza G 7530 JdE 54935	6P 6P	3P 3P	Donadoni Roveri (1969: pl. 28/1)
4	B26 - Anonymous	Giza (G 5230?) JdE 48853	15p 2P + 12p	5p 5p	Donadoni Roveri (1969: pl. 29/2)
4	B32 - Irienwer (prince)	Giza G 7810-20 JdE 48078	12p 2P + 8p	5p 5p	Donadoni Roveri (1969: pl. 29/1)
4	B33 - Anonymous	Giza G 7340 JdE 54934	3d+12n 3d+12n	2d+3n 2d+3n	Donadoni Roveri (1969: pl. 24)
4	B35 - Anonymous	Abu Rawash JdE 66611	14p 2P + 15p	7p 7p	Donadoni-Roveri (1969: pl. 28/2)
4-5	B39 - Anonymous	Giza LG 98 BM 71620	12p 2P + 8p	4p 4p	Donadoni Roveri (1969: 125)
4-5	B40 - Rawer III	Giza LG 94 JdE 51950	4d+15n 4d+15n	1d+6n 1d+6n	Donadoni Roveri (1969: pl. 27/2)
5	B47 - Ptahsedjefa Fefi (priest)	Giza G 8926 JdE 66681	2d+9n 2d+9n	1d+6n 1d+6n	Donadoni Roveri (1969: pl. 25)
5	B50 - Minnefer	Saqqara (?) Leiden AMT106	4d+15n 4d+15n	2d+9n 2d+9n	Donadoni Roveri (1969: pl. 34)
5	B51 - Hetep (priest)	Saqqara *In situ*?	2d+9n 2d+9n	1d+6n 1d+6n	Hassan (1944: 62)
5-6	B61 - Hetepi (official)	Giza G 8298 Location unkn.	3d+12n 3d+12n	1d+6n 1d+6n	Hassan (1953: 103-5, pl. 44A)
6	B75 - Khentika (priest)	Saqqara *In situ*	- 1d + 28P	- -	James (1953: 31, pl. 39)

Table 1. Numerical patterns in Old Kingdom stone sarcophagi decorated with palace-façade panelling.

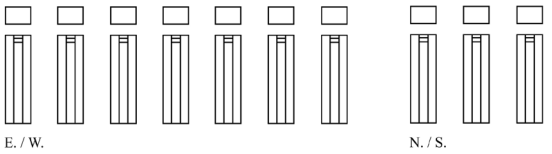

Figure 8. Palace-façade motif of 'type 2' in the sarcophagus of Minkhaf. Diagram by the author.

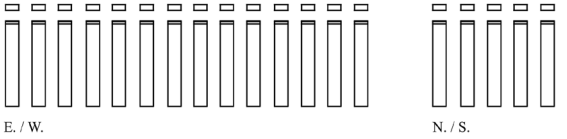

Figure 9. Palace-façade motif of 'type 3' in the sarcophagus of Kaemnefret. Diagram by the author.

tern on the west and east sides is three doors and twelve niches (3d+12n);[36]

2) 'Type 2' is a simplified motif of palace-façade. It is found, for example, on the four sides of the sarcophagus of Khafra's son Minkhaf (see figure 8). The door, or recessed panel constituted by a niche in the middle of two narrow jambs, is similar to the niche in the motif of 'type 1'. Both niches have the drum at the top, generally interpreted as a rolled-up woven curtain. Usually, above the narrow door is a rectangular cut as wide as the door. The elements in the decoration of 'type 2' are identified in table 1 by capital 'P'. For instance, the sarcophagus in pink granite of Minkhaf has seven panels in the west and east sides (7P), and three panels in the north and south sides (3P). Tombs with doors of 'type 2' are rare. Examples of this kind are in Naga-el-Der (Reisner, 1908: fig. 65, pl. 28 c-d; 1936: fig. 51, 128);

3) The simplification is even higher in the motif of 'type 3', which is used, for example, as decoration of the sarcophagus of Kaemnefret (see figure 9). The door is a narrow niche without jambs and with a small upper drum, above which is a small rectangle. This motif, rarely found in tombs, appears on the exterior wall of the cult chapel of the south tomb of Netjerykhet, surmounted by the famous *uraeus*-frieze (Lauer, 1936: pl. 52). Elements of 'type 3' are identified in table 1 by the letter 'p'. For example, the sarcophagus of Kaemnefret has 14 panels on the west and east sides (14p), five panels on the north and south sides (5p).

The analysis of the typological and numerical patterns of the sarcophagi listed in table 1 provides interesting insights. If we compare the scheme 1d+6n on the long sides, 1d+2n on the shorts sides, in the sarcophagus of Horbaf, with the scheme 7P on the long sides, 3P on the short sides, in the sarcophagus of Minkhaf, it seems reasonable to deduce that the meaning of seven elements was attributed to the door of 'type 1' with six niches. This deduction is also supported by the comparison of the decorations in the sarcophagi of Horbaf and Khufuankh: both are characterised by the pattern 1d+6n on the west and east sides, while the sarcophagus of Khufuankh shows three panels (3p) on each of the shorter sides, in place of the door with two niches (1d+2n) in the sarcophagus of Horbaf. The pattern of seven elements on the long sides and three elements on the short ones, in the sarcophagi of Horbaf, Khufuankh, and Minkhaf, can be paralleled to the arrangement of the statues of the king in the T-shaped pillared hall of the valley temple of Khafra, set up in groups of 3, 7, 3, 7, 3. Two dyads of the seated king were also situated in the chambers behind the entrances, for a total of 27 statues (see Hölscher, 1912: 89-104; Arnold, 1999: 41; Ćwiek, 2003: 99).[37] A numerical pattern in palace-façade decorations of 4th Dynasty sarcophagi envisages seven or 14 elements of decoration on each of the long sides. Evident instances are the sarcophagi of Minkhaf, with seven panels (7P), and Kaemnefret, with 14 panels (14p). The inscription of the seven granaries in offering lists with the *ḥtp dj nswt* formula, on the sarcophagi of Meresankh II and Minkhaf, may be linked to the decorative scheme of panelling based on the number seven.[38]

No Old Kingdom sarcophagus shows the numerical arrangement of 15 palace doors from the precinct of the funerary complex of Netjerykhet. A total of 14 doors, though, occurs in the uninscribed sarcophagus Brooklin 48.110, which was found in Pit C of Tomb G 7650 of the high priest Akhethetep and his wife Meretites (Khufu's daughter), in the eastern cemetery at Giza (Reisner, 1942: 47, 118, fig. 9; Fazzini *et al.*, 1999: 47).

The palace-façade pattern in the sarcophagus of Menkaura, later also adopted in the sarcophagus of the high official Hetepi, is characterised by 15 elements on each of the longer sides (3d+12n). As we will see, a total of 30 panels of 'type 2' are chiseled on the four walls of the vestibule in the pyramid of Menkaura. Panels of 'type 3' in number of 15 are found on the

west side of the anonymous sarcophagus Cairo JdE 48853, which counts 14 panels on the opposite side (2P+12p). Fifth Dynasty sarcophagi listed in table 1 show on the long sides the pattern of two doors of 'type 1' and nine niches (2d+9n), for a total of 11 elements, identifiable also in the palace-façade decoration of each of the three walls around the sarcophagus in the burial chamber of Unas.[39] Of particular interest is the sarcophagus of Khentika, a high priest under Teti or Pepi I (6th Dynasty): it displays on the east side a double-leaf-door that is decorated with the sacred eyes, flanked by 14 panels of 'type 2' on each side, for a total of 28 panels. The motif of the two *wḏ3t* eyes on the east side of sarcophagi appears for the first time in the 6th Dynasty and is canonically used in the Middle and New Kingdom.

The arrangement in groups of seven, 14, 28 doors indicates that the numerical pattern of 14 dummy gates in the precinct of the mortuary complex of Netjerykhet was linked to the symbolic number seven. However, given the various numerical patterns in palace-façade decorations of royal monuments, *e.g.* in the sarcophagus of Menkaura and in the burial chamber of Unas, it is unlikely that, as suggested by some scholars, the arrangement of 14 false doors was associated to the concept of the 14 *k3w* of the king and the sun god.[40]

Architectural elements in the 4th Dynasty are frequently arranged in groups of seven along the sides of rectangular structures. Instances of this kind have been previously cited: seven and 14 corbels in chambers of the pyramids of Snefru; seven corbels in the grand gallery of the pyramid of Khufu; seven and 14 columns on the sides of the open court in the valley temple of Khufu; seven statues on the longest sides of the main hall in the valley temple of Khafra; seven or 14 elements on the sides of sarcophagi decorated with the palace-façade motif, etc. The arrangement of 28 slots on the long sides of the grand gallery can be undoubtedly ascribed to such scheme, which, on the other hand, is identifiable also in New Kingdom iconographic material.

Table 2 is a list of friezes from the 18th to the 21st Dynasty, mostly *uraeus*-friezes in drawings of papyri and wall paintings of tombs. A group of seven *uraei*, depicted in the Book of the Dead of Ani (BM AE 10470, 37), is a magical construction illustrated in Pyramid Texts (Par. 511), Coffin Texts, Book of the Dead (Chapter 83), and various magical texts (Dawson, 1927: 97-98).[41] In the first twelve examples listed in table 2, the elements of the frieze are multiples of the numbers seven, nine, 11 and 12, while the last eight instances do not belong to such numerical patterns. The frequent occurrence of multiples of seven, nine and 12 elements in *uraeus*-friezes is mentioned in the *Lexikon der Ägyptologie* (Martin, 1986: 866). That multiples of 11 constituted a numerical pattern even in this period is confirmed by the repeated depiction of 11 gods, *e.g.* in the Book of the Dead of Anhay (BM 10472, 4; Pinch, 1994: fig. 15) and in the Book of the Dead of Ani (BM 10470, 9; Quirke, 1993: 24).[42] The proposed list has obviously a limited statistical value, but several other examples of friezes arranged in symbolic number can be added, including also material from the Late Period. For instance, the stela Pelizaeus 2127 (25th Dynasty) is surmounted by 27 (= 9 x 3) *uraei* (Röder, 1921: 92-93, pl. 31).

Uraeus-friezes are commonly used in the New Kingdom as decoration of the Osiris shrine. The famous Tutankhamun's canopic shrine (JE 60686) is composed of an inner and outer shrine set on a sledge, each surmounted by cavetto cornice with a *uraeus*-frieze on all four sides. The upper frieze at the top of the outer shrine is composed of 14 elements on each of the north and south sides, 13 elements on each of the west and east sides; the lower frieze at the top of the inner shrine comprises 15 *uraei* on each of the four sides (see figure 10). Four

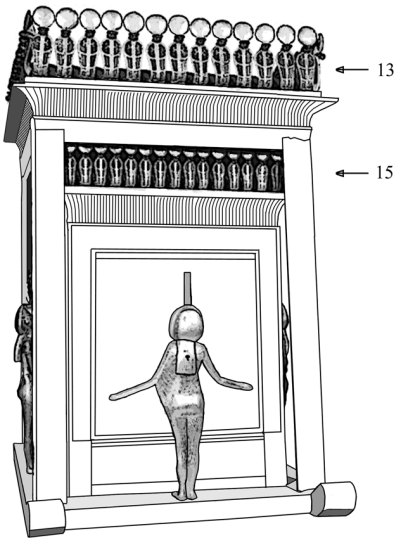

Figure 10. *Uraeus*-friezes on the west side of Tutankhamun's canopic shrine. Drawing by the author.

Dynasty	Frieze	No. of Elements	Reference
19	Book of the Dead of Ani, BM AE 10470, 37: shrine	7 *uraei*	Quirke (1993: 24)
21	Book of the Dead of Pinedjem, Cairo SR 11488: shrine	7 + 4 (= 11) *uraei*	Saleh & Sourouzian (1986: n. 235)
18	Book of the Dead of Nebseny, BM AE 9900, 10: shrine	14 (= 7 x 2) grapes	Munro (1988: 281)
19	Book of the Dead of Hunefer BM AE 9901, 3: shrine	28 (= 7 x 4) *uraei*	Corzo (1996: 177)
18	Thutankhamun canopic shrine, Cairo JE 60686, W./E. side	28 (= 7 x 4) *uraei* 15 (lower) + 13 (upper)	James (2000: 100)
18	Tomb of Paheri, el-Kab, niche in the N. wall of the main chamber	28 (= 7 x 4) *ḫkr*	Tylor & Griffith (1894: pl. 9)
19	Book of the Dead of Ani, BM AE 10470, 31-32: shrine	42 (= 7 x 6) *uraei*	Quirke (1993: 24)
19	Book of the Dead of Ani, BM AE 10470, 20: shrine	9 *uraei* 9 *ḫkr*	Corzo (1996: 185)
21	Book of the Dead of Nedjimet, BM AE 10541: shrine	11 *uraei*	Kitchen (1989: 100)
18	Tomb of Nefertari QV66, antechamber, E. wall	11 *uraei*, 9 *mꜣʿt* feathers	Corzo (1996: p. 64, pl. 14)
19	Book of the Dead of Ani, BM AE 10470, 4: shrine	12 *uraei*	Quirke (1993: 24)
19	Tomb of Sennedjem TT1, Deir el-Medina, chamber C, W. wall: shrine	24 (= 12 x 2) *uraei*	Bruyère (1959: pl. 20)
18	Book of the Dead of Kha, Museo Egizio di Torino: shrine	13 *uraei*	Corzo (1996: 66)
20	Tomb of Ramses III KV11, access stairway: shrine	13, 16 *uraei*	Reeves & Wilkinson (1996: 159)
19	Tomb of Sennedjem TT1 (Deir el-Medina), chamber C, N. wall: shrine	19 *uraei*	Bruyère (1959: pl. 29)
18	Tomb of Tutankhamun KV62, burial chamber, E. wall: shrine	20, 23 *uraei*	Reeves & Wilkinson (1996: 45)
21	Book of the Dead of Nestanebtasheru, BM AE 10554, 79, shrine	23 *uraei*	Quirke (1993: 145)
20	Book of the Dead of Anhay, BM AE 10472, 5: shrine	26 *uraei*	Strudwick (2006: 236)
18	Tutankhamun canopic shrine, Cairo JE 60686, N./S. side	29 *uraei* 15 (lower) + 14 (upper)	James (2000: 100)
18	Antechamber of Nefertari QV66, E. and S. wall: shrine	32 *uraei*	Corzo (1996: 64, pl. 14)

Table 2. Number of elements in New Kingdom friezes.

statues of goddesses in gilded wood protect the reliquary at the four cardinal points: Isis (west), Nephthys (east), Selkis (south), Neith (north). Numerical patterns are clearly constructed with reference to each side of the shrine. The choice of 14 and 15 elements on each of the north and south sides is presumably related to the previously-described symbolic association between the two numbers, traceable back to the arrangement of gates in the precinct of the funerary complex of Netjerykhet. Remarkable is the fact that the previously-mentioned cenotaph sarcophagus of Padi-imenipet at Asasif, decorated with 15 palace doors, was also surrounded by protectress goddesses on the four sides.

The numerical pattern on each of the west and east sides, instead, presumably consists of a total of 28 elements. As indicated in table 2, a frieze of 28 elements occurs also as decoration of the Osiris shrine in the Book of the Dead of Hwnefer (BM AE 9901, 3). It is interesting to note that in this vignette the rightmost cobra lies in an external position, on the right of the shrine's wall.[43] Such arrangements can be paralleled to the 27 slots on each ramp bench of the grand gallery in the pyramid of Khufu, with a last notch on the great step, for a total of 28 elements. A further example of frieze composed of 28 elements from the 18th Dynasty is indicated in table 1: a niche with three statues in Paheri's tomb at el-Kab is surmounted by 28 *ḫkr* signs.

Some decorative patterns were established for the entire history of Egypt, and groups adding up to multiples of seven on the sides of a funerary monument are found in all periods. An example from the 26th Dynasty is the magnificent sarcophagus of Ankh-hor (Berlin ÄMP 41), in which 21 (= 7 x 3) mummified gods are depicted on each long side, according to the canonical representation of the 42 mummified gods in the so-called negative confessions (Book of the Dead, Chapter 125; Schoske & Wildung, 2008: 10-11, fig. 1).

In the light of the proposed analysis on the use of the numerical symbolism in dimensions and entities, in particular at the beginning of the 4th Dynasty, one can reasonably deduce that the numerical pattern of decoration envisaging multiples of seven on the sides of an architectural structure was used to establish the number of slots along the walls of the grand gallery in the pyramid of Khufu.

A New Hypothesis on the Function of Slots, Niches, Cuttings and Grooves in the Grand Gallery

Returning to the problem of the function of the features in the grand gallery, conjectures should take into account the following premises:
1) Probably, slots and niches were devised to function together;
2) The granite plugs, presumably numbering three or four,[44] were roughly in state of balance of forces on the gallery floor and hence needed a 'safety system', more than a 'retaining system';
3) The slots were conceived in symbolic number, according to a pattern envisaging multiples of seven elements at the sides of an architectural structure;
4) The grooves are scarcely suitable for the insertion of large boards - it is more likely that they were constructed to lodge a cross beam, which can be inserted deeply. A transverse beam can be part of a movable structure to lift up heavy objects by means of ropes; it can be interlocked by a vertical board (figure 11, left) that is fixed at the centre of the floor by two side planks (figure 11, right). The continuity of the grooves along the walls would allow to move easily such simple device from the north part of the gallery to its upper end.

On the basis of the various premises and restrictions, let us first consider the hypothesis that 28 decorative and symbolic objects in stone (slab stelae) were installed along both sides of the grand gallery. This was done by means of a lifting structure, with the accessory purpose to create a safety system for the granite plugs. Considering the architecture and decoration programme of 4th Dynasty pyramids, *the only attested multiple motif in a corridor-chamber inside the tomb is the palace-façade panelling.* In fact, 30 doors of 'type 2', or recessed panels, are carved on the white limestone walls of the corridor-chamber in the pyramid of Menkaura: 11 panels on each of the west and east walls, two pairs on each of the north and south walls, for a total of 15 panels on each side of the doorways (see figure 12).[45] This vestibule, introduced also in the architecture programme of 5th and 6th Dynasty pyramids (see Appendix), precedes the portcullises and the antechamber, exactly as the grand gallery in the pyramid of Khufu. An antecedent to its wall decoration can be identified in the three limestone panels inserted into doorway niches, and thus acting as false

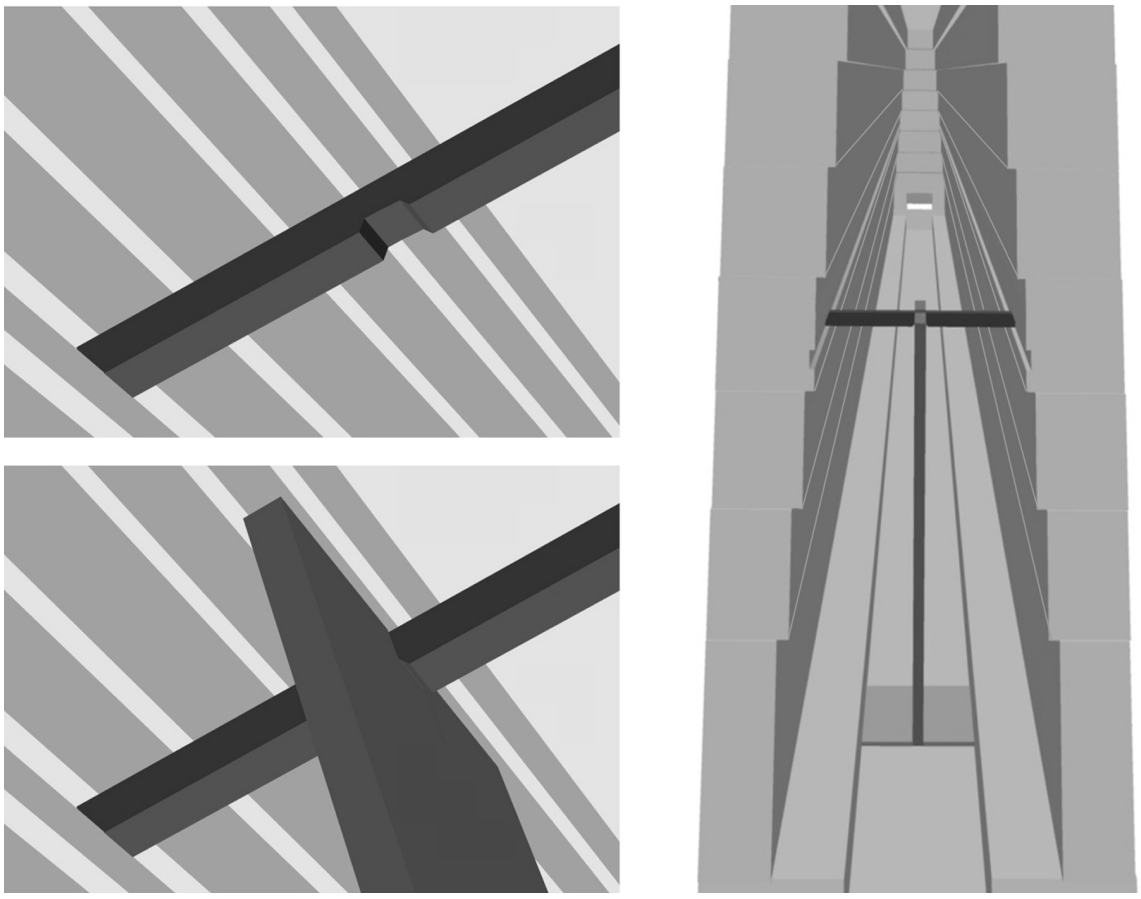

Figure 11. Hypothetical movable wooden structure to lift up objects. Diagram by the author.

doors, in the underground corridor of pyramid and south tomb of Netjerykhet.[46] A simplified palace-façade panelling of 'type 1', composed of a series of doors alternated to three niches, was executed also on the four inner walls of the open court in the upper and valley temples of Menkaura (Reisner, 1931: 25, 40; 1942: 380).

The use of the palace-façade in tombs of the royal family and high officials at Giza follows a scheme established at Saqqara from the 3rd to 4th Dynasty. Several stages of development of the palace-façade motif can be identified in the Thinite period. In 1st Dynasty mastabas at Naqada, Tarkhan and Saqqara, recesses alternated with projections decorate the four exterior walls in crude bricks of the superstructure, containing store-rooms.[47] The palace-façade motif is also depicted on round topped *srḫ* stelae set in front of the tombs at Abydos.[48] As early as the 2nd Dynasty, a section of the panelling appears at Saqqara as ornament of the tomb: a palace door is withdrawn on the east wall of the mastaba, at its southern and northern end (Hassan, 1944: 71). In tomb No. 2331, the upper part of the larger southern door is decorated with

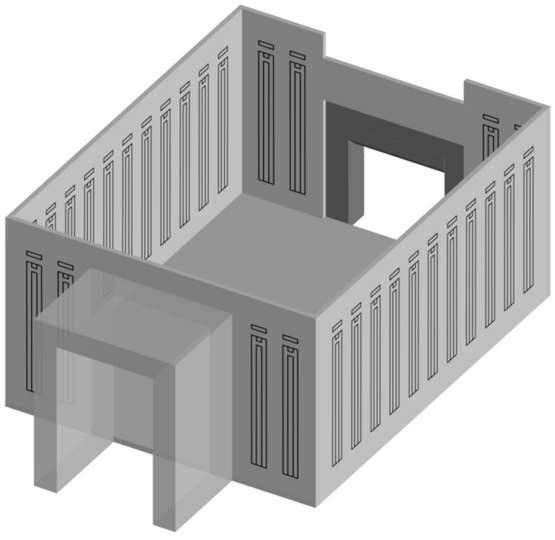

Figure 12. The panelled vestibule in the pyramid of Menkaura. Diagram by the author.

a stela representing the deceased seated before the offering table with loaves bread (Quibell, 1923: pl. 28). This is one of the earliest examples of this important scene, canonically employed in later Old Kingdom tombs.[49] During the 3rd and 4th Dynasty, the use of the palace-façade is relatively standardised: it is executed on the

eastern external wall of the mastaba, usually not extensively, and on the west wall of the interior funerary chapel. The palace-façade door, which can be considered the oldest form of false door, is often found as accessory of conventional false doors. When a complete panelling occurs, this can be usually found on the east façade of the monument, as in the 3rd Dynasty tomb of Hesira. There the motif on the east wall in crude bricks is composed of 11 recessed doors, each containing a painted wooden panel, alternated to projections with three niches (Quibell, 1913: pls. 1-5). Five wooden panels remain in good condition, one depicting the deceased before the table of bread loaves. Rather than store-rooms in the superstructure, a series of paintings, representing the mortuary equipment of the deceased (vessels, furniture, tools, games, etc.), were painted on a brick wall in front of the palace-façade. The scheme of panelling in 4th Dynasty tombs at Saqqara can also be identified in the necropolis of Giza, as the following list indicates (*cf.* Reisner, 1942, 380-382):[50]

1) Palace-façade on the west wall of the interior funerary chapel.

A palace door is used as chief false door in several tombs:
- G 7530 + 7540: Queen Meresankh III, wife of Menkaura, 4th Dynasty (Flentye, 2006: fig. 8);
- G 7050: Nefertkau, probably daughter of Snefru, 4th Dynasty;
- G 7060: Nefermaat, son of Nefertkau, 4th Dynasty (Lepsius, 1849-1858: pl. 17);[51]
- G 7070: Snefrukhaf, son of Nefermaat, 4th Dynasty (Mariette, 1885: 533);
- G 2097: Niimatra, late 5th Dynasty; palace door on the west wall of a recess in the chapel (Roth, 1995: pls. 90, 186).

In some cases, the palace door is withdrawn beside the conventional false door on the west wall of interior chapels:
- G 7650: Akhethetep, priest of Khufu (Hassan, 1932: 81, fig. 141, pl. 51);
- G 7150: prince Khufukhaf II, 5th Dynasty, reign of Niuserra.

A 'hybrid' configuration is obtained by adding elements of the palace door, in particular the niches, to a conventional false door:
- G 7760: prince Mindjedef, reigns of Khafra to Menkaura (Lepsius, 1849-1858: pl. 33);
- G 8090 (LG 90): Debehen, reign of Menkaura (Hassan, 1943: 182, fig. 128);
- G 7810: prince Djaty, 4th to 5th Dynasty;
- G 7948: Khafra-ankh, 5th Dynasty or later (Lepsius, 1849-1858: pl. 10).

A palace-façade door appears in the middle of two conventional false doors on the west wall of the offering chamber in the following tombs:
- G 8172 (LG 86): Prince Nebemakhet, reigns of Khafra to Menkaura or later;
- G 2415: Weri and his wife Meti, late 5th Dynasty;
- G 1301: Mernisut, 5th Dynasty (Peck, 1972: 66, fig. 3);
- G 5340: Kaswedja, 5th to 6th Dynasty;
- G 2091: Kapi, 5th to 6th Dynasty (Roth, 1995: 103, pl. 53c);
- G 2184: Akhetmerutnisut, 5th to 6th Dynasty.

In the temples of the subsidiary pyramids of Menkaura, a panelling is executed on the west wall of the offering chamber:
G3-a, G3-b, and G3-c: Queens under the reign of Menkaura. In the temples of G3-a and G3-c, an actual doorway to an accessory cult room is in the middle of two palace doors of 'type 1', each flanked by three niches on each side (Reisner, 1931: plans 4-6).

In one case, an actual doorway in the west wall of the alcove chamber is decorated as a palace door of 'type 1', flanked by three niches on both sides:
G 8080 (LG 92): rock-cut tomb of prince Iuenmin, late 4th Dynasty (Mariette, 1885: 545).

In two false doors, the scene of the deceased before the table of bread loaves on the architrave is flanked by a palace door on both sides:
BM 157 a/b: false doors of the official Tjeti and his wife Debet, 5th Dynasty (James, 1961: pls. 6-8; Porter & Moss, 1974: 302).

Exceptional is the position of the palace door on the north wall of the inner chapel in the tomb G 8154 of Sekhemkara, dated to the 4th to 5th Dynasty (Junker, 1938: 49; Hassan, 1944: 76).

2) Palace doors on the east façade of the tomb.

Relatively rare is the panelling on the eastern exterior wall of tombs at Giza:

- Mastaba IV (G I S, No. 3): prince Khufudjedef, 4th Dynasty; on each side of the doorway to an interior chapel is a palace door;
- Pyramid G1-c: Henutsen, Queen under the reign of Khufu; the east wall of the exterior chapel in white stone shows a palace-façade panelling on each side of the entrance;
- G 5150: prince Seshathetep, 4th to 5th Dynasty; a palace door is present on each side of the entrance (Kanawati, 2002: pl. 41; Der Manuelian, 2003: 211);
- G 8172 (LG 86): prince Nebemakhet, 4th Dynasty, Khafra to Menkaura; the entrance of the rock-cut tomb is decorated by simplified panelling, flanked by a pair of false doors on both sides (Hassan, 1943: 129, fig. 171);
- Mastaba IX (G I S, No. 8): Sekhemka, late 5th Dynasty; a palace door is carved on the exterior *serdab*, over the entrance to a sloping passage leading to the burial chamber;
- G 5080: Seshemnefer II, 5th Dynasty; unfinished panelling in two places;
- G 2184: Akhmerutnisut, 5th to 6th Dynasty; several stages of panelling, the last of which featuring three palace doors separated by wall scenes in relief.

A peculiar palace-façade panelling is found in the two steps mastaba of Queen Khentkaus I (5th Dynasty): it was carved on the rock core on the south side and then covered by the casing, which is now completely lost (Hassan, 1943, 15; Maragioglio & Rinaldi, 1967: 170-72; pl. 18, fig. 7). It is possible that the motif was executed also on the core at the other sides, where the casing is still present, to imitate the decoration in crude-brick mastabas of the earliest Dynasties.

The central element of the palace-façade panneling on the eastern exterior wall of tombs is usually the actual doorway. This concept is identifiable also in the vestibule of the pyramid of Menkaura, and, hypothetically, in the grand gallery of the pyramid of Khufu. However, in these cases the doorways are inside the tomb: both rooms are located before the portcullises and mark the access to a horizontal corridor, antechamber and burial chamber. In analogy, in the temples of the pyramid of Menkaura and in those of the subsidiary pyramids G3-a and G3-c, the panelling marks the access to cult rooms. Whether the upper temple of 4th Dynasty pyramids included an offering chamber with false door, as argued by Stadelmann (1985: 213), or whether this scheme was introduced in the 5th Dynasty, as suggested by Jánosi (1994), is still matter of discussion.

According to Lauer (1948: 3-16) the palace-façade of tombs represented the royal palace, which is depicted in the *srḫ* sign and would have resulted from the merging of the architecture in bricks (Lower Egypt) with the architecture in wood and matting (Upper Egypt), during the unification of the country. Lauer's interpretation was, however, disputed by other researchers, *e.g.* Kees (1963: 111), who argued that the royal palace could not have the same large number of doors as the mastabas. But the palace-façade did not mark simply an earthly palace: it was the divine palace in the sky, presumably depicted on the east wall of the tomb to indicate the divine abode in the horizon of Ra. As previously-mentioned, the palace-façade appears at the beginning of the 4th Dynasty as decoration of stone sarcophagi (which were also inscribed for the first time in this period) with offering formulae and titles of the deceased. Gods mentioned in the mortuary formulae are Anubis, invoked to concede offerings with his divine attributes of *ḫnty sḥ-nṯr*, "foremost of the divine booth", and *nb tȝ ḏsr*, "lord of the sacred land", and a god called *nṯr ʿȝ* "the great god", and *nb pt*, "lord of the sky", probably Horus (Junker, 1934: 51). In royal *srḫ* stelae, the depiction of the Horus falcon on top of the royal palace designates a sky god, as the etymology of *ḥrw* "Horus" (Pyramid Texts, Par. 1690), from *ḥry*, "who is over", suggests. The round-shaped top of Thinite funerary stelae may have also denoted the celestial vault, considering that the semi-circular shaped panels with *ḏd*-frieze in underground chambers of the pyramid of Netjerikhet are apparently symbolic of the support of the sky (Clark, 1959: 236-37). Connected to the identification of the sarcophagus with a divine palace, in the nightly sky of the *dwȝt* and/or in heaven, is the concept of rebirth of the king from a sky-mother, and consequently the association of Nut with sarcophagus and tomb, described in the Pyramid Texts (Par. 616). Grand gallery in the Khufu pyramid and panelled vestibule in the Menkaura pyramid are doubtless cosmic constructions, as other parts of the pyramid: both corbelled roof of the gallery and blue-

ish ceiling of the vestibule can be considered representations of the sky.[52] The great step lies in the middle axis of the Khufu pyramid and, as indicated by Allen (1994: 24-28), the antechamber of 5th Dynasty pyramids in the middle axis of the pyramid was associated to the *3ḫt*, while the corridor before the antechamber represented the entrance into the day sky.[53] The palace-façade panelling in both temples of Menkaura was probably associated to the double shrines (*jtrty*), frequently mentioned in the Pyramid Texts (Par. 256, 577, 731, 1159, 1345, etc.) to indicate the gathering place of the king with the gods. In the interpretation of the decoration programme proposed by Hawass (1995: 253), Horus was worshipped at Giza in the valley temple, Ra in the upper temple.

Thus, the palace-façade is used in the necropolis of Giza during the 4th and 5th Dynasty by members of the royal families and high officials as decoration of exterior walls of tombs and interior chapels. Both in a royal and private context, walls of burial chambers and *serdabs* were bare of any decoration until the late 5th Dynasty, when the pyramid of Unas was inscribed with the Pyramid Texts (*cf.* Kanawati, 2005). A splendid polychrome palace-façade panelling is painted on each of the three walls around the sarcophagus in the burial chamber of Unas. As early as the 4th Dynasty, the palace-façade motif appears on stone sarcophagi of members of royal families and high officials, introduced by sons of Khufu and adopted by Menkaura. As highlighted in the previous section, an important numerical pattern in sarcophagi decorated with palace doors envisaged seven or 14 elements on the long sides. Moreover, a possible reference to the numerical pattern of 28 slots along the walls of the grand gallery can be identified in the 28 panels on the east face of the sarcophagus of the high priest Khentika at Saqqara. Remarkable is also the dimensional parallelism between the grand gallery of Khufu and the burial chamber of Unas: the perpendicular height of the gallery is 14 cubits from the top of the ramp benches, 15 cubits from the floor; the length of the burial chamber of Unas is 14 cubits in the lower section to the palace-façade in the west wall, 15 cubits in the upper section to the gable. The numerical pattern of 14/15 palace doors in the precinct of the mortuary complex of Netjerykhet is apparently proposed in a dimensional level, as extent of 14/15 cubits(!). Also, the panelled vestibule of Menkaura measures 7 1/2 cubits, the half of 15 cubits (see P6 in the Appendix). The burial chambers of Teti, Pepi I, Merenra and Pepi II, all decorated with the palace-façade, are 15 cubits in length.[54]

If we agree that a series of palace-façade stelae were installed in the grand gallery of the Khufu pyramid, the choice of slabs, rather than direct carving on the walls, can be explained by the fact that it is extremely difficult to apply a large number of complicated motifs on the wall proper. This also explains the relative rarity of palace-façade decorations on stone-cased mastabas. An example of palace-façade stela is Cairo CG 1377, inscribed with the name of Setju (Frankfort, 1941: 348, pl. 1), who is the owner of the tomb G 4710 at Giza (5th Dynasty).

It is noteworthy that a slot on the ramp benches with sloping length of 59.2 cm has the horizontal length of 53 cm, *i.e.* one cubit.[55] Small false doors have frequently a length of one cubit. An example of slab fitting into the longer slots of the grand gallery is the false door of Irienra from Giza, now in the Kunsthistorisches Museum (Inv. No. 8013, 5th to 6th Dynasty; length 51.5 cm, width 13.5 cm, height 90 cm; see Junker, 1938: 158-9, fig. 24e; Porter & Moss, 1974, 144). In the hypothetical emplacement in the gallery, the alternation of long and short stelae would identify pairs of symbolic elements: 14 pairs on each of the west and east walls. It is possible that a palace door of 'type 1' was hewn in the middle of six niches (d+6n) on a 53 cm long slab, and in the middle of four niches (d+4n) on a 47 cm long slab. A round-topped stela of Snefru from the satellite pyramid at Dahshur shows a palace door with four niches.[56]

The operations for the creation of the supposed installation in the gallery would have been performed as follows:

- 56 palace-door slabs were carved with a basement ('A' in figure 13) to be inserted into the slots. The lower corner of the slabs was bevelled;
- All stelae but three pairs were endowed with a tenon chiseled in their reverse ('B' in figure 13), to be joined to the niches, used as mortise. The height of the tenon was lower than the height of the niche less the depth of the corresponding slot, to allow the insertion;
- For some reason, the initially conceived fixing method involving the niches was abandoned.[57] In order to reinforce the lateral hold of the objects, the builders devised an

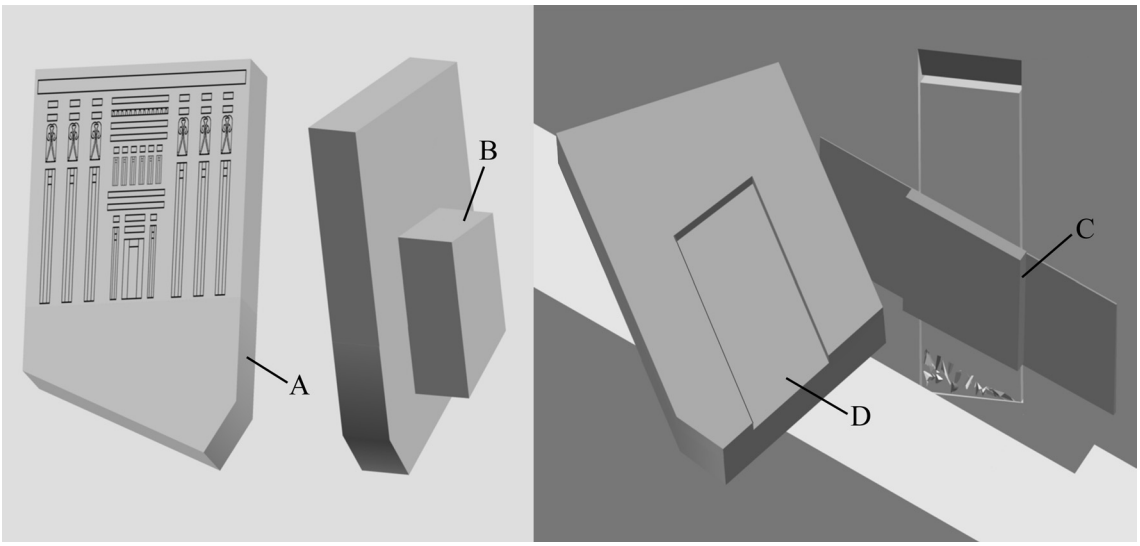

Figure 13. Hypothetical palace-door slab with fixing elements A, B, C, D. Diagram by the author.

alternative method: all the tenons 'B' were removed, and trapezoidal boards with tenon ('C' in figure 13) were inserted into trapezoidal cuttings carved on the walls;

- A mortise ('D' in figure 13) was chiseled on the reverse of the slabs, to be joined to the element 'C'. The three northernmost pairs of stelae and the pair on the great step, which were not subject to possible side forces, were installed without reinforcement. In fact, the insertion of the basement 'A' is sufficient to guarantee an acceptable basic fixing.

Traces of red mineral on patches of niches and on parts of the walls in the grand gallery may indicate that the stelae were painted red in background, as it is the case, for example, with the palace doors in the sarcophagus of Khufu's daughter Meresankh II (table 1). The red colour is a common feature, also in conventional false doors, and its use can be traced back to archaic tombs at Naga-ed-Der, Tarkhan and Abydos, in which the actual doorways into the store-rooms were bricked-up, plastered and painted red, in order to imitate a wooden door-leaf (*cf.* Hassan, 1944: 68).

Wooden cross beams leaning against pairs of slabs on the sides of the gallery would have provided a safety system for the granite plugs (see figure 14).[58] Furthermore, the workers could have found a useful foothold in each reinforced object while leading the blocks down the floor of

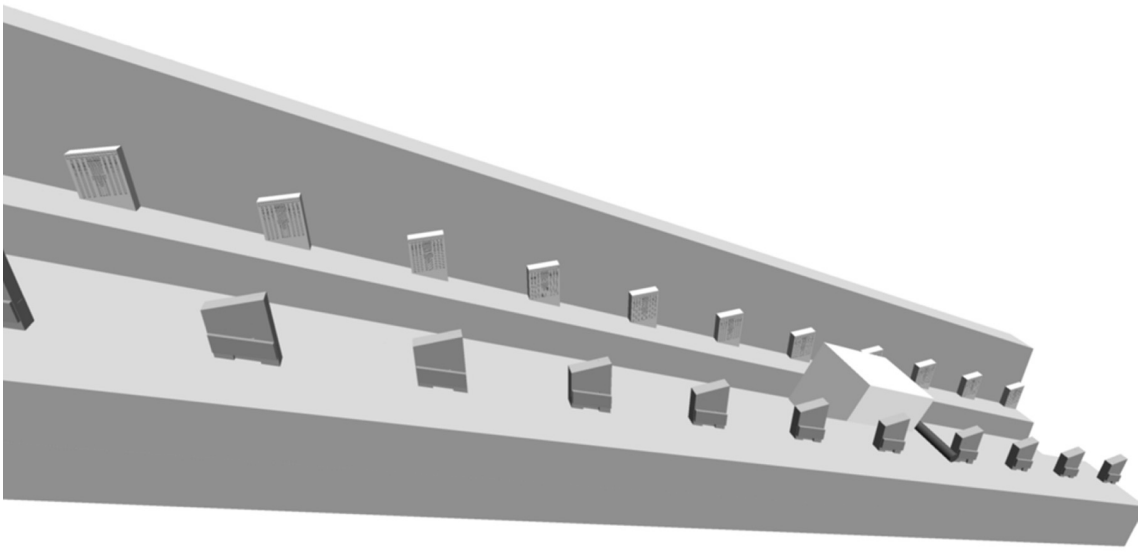

Figure 14. Hypothetical palace-door slabs emplaced in the gallery, and parking of a granite plug. Diagram by the author.

the gallery, presumably by means of ropes. The function of foothold would explain the necessity to reinforce the side hold of a large number of objects, corresponding to Nos. 4-27 in figure 1.

When the 'bridge' that covered the interrupted segment at the bottom of the gallery was installed,[59] the granite plugs were presumably lowered to the northern part of the gallery. After the burial of the royal body, bridge and ascending corridor were spread with lubricant, then the supposed safety cross beams (and possibly also chocks) were removed, and the granite plugs were slid down to the ascending corridor, to be restrained by the narrowing of the lower part of the corridor and, as small holes on the side walls just in front of the lowest plug indicate, by a wooden cross beam.[60] Lauer (1971: 139) suggested that the granite plugs were released from beneath the passage by pulling away a chock with a long rope, in accordance with the system used in the Bent Pyramid's satellite. Since the blocks were roughly in balance of forces, it is more likely that they were pushed down by the workers, and that the well shaft linking the gallery to the subterranean passage was used as escape.

Conclusions

The identification of the functions of the peculiar features on the west and east sides of the grand gallery is one of the most difficult problems in Old Kingdom architecture, because of the multiple variables involved. The large number and systemic regularity of slots, niches and trapezoidal cuttings cannot be related exclusively to the function of parking the granite plugs, which were probably only three or four. Also, the granite plugs in the gallery were roughly in balance of forces and therefore a 'safety system' was required, rather than a 'retaining system'. The slots appear to be sockets for vertical objects and were likely conceived to function with the niches. Also, the grooves in the third corbel do not seem to be appropriate for the insertion of large planks. It is, therefore, more plausible that they were conceived for a transversal beam, which would have allowed to lift up stone objects.

Multiples of seven, nine and 11 cubits occur frequently in the design of the pyramids of Snefru and in the great pyramid. A parallel phenomenon is the recurrent use of particular numbers of elements in architectural and iconographical features. A numerical pattern, for example recognisable in the arrangement of columns in the upper temple of Khufu and in the disposition of statues of the king in the valley temple of Khafra, envisaged seven elements or multiples of seven along the sides of a rectangular structure. This scheme is found also in palace-façade decorations of Old Kingdom sarcophagi at Giza, introduced for the first time by sons of Khufu, and in later symbolic representations. Numerical arrangements such as the 14 panels on each of the west and east sides of the sarcophagus of Kaemnefret probably made reference to the scheme in the grand gallery of Khufu, in which 14 pairs of palace-façade slabs would have been inserted into the slots on each of the west and east sides of the monument. The palace-façade is used in the Giza necropolis during the 4th Dynasty as decoration of tombs and chapels of members of the royal family and high officials, according to a scheme derived from Saqqara. In the pyramid complex of Menkaura, a simplified palace-façade panelling is found in the corridor-chamber of the pyramid (which is located, exactly as the grand gallery, before the portcullises), and on the inner walls of the open court in both temples. The analysis of the dimensions of the grand gallery provides a further crucial evidence: the perpendicular height of the grand gallery is 14 cubits from the top of the ramp benches, 15 cubits from the floor. The length of the burial chamber of Unas is 14 cubits in the lower section, characterised by a palace-façade decoration, and 15 cubits in the upper section of the gable. All burial chambers decorated with palace doors, from Teti to Pepi II, are 15 cubits long, and the panelled vestibule in the Menkaura pyramid measures 7 1/2 cubits, which is half of 15 cubits. The use of the numbers 14 and 15 for the dimensions in cubits of a room in Old Kingdom pyramids can be traced back to the numerical pattern of 14/15 palace doors in the temenos wall of the mortuary complex of Netjerykhet. Fundamental in such pattern is the number 14, and this would account for the choice of 14 pairs of palace-façade stelae on each of the west and east walls of the grand gallery. Numerical choices in the design of the gallery and its features can be thus considered *architectural markings* of a room decorated with the palace-façade. Further to express a symbolic significance, palace-door stelae inserted into the notches in the grand gallery presumably served

as safety system for the granite plugs and as footholds in the lowering of the plugs to the northern part of the gallery.

The architecture and decoration programme of Old Kingdom royal mortuary complexes involved ideological schemes, based in particular on the representation of the three Egyptian cosmic realms (netherworld, world, heaven) and their interaction, but the forms in which the individual principles were realised in tombs and temples were various and interchangeable.[61] The grand gallery represented the divine palace, the ideological complement of a gigantic superstructure built to celebrate the king as sun-god. A parallel scheme would have been more soberly realised in the refined vestibule of the pyramid of Menkaura.

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Notes

1 Detailed descriptions were also proposed by Borchardt (1932), Maragioglio & Rinaldi (1965: 36-8, 118-19) and Lauer (1971).

2 The royal cubit is about 52.4 cm.

3 Borchardt (1932: 8) reported that the inside surfaces of the niches in which the patches were removed, were clean and white.

4 In several pyramids the path to the burial chamber is characterised by narrow turns and passages, climbs and obstacles.

5 The source for the length of the three plug blocks is the graph in Maragioglio & Rinaldi (1965: pl. 5, fig. 1); breadth and height are also given by Petrie (1883: 63-64).

6 For a description of the portcullis chamber, see Maragioglio & Rinaldi (1965: 44-48, pl. 7).

7 $F = \sin(\alpha)\ w$; $H = \mu \cos(\alpha)\ w$; $F = H \rightarrow \mu = \tan(26.2^\circ) = 0.492$.

8 1.65 m x 1 m x 1.2 m = 1.98 m^3; 1.98 m^3x 2,500 kg/m^3 = 4,950 kg.

9 The slope of 26°16'40" is given by Maragioglio & Rinaldi (1965: pl. 6, fig. 1). The linear measure of slope called *sḳd* in pRhind 56-60 is definable as the horizontal distance corresponding to a vertical extent of one cubit, or seven palms.

10 46.12 m, according to Petrie (1883: 71), and Maragioglio & Rinaldi (1965: pl. 6, fig. 1).

11 According to Maragioglio & Rinaldi (1965: pl. 6, fig. 1), the vertical height of the gallery varies from 8.48 to 8.74 m, mean 8.61 m, hence: $x^2 + x^2/\tan(63.8^\circ)^2 = 8.61^2$; x = 7.73 m = 14.8 cubits.

12 The perpendicular height of the ramp benches is 0.52 m, or one cubit; the perpendicular height from the top of the benches to the first corbel is about 1.65 m, or 3.1 cubits: see Maragioglio & Rinaldi (1965: pl. 6, fig. 1).

13 A list of Old and Middle Kingdom true pyramids, with dimensions and angles of the superstructure, is provided by Rossi (2003: 243-54). For a list of pyramids and pyramid-like monuments, see Swelim (1994).

14 For the measurements of the Netjerykhet pyramid, see Lauer (1936: 10 -26). On the use of symbolic numbers in the design of the pyramid, see Miatello (2005: 7-10).

15 On this question, see Miatello (2009).

16 On the presumable use of triplets as practical device in the construction of pyramids, see Rossi (2004: 64).

17 A ratio of 10 : 7 for the lower inclination of the Bent Pyramid is indicated by Dorner (1986: 54). In the pyramid G3-a at Giza, the angle of the walls of 52°15' corresponds to a ratio of 9 : 7. In fact, the side of base is 84 = 7 x 12 cubits, and the height is 54 = 9 x 6 cubits. According to Verner (2001: 144), a ratio of 9 : 7 was used for the slope of the pyramid of Queen Khentkaus II

18 Each of the lower shafts was closed at both ends, and the upper shafts were sealed in correspondance with the pyramid casing; *cf.* Stadelmann (2003: 124).

19 On the hypothesis that the shafts represented *sḫnwy pt*, "the two reed-floats of the sky" (Pyramid Texts, Par. 337), *i.e.* directional forces of the sun, and that the upper shafts were functional for the subdivision of the pyramid into *dw3t*, *3ḫt* and day sky, see Miatello (2005-6; 2008); the two holes on the walls of the burial chamber of Khafra had probably a comparable symbolic significance. Sakovich (2005-6) interpreted the shafts as water canals linking the northern and southern celestial waterways.

20 On the design of the oblique shafts, see Stadelmann & Gantenbrink (1994), Potter (2001) and Miatello (2005-6: 55-58).

21 The length of the burial chambers of Khafra and Menkaura seems to be one-tenth of the pyramid height: the burial chamber of Menkaura is 6.60 m, i.e. 1/10 of 126 cubits; see Miatello (2008: 53).

22 The angle measured by Lauer (1960: 95) ranges from 56 to 57°, while the measure of 56°18', usually given as slope of the pyramid, results from Lauer's conjecture that a ratio of 3 : 2 was used.

23 On the possibility that the level of about 95 cubits above the base had a symbolic meaning in the pyramid of Khafra, see Miatello (2008: 50-53).

24 The dimensions of this pyramid are described in pRhind 57, 58; see Imhausen (2003: 260-263).

25 A survey published by Cauville & Devauchelle (1984) confirms the correctness of the dimensions.

26 Oddly enough, the first example of uraeus-frieze in architecture after Netjerykhet is dated to the New Kingdom, under the reign of Amenhotep III, in the temple of Sanam in Nubia; *cf.* Johnson (1990: 73), Ćwiek (2003: 69-70).

27 The panel in the Cairo Museum (JE 68921) has 11 pilars.

28 Eight square holes are added on the upper part of pilasters and niches. This motif, representing archaic architectural features of buildings, is depicted already in the Hierakonpolis tusk decoration (1st Dynasty): see Quibell (1900: pl. 14).

29 According to Kees (1963: 111), 15 doors decorated the enclosure wall of the temple, in which several inscriptions illustrate the first heb-sed festival of Amenemhat III.

30 In the inscriptions on the four sides, each door has a title (*e.g.* on the east side: 1. great door; 2. king's door; 3. door of the lake; 4. door of the granary; 5. door of

the south) and associated with parts of the dismembered body of Osiris; e.g. the 'great door' corresponds with the head of Osiris, the 'king's door' with the neck (Piankoff, 1947; Kees, 1963: 97-109).

31 A parallelism can be made with the 'lion-bed' from the Niuserra heb-sed reliefs in the sun temple at Abu Gurab (Westendorf, 1991).

32 The day 15 of the lunar month is mentioned in Book of the Dead, Chapter 114.

33 As early as the 2nd and 3rd Dynasty, wooden sarcophagi from Tarkhan, Saqqara, Sidmant, Nuerat and el-Gebeleyn are decorated with panelling, imitating a wooden house. It is characterised by central niches containing a series of horizontal drums (Petrie et al., 1913: 27, pl. 28; Donadoni Roveri, 1963: 85-86).

34 For the inscriptions on the sarcophagus, see Borchardt (1964: 209-12, pl. 112).

35 For example Emery (1954: pl. 1). Recesses with a door alternated to projections with three niches appear also on the façade of Mesopotamian temples (Frankfort, 1941; Donadoni Roveri, 1969: 81, fig. 18).

36 From the 3rd to 4th Dynasty, the preferred position of the body in the sarcophagus, previously with the head to the south facing the west, changes in head to the north facing the east, in accordance with the canons of the solar religion. Cf. Donadoni Roveri (1969: 24).

37 Plan of the valley temple: Hölscher (1912: pl. 17).

38 The seven granaries are inscribed in a horizontal line on the south side of the sarcophagus of Meresankh II, with the number 1,000 beneath each granary sign: 1,000 barley (*it*), 1,000 emmer (*bd.t*), 1,000 wheat (*sw.t*), 1,000 *bš3*-fruit, 1,000 dates (*bnr*), 1,000 *dḏw*-grain (?), 1,000 carob-beans (*wʿḥ*). On the west side of the sarcophagus of Minkhaf, the seven granaries appear on the second of the inscribed columns flanking the seven panels: 1,000 upper Egyptian barley (*it šmʿwy*), 1,000 lower Egyptian barley (*it mḥy*), 1,000 emmer (*bd.t*), 1,000 wheat (*sw.t*), 1,000 *bš3*-fruit, 1,000 dates (*bnr*), 1,000 *dḏ.w*-grain(?) (Smith, 1933: 151-52, pl. 23).

39 For a photo of the burial chamber, see Ćwiek (2003, fig. 31).

40 The reference to the 14 *k3w* appears in the papyrus BM 10542 (21st Dynasty), but the idea may have originated in the Old Kingdom. In Niuserra's heb-sed relief (Berlin 16100), illustrated in Borchardt (1907: fig. 6, pl. 16), the king receives seven *ʿnḫ*-signs from Anubis. On this interpretation and the possible connection with the 14 *k3w* of the king, see Ćwiek (2003: 332-33).

41 A further pattern concerns the group of four uraei, in accordance with the canonical association of the number four with the cardinal directions (Ritner, 1990).

42 Eleven gods, alternated to eleven columns of hieroglyphic inscriptions, are depicted on each long side of a sarcophagus in black basalt from the so-called Campbell's tomb at Giza (26th Dynasty; Perring, 1842: pls. 21-22).

43 The rightmost uraeus is cut off in the photo published by Corzo (1996: 177). An image of BM AE 9901, 3 can be found on the website of the British Museum, collection database.

44 According to Lauer (1971: 139), if more than four plug blocks were placed in the ascending corridor, there would be traces of removal. Maragioglio & Rinaldi (1965: 112-14) favoured the hypothesis that only three plugs were used.

45 The plan of the chamber is given by Maragioglio & Rinaldi (1967: pl. 7).

46 For a detailed analysis of these panels: Friedman (1995). See also Lauer (1957).

47 For examples from Naqada: De Morgan (1926: 163-76); Reisner (1936: 27-29, fig. 21). Decoration of the external walls of tombs at Tarkhan: Petrie et al. (1913: 13-14, pls. 25, 28); Reisner (1936: 31-33, fig. 24).

48 E.g. *srḫ* stelae of Peribsen, with Seth animal, published by Petrie (1901: pl. 31); Khasekhemui, with Seth and Horus animal: Farag (1980: 77-79, pl. 26).

49 Several stelae of this kind were found by Saad in 2nd Dynasty tombs at Helwan (Saad, 1957). On the stages of development of table scenes in the Old Kingdom, see Bárta (1995).

50 Photos of palace doors in the list can be found at the website www.gizapyramids.org.

51 On the east wall of the chapel is depicted, for the first time, the long version of presenting the *nḏt-ḥr*-offerings (Altenmüller, 2006: 25).

52 The use of four corbels and quarters of cubit in the design of the niche in the queen's chamber (see figure 4) is presumably connected to the symbolism of the four cardinal points and the division of the sky into four parts. Groups of four objects and entities, invocations and spells repeated four times, occur frequently in the Pyramid Texts and in later religious and magical texts; cf. Ritner (1990: 35).

53 For the interpretation of the superstructure of the three pyramids of Giza as subdivided into *dw3t, 3ḫt* and day sky, see Miatello (2008). On the symbolic significance of architectural elements of the pyramid see also O'Connor (1998).

54 For an analysis of the palace façade in these chambers, see Labrousse (2000, 139-41).

55 $x^2 + x^2 \tan(26.2^\circ)^2 = 0.592^2$; $x = 0.531$. *Cf.* Petrie (1883: 72).

56 Stela in front of the Cairo Museum (JE 8929c); see a photo in Stadelmann (2003: 112).

57 Possibly, misalignments made the insertion of the slabs, which could have small holes to allow their lifting by means of ropes with hooks, more difficult than expected, and the consequent decision to seal all the niches was taken when some of them were only sketched. The alleged presence of 'fake' niches would indicate that the niches were soon abandoned before they were finished. All wiches were probably first outlined on the walls, before performing deeper cuts, possibly beginning from the north and south part of the gallery.

58 Each hypothetical slab, weighing at least 200 kg and reinforced by trapezoidal elements, could bear heavy side loads.

59 Thick wooden beams presumably fitted into the pairs of large rectangular holes at the sides of the interrupted passage.

60 See Petrie (1883: 63). When and how the pyramid of Khufu was first violated is unknown. Petrie (1883: 217) suggested that the pyramid was plundered during the civil wars of the First Intermediate Period, by robbers who knew about the well shaft. All we know is that Al Mamun in 820 C.E. made an intrusive passage to the ascending corridor, but, as pointed out by numerous scholars (*e.g.* Maragioglio & Rinaldi, 1965: 146), it is possible that a bypass of the plug blocks from the subterranean passage was dug long before.

61 A simple example is provided by the reliefs in Khufu's temples, almost completely missing in Khafra's and Menkaura's temples, characterised by the wide use of sculptures (Ćwiek, 2003: 3; Hawass, 1995).

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Appendix

P1 - Snefru, Bent Pyramid, Dahshur (4th Dynasty)

Pyramid *sḳd* (palms) - lower part	5-1/10	Dorner (1986: 54)
Pyramid *sḳd* (palms) - upper part	7 1/2	Dorner (1986: 54)
Pyramid side of base	362	Dorner (1986: 54)
Pyramid side of base (at initial base level)	**360**	Dorner (1986: 57)
Pyramid bending line	236	Dorner (1986: 54)
Pyramid height - lower part	**90**	Dorner (1986: 54)
Horiz. dist. of bending line from pyr. side	**63**	Dorner (1986: 56)
Pyramid height - upper part	**110**	Dorner (1986: 54)
Pyramid height	200	Dorner (1986: 54)
Level above base of the W. corridor	**≈ 63**	Dorner (1986: 54)
Level above base of the N. corridor	23	Dorner (1986: 54)
Antechamber length	10	Stadelmann (1985: 92)
Antechamber height	24	Fakhri (1959: 47)
Lower chamber length	12	Fakhri (1959: 47)
Lower chamber width	9 1/2	Fakhri (1959: 47)
Lower chamber height	**33**	Fakhri (1959: 47)
Upper chamber length	**15**	Stadelmann (1985: 93)
Upper chamber width	10	Fakhri (1959: 52)
Upper chamber height	31 1/2	Fakhri (1959: 52)

P2 - Snefru, Red Pyramid, Dahshur (4th Dynasty)

Pyramid *sḳd* (palms)	7	Dorner (1998: 25)
Pyramid side of base	**418**	Dorner (1998: 25)
Pyramid height	**209**	Dorner (1998: 29)
Height above base of the entrance	58 1/2	Dorner (1998: 29)
Descending corridor length	106	Dorner (1998: 29)
Lower horizontal corridor length	**14**	Dorner (1998: 28)
First chamber length	16	Dorner (1998: 28)
First chamber width	**7**	Dorner (1998: 28)
First chamber height	23 1/2	Stadelmann (1985: 101)
Second chamber length	16	Dorner (1998: 28)
Second chamber width	**7**	Dorner (1998: 28)
Second chamber height	23 1/2	Stadelmann (1985: 101)
Level above base of the lower chambers	**5** 1/2	Dorner (1998: 29)
Level above base of the upper chamber	**22**	Dorner (1998: 28)
Upper horizontal corridor length	**14**	Dorner (1998: 28)
Upper chamber length	16	Dorner (1998: 28)
Upper chamber width	8	Dorner (1998: 28)
Upper chamber height	**28**	Stadelmann (1985: 101)

P3 - Snefru, Meidum Pyramid (4th Dynasty)

Pyramid *sḳd* (palms)	5 1/2	Petrie (1892: 6)
Pyramid side of base	**275**	Petrie (1892: 6)
Pyramid height	**175**	Petrie (1892: 6)
Entrance horizontally from N. base	**28**	Petrie (1892: 10)
Entrance, level above base	**35**	Petrie (1892: 10)
Entrance, horizontally from pyr. mid. axis	**110**	Petrie (1892: 10); Legon (1990, fig. 2)
Descending corridor length	**≈ 110**	Petrie (1892: 10); Legon (1990, fig. 2)

Horizontal corridor length	**18**	Petrie (1892: 11)
Niche length	5	Petrie (1892: 11)
Niche width	4	Petrie (1892: 11)
Corridor length from 2nd niche to well	**7**	Petrie (1892: 11)
Burial chamber length	**11**	Petrie (1892: 11)
Burial chamber width	5	Petrie (1892: 11)
Burial chamber height	**11**	Petrie (1892: 11)

P4 - Khufu, Giza (4th Dynasty)

Pyramid *sḳd* (palms)	5 1/2	Petrie (1883: 42-43)
Pyramid side of base	**440**	Petrie (1883: 39)
Pyramid height	**280**	Petrie (1883: 43)
N. upper oblique shaft, sqd (palms)	**7**	Stadelmann & Gantenbrink (1994: 293)
S. upper oblique shaft, sqd (palms)	**11**	Stadelmann & Gantenbrink (1994: 293)
N. lower oblique shaft, sqd (palms)	8 1/2	Stadelmann & Gantenbrink (1994: 288)
S. lower oblique shaft, sqd (palms)	8 1/2	Stadelmann & Gantenbrink (1994: 294)
Descending corridor length	201	Petrie (1883: 57)
Horizontal corridor to underground cham.	17	Petrie (1883: 59)
Underground chamber length	**27**	Petrie (1883: 59)
Underground chamber width	16	Petrie (1883: 59)
Ascending corridor length	**75**	Petrie (1883: 63)
Horizontal corridor to queen's chamber	74	Petrie (1883: 66)
Queen's chamber length	**11**	Petrie (1883: 66)
Queen's chamber width	10	Petrie (1883: 66)
Queen's chamber height at base of gable	**9**	Petrie (1883: 66)
Queen's chamber height at top of gable	12	Petrie (1883: 66)
Gallery, length from N. wall to ramp end	**88**	Maragioglio & Rinaldi (1965: pl. 6)
Gallery, perp. height from top of bench	**14**	Maragioglio & Rinaldi (1965: pl. 6)
Gallery, perpendicular height	**15**	Maragioglio & Rinaldi (1965: pl. 6)
Antechamber length	**5** 1/2	Petrie (1883: 77)
Antechamber width	3	Petrie (1883: 77)
Antechamber height	**7**	Petrie (1883: 77)
King's chamber length	20	Petrie (1883: 80)
King's chamber width	10	Petrie (1883: 80)
King's chamber height	**11**	Petrie (1883: 83)
Mid. of all chambers E. of pyr. mid. axis	**14**	Petrie (1883: 95)

P5 - Djedefra, Abu Rawash (4th Dynasty)

Pyramid *sḳd* (palms)	5 1/2?	Valloggia (2001: 57)
Pyramid side of base	202-203?	Valloggia (2001: 57)
Pyramid height	129?	Valloggia (2001: 57)
Descending corridor length	84 1/2	Valloggia (2001: 58)
Horizontal corridor length	10 1/3	Valloggia (2001: 58)
Burial chamber width	10	Valloggia (2001: 61)
Burial chamber length	13 1/2	Valloggia (2001: 61)

P6 - Khafra, Giza (4th Dynasty)

Pyramid *sḳd* (palms)	5 1/4	Petrie (1883: 98)
Pyramid side of base	411	Petrie (1883: 97)
Pyramid height	274	Petrie (1883: 98)

Subsidiary chamber length	20	Petrie (1883: 108)
Subsidiary chamber width	6	Petrie (1883: 108)
Subsidiary chamber height at base of gable	3 1/2	Maragioglio & Rinaldi (1966: pl. 9)
Subsidiary chamber height at top of gable	5	Maragioglio & Rinaldi (1966: pl. 9)
Descending upper corridor length	70 1/2	Legon (1989: 30, tab. 1)
Horizontal upper corridor length	110 1/2	Legon (1989: 30, tab. 1)
Horizontal upper corridor height	3 1/2	Petrie (1883: 105)
Burial chamber length	**27**	Petrie (1883: 105)
Burial chamber width	9 1/2	Petrie (1883: 105)
Burial chamber height at base of gable	10	Petrie (1883: 105)
Burial chamber height at top of gable	12	Petrie (1883: 106)

P7 - Menkaura, Giza (4th Dynasty)

Pyramid *sḳd* (palms)	5 1/2 1/10?	Petrie (1883: 112)
Pyramid side of base	201 1/2?	Petrie (1883: 111)
Pyramid height	**126**?	
Vestibule length	7 1/2	Petrie (1883: 117)
Vestibule width	6	Petrie (1883: 117)
Vestibule height	4	Maragioglio & Rinaldi (1967: pl. 7)
Corridor after portcullises, height	3 1/2	Petrie (1883: 118)
Antechamber length	**27**	Petrie (1883: 118)
Antechamber width	7 1/3	Petrie (1883: 118)
Antechamber height	9 1/3	Petrie (1883: 118)
Burial chamber length	12 1/2 1/10	Petrie (1883: 119)
Burial chamber width	5	Petrie (1883: 119)
Burial chamber height at the sides	5	Petrie (1883: 119)
Burial chamber height in the middle	6 1/2	Petrie (1883: 119)

P8 - Baka?, Zawiyet el-Aryan (4th Dynasty?)

Pyramid angle	?	
Pyramid side of base	400-410?	Maragioglio & Rinaldi (1970: 22)

P9 - Userkaf, Saqqara (5th Dynasty)

Pyramid *sḳd* (palms)	5 1/4	Stadelmann (1985: 160)
Pyramid side of base	**140**	Stadelmann (1985: 160)
Pyramid height	93 1/3	Stadelmann (1985: 160)
North chapel, ext. length	40	Maragioglio & Rinaldi (1970: 16)
North chapel, ext. width	**15**	Maragioglio & Rinaldi (1970: 16)
Descending corridor length	37	Stadelmann (1985: 161)
Horizontal corridor length	35 1/3	Stadelmann (1985: 161)
T-chamber, length of smaller room	10	Stadelmann (1985: 161)
T-chamber, width of smaller room	5	Stadelmann (1985: 161)
T-chamber, length of larger room	20	Stadelmann (1985: 161)
T-chamber, width of larger room	5	Stadelmann (1985: 161)
Antechamber length	8	Stadelmann (1985: 161)
Antechamber width	6	Stadelmann (1985: 161)
Burial chamber length	**15**	Stadelmann (1985: 161)
Burial chamber width	6	Stadelmann (1985: 161)

P10 - Sahura, Abusir (5th Dynasty)

Pyramid *sḳd* (palms)	5 1/2 1/4	Maragioglio & Rinaldi (1970: 46)
Pyramid side of base	**150**	Maragioglio & Rinaldi (1970: 46)
Pyramid height	91 1/3	Maragioglio & Rinaldi (1970: 46)
Descending corridor length	8	Maragioglio & Rinaldi (1970: 48)
Ascending (5°) corridor length	42 1/2	Maragioglio & Rinaldi (1970: 48)
Horizontal corridor	6	Maragioglio & Rinaldi (1970: 48)
Burial chamber width	6	Maragioglio & Rinaldi (1970: 50)
Burial chamber length	24?	Stadelmann (1985: 166)

P11 - Neferirkara, Abusir (5th Dynasty)

Pyramid angle	?	
Pyramid side of base	200?	Stadelmann (1985: 171)

P12 - Neferefra, Abusir (5th Dynasty)

Pyramid angle	?	
Pyramid side of base	123-124?	Maragioglio & Rinaldi (1970: 178)

P13 - Neuserra, Abusir (5th Dynasty)

Pyramid *sḳd* (palms)	5 1/2	Stadelmann (1985: 175)
Pyramid side of base	**150**	Stadelmann (1985: 175)
Pyramid height	95 1/2	Stadelmann (1985: 175)
Burial chamber length	25-27?	Stadelmann (1985: 176)
Burial chamber width	6?	Stadelmann (1985: 176)

P14 - Lepsius 29 Menkauhor?, Saqqara (5th Dynasty?)

Pyramid angle	?	
Pyramid side of base	125-130?	Maragioglio & Rinaldi (1977: 62)

P15 - Djedkara Isesi, Saqqara (5th Dynasty)

Pyramid *sḳd* (palms)	5 1/2	Stadelmann (1985: 180)
Pyramid side of base	**150**	Stadelmann (1985: 180)
Pyramid height	95 1/2	Stadelmann (1985: 180)
North chapel, ext. length	13	Stadelmann (1985: 180)
North chapel, ext. width	**9**	Stadelmann (1985: 180)
Descending corridor length	17 1/2	Stadelmann (1985: 180)
Horizontal corridor length	47 1/2	Stadelmann (1985: 180)
Chamber with three niches, length	13	Stadelmann (1985: 180)
Chamber with three niches, width	4	Stadelmann (1985: 180)
Antechamber length	7 1/2	Stadelmann (1985: 182)
Antechamber width	6	Stadelmann (1985: 182)
Burial chamber length	**15**	Stadelmann (1985: 182)
Burial chamber width	6	Stadelmann (1985: 182)
Burial chamber height at base of roof	6 1/2	Maragioglio & Rinaldi (1977: pl. 10)
Burial chamber height at top of roof	**9**	Maragioglio & Rinaldi (1977: pl. 10)

P16 - Unas, Saqqara (5th Dynasty)

Pyramid angle	56°-57°	Lauer (1960: 95)
Pyramid side of base	**110**	Lauer (1960: 95)
Pyramid height	**84**?	Lauer (1960: 95)
North chapel, ext. length	10 1/2	Labrousse (2000: 203)
North chapel, ext. width	14 1/3	Labrousse (2000: 203)
Descending corridor length	30	Labrousse (2000: 204)
Vestibule, length	7 1/3	Labrousse (2000: 204)
Vestibule, width	4	Labrousse (2000: 204)
Horizontal corridor length	**27**	Stadelmann (1985: 185)
Chamber with 3 niches (serdab), length	13	Labrousse (2000: 208)
Chamber with 3 niches (serdab), width	4	Labrousse (2000: 208)
Antechamber length	**7**	Labrousse (2000: 206)
Antechamber width	6	Labrousse (2000: 207)
Burial chamber length to palace façade	**14**	Labrousse (2000: 210)
Burial chamber length to gable	**15**	Labrousse (2000: 210)
Burial chamber width	6	Labrousse (2000: 210)
Burial chamber height at base of roof	6	Labrousse (2000: 210)
Burial chamber height at top of roof	9 1/2	Labrousse (2000: 211)

P17 - Teti, Saqqara (6th Dynasty)

Pyramid *sḳd* (palms)	5 1/4?	Rossi (2004: 249)
Pyramid side of base	**150**	Rossi (2004: 249)
Pyramid height	100?	Rossi (2004: 249)
North chapel, ext. length	10	Labrousse (2000: 203)
North chapel, ext. width	**14**	Labrousse (2000: 203)
Descending corridor length	35	Labrousse (2000: 204)
Vestibule, length	8 1/2	Labrousse (2000: 204)
Vestibule, width	4	Labrousse (2000: 204)
Horizontal corridor	41 1/2	Labrousse (2000: 206)
Chamber with three niches, length	13	Labrousse (2000: 208)
Chamber with three niches, width	4	Labrousse (2000: 208)
Antechamber length	**7**	Labrousse (2000: 206)
Antechamber width	6	Labrousse (2000: 207)
Burial chamber length	**15**	Labrousse (2000: 210)
Burial chamber width	6	Labrousse (2000: 210)
Burial chamber height at base of roof	6	Labrousse (2000: 210)
Burial chamber height at top of roof	9 1/2	Labrousse (2000: 211)

P18 - Pepi I, Saqqara (6th Dynasty)

Pyramid *sḳd* (palms)	5 1/4	Rossi (2004: 249)
Pyramid side of base	150	Rossi (2004: 249)
Pyramid height	100	Rossi (2004: 249)
North chapel, ext. length	10	Labrousse (2000: 203)
North chapel, ext. width	**14**	Labrousse (2000: 203)
Descending corridor length	35	Labrousse (2000: 204)
Vestibule, length	8 1/2	Labrousse (2000: 204)
Vestibule, width	4	Labrousse (2000: 204)
Horizontal corridor length	40	Labrousse (2000: 206)
Chamber with three niches, length	12 1/2	Labrousse (2000: 208)

Chamber with three niches, width	5	Labrousse (2000: 204)
Antechamber length	**7**	Labrousse (2000: 206)
Antechamber width	6	Labrousse (2000: 207)
Burial chamber length	**15**	Labrousse (2000: 210)
Burial chamber width	6	Labrousse (2000: 210)
Burial chamber height at base of roof	6	Labrousse (2000: 210)
Burial chamber height at top of roof	9 1/2	Labrousse (2000: 211)

P19 - Merenra, Saqqara (6th Dynasty)

Pyramid *sḳd* (palms)	5 1/4?	Rossi (2004: 250)
Pyramid side of base	**150**	Rossi (2004: 250)
Pyramid height	100?	Rossi (2004: 250)
North chapel, ext. length	10	Labrousse (2000: 203)
North chapel, ext. width	**14**	Labrousse (2000: 203)
Descending corridor length	34	Labrousse (2000: 204)
Vestibule, length	8	Labrousse (2000: 204)
Vestibule, width	4	Labrousse (2000: 204)
Horizontal corridor length	40	Labrousse (2000: 206)
Chamber with three niches, length	12 1/3	Labrousse (2000: 208)
Chamber with three niches, width	6 2/3	Labrousse (2000: 208)
Antechamber length	**7**	Labrousse (2000: 206)
Antechamber width	6	Labrousse (2000: 207)
Burial chamber length	**15**	Labrousse (2000: 210)
Burial chamber width	6	Labrousse (2000: 210)
Burial chamber height at base of roof	6	Labrousse (2000: 210)
Burial chamber height at top of roof	9 1/2	Labrousse (2000: 211)

P20 - Pepi II, Saqqara (6th Dynasty)

Pyramid *sḳd* (palms)	5	Rossi (2004: 250)
Pyramid side of base	**150**	Rossi (2004: 250)
Pyramid height	100	Rossi (2004: 250)
Descending corridor length	30-31?	Stadelmann (1985: 196)
Horizontal corridor length	44?	Stadelmann (1985: 196)
Antechamber length	**7**	Stadelmann (1985: 196)
Antechamber width	6	Stadelmann (1985: 196)
Burial chamber length	**15**	Stadelmann (1985: 196)
Burial chamber width	6	Stadelmann (1985: 196)
Burial chamber height at base of roof	6	Jéquier (1936: 10)
Burial chamber height at top of roof	9 1/2?	Jéquier (1936: pl. 25)