The Pyramid of Khafre, Giza

A Layman's Guide

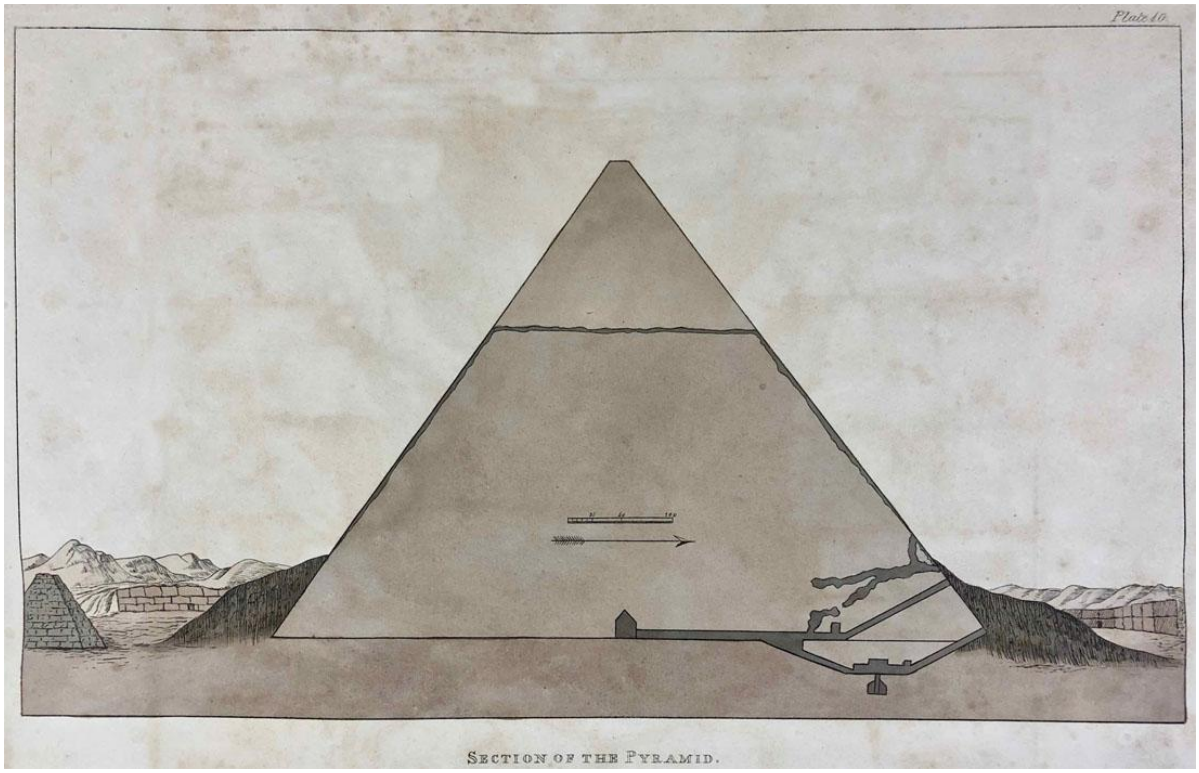
Keith Hamilton 17th May 2021

Image courtesy of Isida Project

The pyramid attributed to Khafre (sometimes referred to as Chephren: Greek variant) is the second largest pyramid at Giza, and easily recognised by the significant limestone casing which still adheres to the top of the structure. Largely overshadowed by its famous neighbour, the Great Pyramid, we know surprisingly little about this giant, and once again we are heavily reliant on old reports for primary information.

Though Egyptology has produced many valid reasons to attribute the pyramid to Khafre, there are other interesting ideas, such as that suggested by Giulio Magli who suggests that like his father Sneferu, Khufu may have elected to build a double pyramid project, which Khufu failed to complete and it was therefore taken over and used by Khafre.[1] The internal structure of this pyramid is rather plain and simple, compared to the complexity shown inside Khufu's pyramid, and no doubt this has not endeared itself to the same scrutiny afforded to its neighbour, which is a pity.

[1] The Giza "written" landscape, and the double project of king Khufu. Available at Academia.edu



Exploration

The above section of Khafre's pyramid, to be found in Belzoni's work[2] is more a schematic view of the structure, and given the conditions and the era in which it was made, we can forgive some of the errors in this drawing. Giovanni Belzoni was the first person in modern times to discover the entrance and enter the pyramid, though undoubtedly it had been entered in antiquity numerous times over different epochs.

Belzoni was a giant of a man, who probably deserves more praise for his many achievements; his life was varied and could never be described as boring. He originally set out to Egypt in the hope of selling an irrigation machine; exploring ancient Egyptian structures was not on his radar at this time. The adventure did not get off to a good start, for the party arrived at Alexandria on the 9th of June 1815 during an outbreak of the plague.[3] Having survived the plague, his luck held out for another event; he tells us,

"During my stay in Soubra, a circumstance took place, which I shall remember as long as I live, and which showed me plainly the country I was in, and the people I had to deal with. Some particular business calling me to Cairo I was

[2] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni 1820, plate 10
[3] His party consisted of his wife Sarah, and an Irish lad called James Curtain

on my ass in one of the narrow streets, where I met a loaded camel. The space that remained between the camel and the wall was so little, that I could scarcely pass; and at that moment I was met by a Bimbashi, a subaltern officer, at the head of his men. For the instant I was the only obstacle that prevented his proceeding on the road; and I could neither retreat or turn round, to give him room to pass. Seeing it was a Frank who stopped his way, he gave me a violent blow on my stomach. Not being accustomed to put up with such salutations, I returned the compliment with my whip across his naked shoulders. Instantly he took his pistol out of his belt; I jumped off my ass; he retired about two yards, pulled the trigger, fired at my head, singed the hair near my right ear, and killed one of his own soldiers, who, by this time, had come behind me. Finding that he had missed his aim, he took out a second pistol; but his own soldiers assailed and disarmed him."[4]

Belzoni's luck did not hold out for the success of his hydraulic machine; but what was a loss to Egyptian agriculture, was a win for the British consul Henry Salt, who would use Belzoni's talents to recover the 7 ton bust of Ramesses II, which is now displayed in the British museum. This would be the start of a lucrative new career for Belzoni, who would make considerable discoveries; though from his accounts, he and Salt appeared to have had a somewhat fractured relationship.[5]

Belzoni's work, would give him a purse of some 200 pounds, of which he spent some 150 on breaking into the pyramid of Khafre, which he succeeded in doing on March 1818. Salt had offered to pay Belzoni's expense; but Belzoni states, *"but this I positively refused, as I thought it would not be fair and right that he should pay for what he had nothing to do with".*[6] But one wonders if there was another motive for this refusal, as Belzoni at times appears very protective of his discoveries, and was likely concerned that if Salt paid for the expense, that he might lose claim to the discovery. This refusal of Salt's assistance, meant he had not the finance to open Menkaure's pyramid, which he was very close to doing before he ran out of funds.

Belzoni's description of the pyramid is not particularly detailed, but informative nonetheless. We would obtain some further detail on the structure when Howard

[4] Ibid, page 20

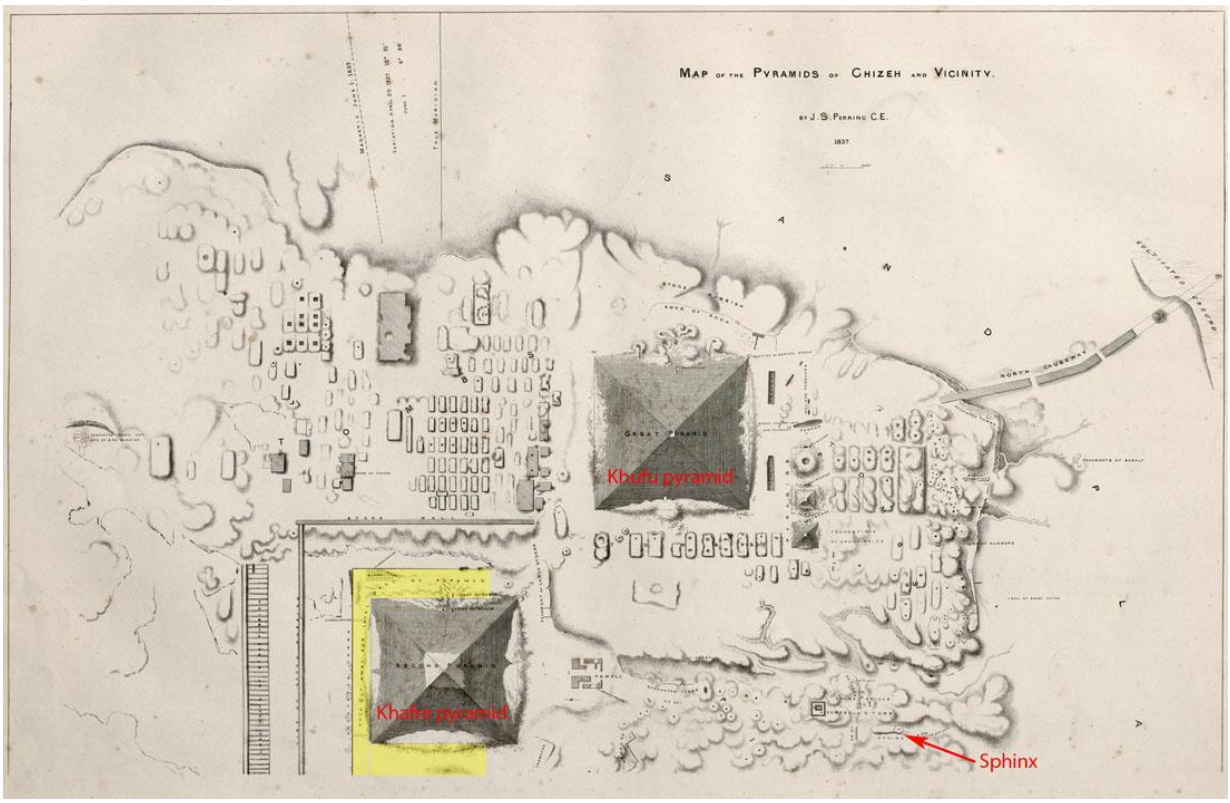
[5] I will leave the reader to form their own views from Belzoni's accounts and an excellent book on Henry Salt, by Deborah manley, and Peta Ree, published in 2001.

[6] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni 1820, page 281

Vyse, along with the engineer John Perring, provided more accurate drawings and dimensions of the structure in 1837[7]. Piazzi Smyth published a few further details on the structure in 1867[8] as does Flinders Petrie in 1883[9]. Further detailed drawings and observations were provided by the Italian scholars Maragioglio and Rinaldi (M&R) in 1966.[10] Unfortunately, like too many structures in Egypt, our picture of the pyramid is rather basic and incomplete as our primary data comes from mostly dated reports.

I would like to thank the Isida Project, Jon Bodsworth, and Charles Rigano for the kind use of their images, which greatly help in creating this guide; suffice to say that any ideas or suggestions that I may make on the structure, are not necessarily reflected by the above.

The Site



In the above drawing by Perring, we can see that the pyramid has been located to the southwest of Khufu's pyramid; many suggestions have been put forward for its location, from a diagonal alignment to Heliopolis, astronomical

[7] Operations carried on at the Pyramids of Gizeh in 1837, 3 volumes.
[8] Life and work at The Great Pyramid, Vol II, 1867
[9] The pyramids and Temples of Gizeh, 1883
[10] L'Architettura Delle Piramidi Menfite, Parte V

alignments, and even a Giza site plan as developed by John Legon: but whatever the motive, immense ground works were required to create this giant. The whole Giza plateau generally slopes downwards from the northwest to the southeast, so when it came to building these giants, the problem arises where one corner of the site is significantly higher or lower than another. In order to level the site, a vast area of rock was removed on the north, south and west sides of the pyramid (which I have roughly highlighted in yellow on the previous page); the rock under the perimeter of the pyramid, which was quite substantial, was left and cut into steps.

In this view looking east, we can see how far the plateau has been cut down, and in the northwest corner of this cutting we can see some of the stumps of rock left during quarrying operations. The approximate distance from the rock cut face above, to the pyramids north face is about 58m; the cutting distance to the west side of the pyramid is about half this distance at around 28m.

In this view from a similar vantage point to the previous image, we are looking south, along the west face of Khafre's pyramid. The rock cut face on the right slopes gently to the south, and is around some 10m high at its highest. On this side of the pyramid the first 4 or 5 visible steps is actually bedrock, and above this is placed the core masonry blocks. The huge amount of excavated rock would not go to waste, but be recycled into the core of the pyramid or in creating massive foundations to support the low southeast corner of the pyramid; here M&R state;

"This is also shown by the fact that in the SE corner there is no sign of rock, as there is along the western part of the south side and in the central part of the east side. This fact is further confirmed by what may be observed in a hole recently dug near the SE corner, 24.20 m. west of it and 21.25 m. south. This hole has revealed how the ground is not farmed of rock at this point but of inserted blocks."[11]

[11] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 44

Looking east, we can see the height of the bedrock at the southwest corner, with the core masonry on top. It is quite eroded at this corner, likely because the strong southerly winds are somewhat bottlenecked at this corner as they rush through the small gap between the rock face some 28m distant and the pyramid.

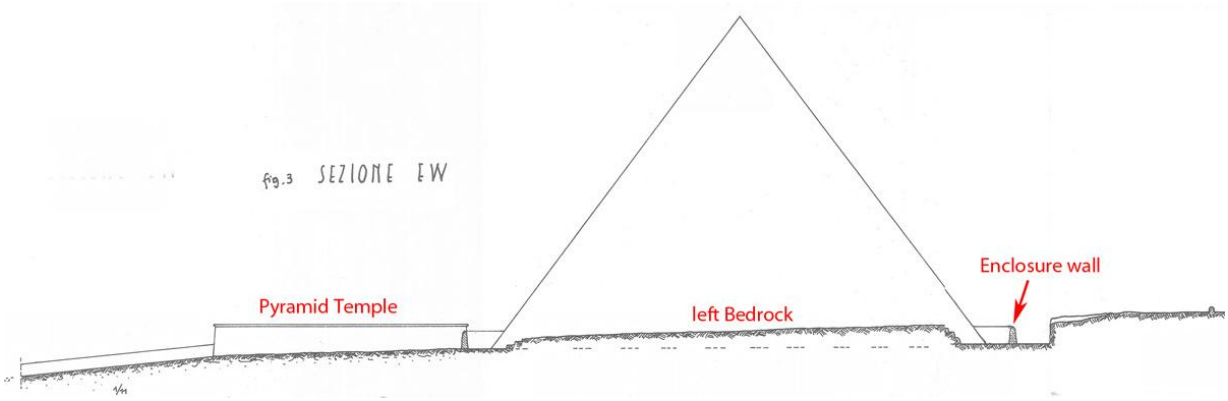
Further along the base of the west side, we can see the better preserved rock cut steps. The plateau is riddled with fissures in the rock, and at times it is hard to differentiate the rock from the masonry elements. The slope of the plateau is greater west to east than north to south.

Image courtesy of Jon Bodsworth

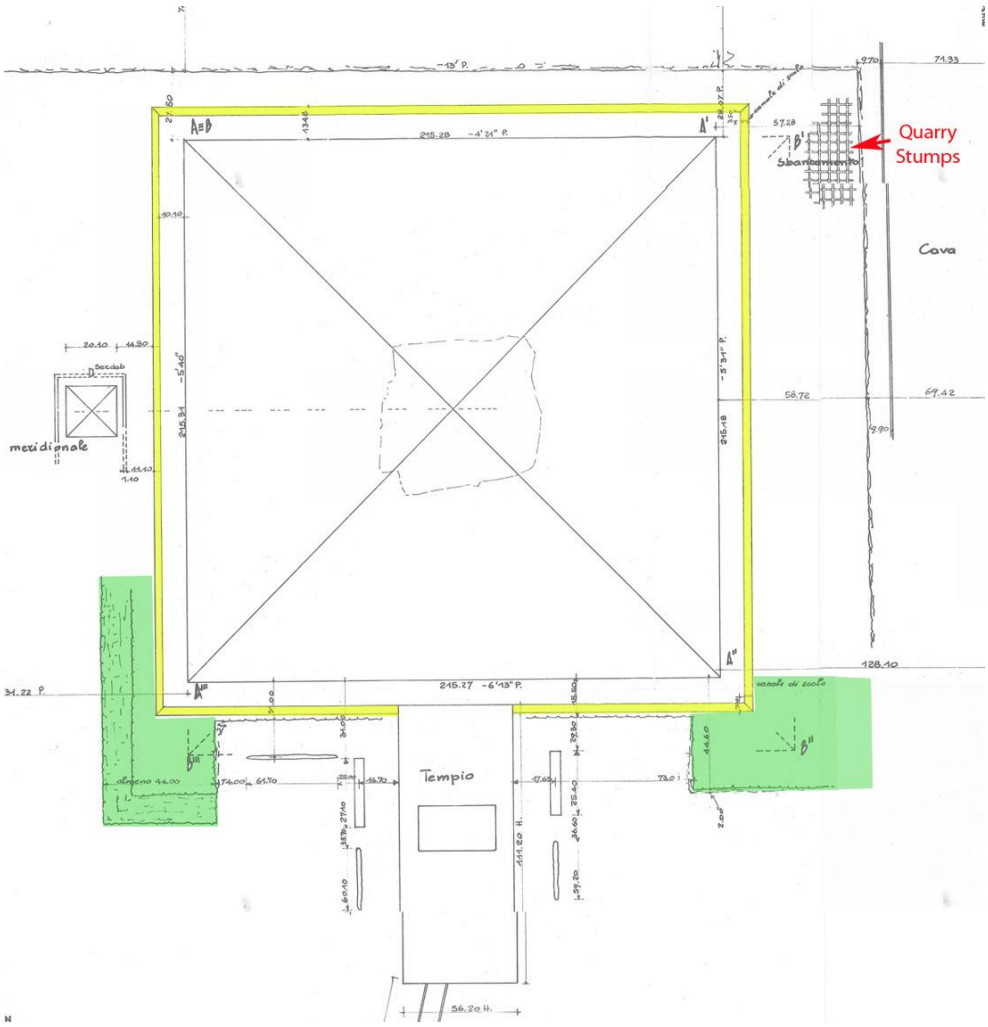
Looking south at the northwest corner from within the quarry stumps, the red line gives a rough indication of how much rock had to be excavated from around the pyramid, and the height of the rock left to form the northwest corner of the pyramid core. The extent of the bedrock steps along the north and south sides of the pyramid is not clear to me from the available images; but M&R report that at the NE & SE corners that there is no rock, with these corners entirely constructed of masonry.[12] These corners are built of enormous masonry blocks as high as two courses (over 2m), and sometimes an offset levelling cut is made midway up to indicate the top of the first casing course.

Though bedrock is absent at these two corners, as we approach the middle of the east face, we meet a spur of rock which forms the first course of the nucleus and at some points the second, before gradually disappearing as we approach the SE corner. This spur would continue further east, where it was levelled to site the pyramid temple.

[12] Ibid, page 46



Above we have part of M&R's E-W section of the Khafre complex, from their TAV 5; the pyramid was surrounded by a stone enclosure wall, thought to be some 8m high, with its base some 3.14m wide. This wall enclosed a paved courtyard, thought to be 20 cubits wide (10.5m) which surrounded the pyramid.



In the above plan from TAV 5 by M&R, I have highlighted the enclosure wall in yellow, and beyond that, what appear to be two massive piers/terraces which extend beyond the NE and SW. Corners.

Image PDM_1993.127.29, courtesy of Giza Project, Harvard University

In the above view looking towards the southwest from Khufu's pyramid, we can see the northern pier/terrace more clearly. This was constructed of massive limestone blocks, and its northern limit merges into the north quarry face. The southern pier/terrace is less well defined, and is described as very much decayed.[13]

M&R also report that at various points around the site, thought was given to drainage, for example they state; "*The bottom of the western part of the terrace is not flat, but shows in the middle a shallow impluvium which allowed the rainwater to run away towards the south."*[14]

The rationale behind these massive extended piers/terraces at the SE & NE corners is not known; though M&R suggested that the pyramid may have been intended to be much larger.[15] The pyramid contains two entrances, both on the north side; one exits though the superstructure whilst the lower entrance exits through the paved courtyard; both are displaced about 12.45m east of the pyramids N-S axis, or to the nearest whole cubit, the passage axis is some 24 cubits east of the pyramids axis. (Belzoni's drawing on page 2 is drawn

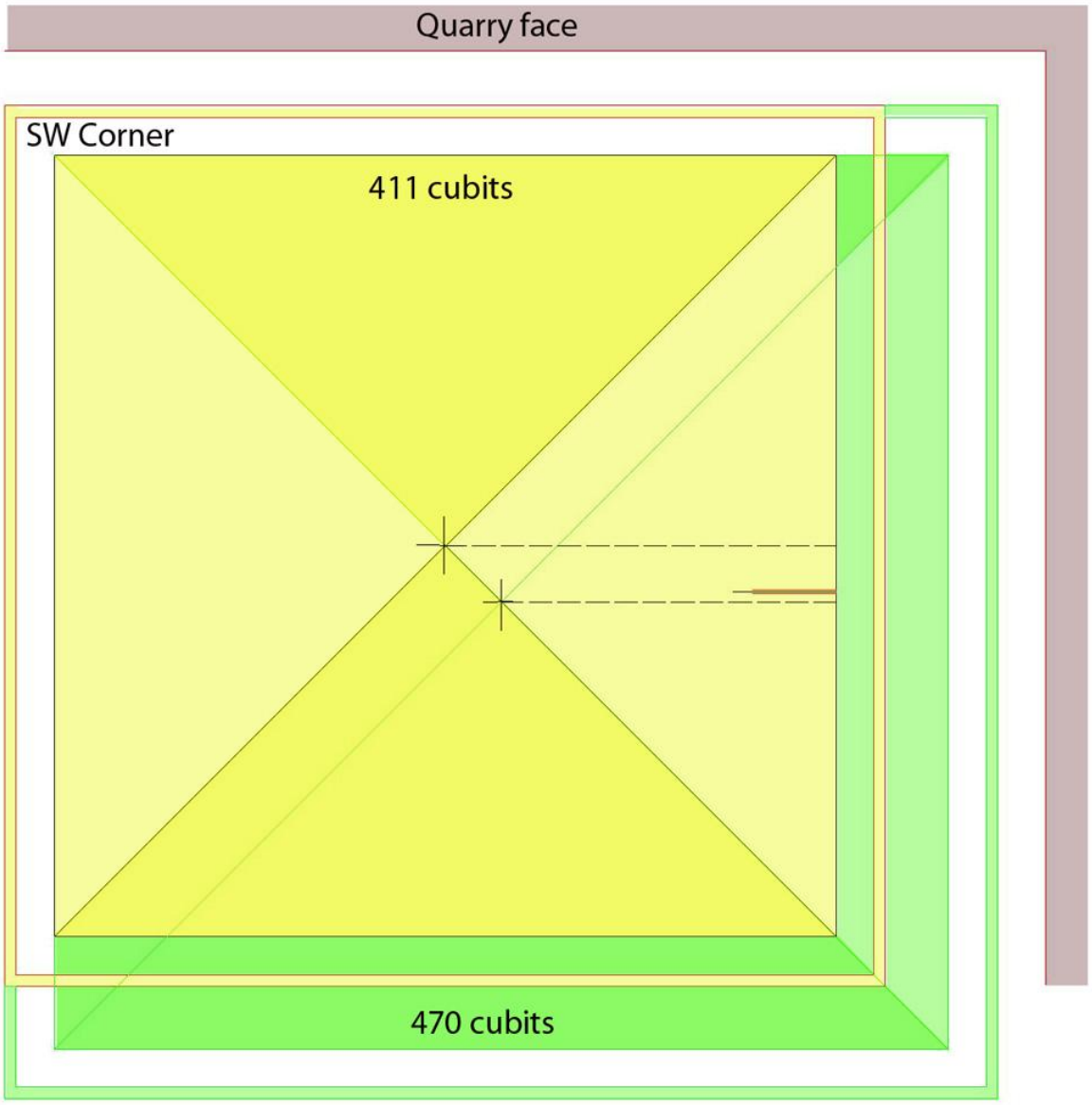
[13] Ibid, page 46
[14] Ibid, page 44
[15] Ibid, page 116-118, observation 27

incorrect, as this suggests that both entrances exit on the pyramid face; moreover the robbers tunnel is located wrong). I.E.S. Edwards would suggest that the lower chamber, which would be accessed by the lower entrance was originally the burial chamber, and in order that the burial chamber be located under the pyramid apex and the entrance exit on the pyramid face, the pyramid would have to be located some 200 feet further north. He would also state; *"An alternative explanation would be that the first intention was to build a pyramid covering a much larger area and that the northern and eastern limits were moved inwards. In either case a possible reason for the change in plan was the discovery of a suitable rock foundation for the causeway concealed beneath the sand on a line south of the one originally chosen."*[16]

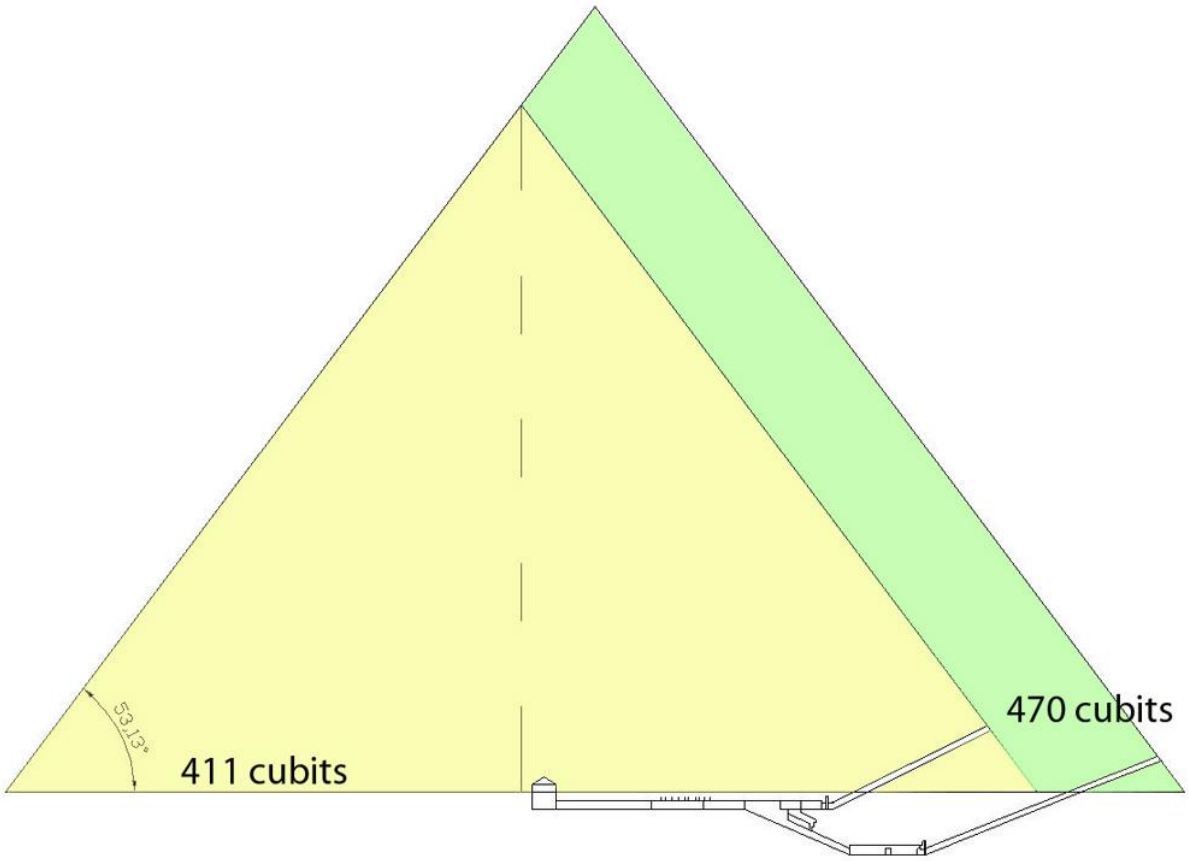
M&R would develop this idea further by suggesting that a pyramid some 470 cubits in length may have been intended; this would be larger than Khufu's whose length is 440 cubits. On M&R's plan on page 10, the pyramids SW corner is fixed and the outer limits of a 470 cubit pyramid are denoted by the dashed corner locations B. These enlarged corner locations fall inside the limits of the piers/terraces; though the piers/terraces are not connected to provide foundations for the east side of the enlarged pyramid, this gap is explained as an early change of plan to reduce the size of the pyramid. This reduction in size, would leave the initial original entrance, no longer exiting through the pyramid face, but through the paved courtyard, and so a new entrance was constructed for the reduced sized pyramid of some 410/411 cubits.

An enlarged pyramid of 470 cubits, whilst maintaining a courtyard of 20 cubits width, would place the north enclosure wall, at a similar distance from the rock quarry face as that found at the western enclosure wall. Though the wider space to the north may have been left for aesthetic reasons, as the visitor approaches the pyramid from the east; the narrower space to the west of the pyramid deemed not so important, as being at the rear, it is somewhat out of sight.

[16] The Pyramids of Egypt, revised edition 1985, page 146



In the above plan image the SW corner is fixed and I have created two superimposed pyramids one of 411 and an enlarged one of 470 cubits. Courtyard is set at 20 cubits width, and enclosure wall at 6 cubits width: the north quarry face is set at 110 cubits from the 411 pyramid and the west quarry face half of this amount. The centres of both pyramids are shown, and the entrance is displaced to the east on the 411 pyramid by 24 cubits, whereas the entrance is displaced to the west in the 470 pyramid by 5.5 cubits. Khufu's pyramid entrance was displaced to the east by 14 cubits, and the Red Pyramid's about 7 cubits; though Menkaure's and the north entrance of the Bent pyramid are located in the centre. For the current entrance to align with the centre axis of the pyramid it would have to have a base length of around 459 cubits, anything smaller than this and the entrance starts to get displaced to the east.



In the above vertical section, we can see the effect of an enlarged 470 pyramid on the lower entrance position; today this entrance is under the courtyard pavement, but if a larger pyramid was intended, its height above the pyramid base would be only around 6.5m (Khufu's is around 17m, Khafre upper passage about 12.80m; Bent just under 12m, the Red over 28m: only the much smaller pyramid of Menkaure at some 4.2m, would be the lowest.) Lehner & Hawass would state that an enlarged 470 pyramid would mean that the lower entrance would exit the pyramid face at the same height as the upper passage, but this would appear incorrect.[17]

Clearly if the enlarged pyramid was smaller than 470, then the lower entrance height above base would reduce further. It would seem strange to create such a huge monster of a pyramid, and expose its entrance so close to the ground for prying eyes; moreover, the angle of the lower passage does not conform to what we normally see; the upper passage does at around 26.5 degrees, but the lower is quite shallow at just over 21 degrees. If the lower chamber was the original burial chamber, it is a significant distance from the 470 apex, which is probably why Edwards suggested that the pyramid was

[17] Giza and the pyramids, 2017, page 190

intended to be some 200 feet further north. In short, the evidence for a larger pyramid is not as clear cut, and I feel the balance of the available evidence (which is quite poor for this structure) tends to favour the current pyramid which we see today, and that no enlargement theory is required to explain its features.

The Size of the Pyramid and Superstructure

Petrie's main contribution to Khafre's pyramid was in determining the size of the structure; but unfortunately he did not undertake a full internal survey, which would help reconcile some of the differences between Perring's and M&R's work.

	Length.	Difference from mean.	Azimuth.	Diff. from mean.
N. side	8471·9	−3·0 inches	−5′ 31″	− 5″
E. „	8475·2	+ ·3	−6′ 13″	−47″
S. „	8476·9	+2·0	−5′ 40″	−14″
W. „	8475·5	+ ·6	−4′ 21″	+65″
Mean	8474·9	1·5	−5′ 26″	33″

The above table of results by Petrie[18] gives the mean length of the pyramid as 8474.9 inches (215.26m). When it comes to intended cubit length, there are several suggestions from different authors; some suggest it was 410 or 411 cubits, and provide varying reasons, which are beyond the scope of this guide. From various clues Petrie would give the best estimate of the pyramids angle as 53° 10′ +/- 4°. (Vyse 52°20′: P.Smyth 52° 50′) Such an angle has been suggested as being a Pathagorean 3-4-5 triangle, though the angle also equates to an Egyptian Seked of 5 palms 1 digit.[19] One reason for possibly selecting a 411 base is that it provides a whole cubit number for the height 274 cubits (410 would give 273.33...)

The base of the pyramid differs somewhat from what we see at Khufu's pyramid; there we have an exceptionally levelled platform on which the first course of casing is laid, but this is not what we find at Khafre's pyramid. The first casing course at Khafre's is of granite; and these sometimes large blocks have a vertical foot of varying heights; moreover, the granite casing stones were placed on a rock foundation of varying height to compensate for the varying

[18] Pyramids and Temples of Giza, 1883, page 97.

[19] The Seked was the horizontal displacement from a vertical height of one cubit. There are 28 digits in one cubit and seven palms in each cubit, with four digits in a palm. Therefore a Seked of 5 palms, 1 digit, is a ratio of 28:21 which is 1.3333...., the same as a 3-4-5 triangle, as 4:3 is 1.3333...

heights of the casing stones. Not including the vertical foot, Petrie would give the height of the granite course as 41.52 +/-.05 inches vertically, from the top to the base of its slope (2 cubits).[20] As the casing foundation was not level, due to the non uniform height of the casing blocks (i.e. including the vertical foot), the pyramid reference level could be said to be the top of the first course. Lehner & Hawass took spot heights of the top of the first step of the core over a length of some 215m and found the level differs only by an average of 3cm.[21]

This view of the south side, we can see some surviving granite casing stones. The one in the foreground has a quite deep vertical foot, whilst the further one back has quite a shallow foot: the space between the two casing stones shows a higher rock foundation than that visible for the casing stone in the foreground. The level reference was the first core step; and at this location near the SW corner, the initial steps are cut from the bedrock, and are not masonry. Granite is hard to cut, so it is simpler to align the granite casing top to the level core step, and adjust the variable casing heights by cutting into the softer limestone of the plateau.

[20] Pyramids and Temples of Giza, 1883, page 98
[21] Giza and the pyramids, 2017, page 193

The above view is of the previous two casing stones, but viewed in the other direction; here the casing stone is sitting on its rock foundation but displays a quite shallow vertical foot. Against this vertical foot would be placed the courtyard pavement. The thickness of the pavement would result in a lower pavement foundation compared to the casing foundation[22]; this left a square of raised rock which helped Petrie determine the size of the pyramid.

The granite casing stones come in a variety of sizes; some would be quite long, placed as a header, reaching as far back to contact the core, and requiring no backing stones, whilst others required various backing stone solutions: like the rock foundation for the casing, it was easier to cut the softer limestone backing stones to fit the irregular granite casing stones.

Vyse would state that there were two courses of granite casing[23], though this observation was not confirmed by other investigators, and today most scholars believe only one course was fitted. M&R would list some reasons why they believe only one granite course was fitted and state; *"The above leads one to believe that the granite casing was restricted to the first course and no more,*

[22] Petrie would report that at the NW corner the whole rock was dressed flat, and so here the paving must have been of the same thickness as the vertical foot of the casing.
[23] Operations carried on at the Pyramids of Gizeh in 1837, Vol 2, page 115

otherwise the rock and the limestone of the second step of the nucleus would show, like those opposite the first, special cuts for the insertion of single blocks of granite which were normally of different sizes."[24]

Image courtesy of Jon Bodsworth

[24] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 100

In the previous image we are looking along the north face, and in the foreground we have the NW corner, which is cut from bedrock. We can see the raised foundation platform for the casing stones, and it confirms Petrie's observation that at the NW, the casing and paving platforms approach the same level. The levelled top of the first step stands out, as does the long stretch of vertical face of the second step, which M&R use to argue against a second course of granite, they state; *"The vertical face of the second step is straight for long stretches and this implies the use at these points of blocks not only of the same height, but also of the same depth. In the case of granite blocks this is so difficult as to be almost impossible"*[25]

However, as the granite casing above at Menkaure's pyramid shows, they were quite capable of fitting courses of granite of the same height; here the granite courses, like at Khafre's have a height of about two cubits so it is not an impossible feat. It would appear that the top of the first step was the builders' reference level for the pyramid, partly constructed of bedrock and masonry; it appears to maintain an accurate level around the pyramid on all four sides, and

[25] Ibid, page 100

seems to maintain long stretches of vertical faces; possibly to provide clear site lines for the builders, for this important course.

Image courtesy of Jon Bodsworth

In the view above we are looking along the west face of the pyramid towards the NW corner; on this side the level first step is entirely of bedrock. In all the images we have a surprising amount of granite littered about on all four sides; this was noted by M&R who would state, *"It should, however, be noted that the quantity of granite, either loose or fixed, now existing at the foot of the pyramid, is very great, which makes one think that only a small part of this stone was taken away and reused."*[26] This seems somewhat surprising, as its quite hard work to split granite; the procedure can be seen on the casing stones on pages 16 & 17. Here they appear to cut a groove partially along the middle of the casing stone, then drive wedges at intervals to fracture the stone along this line: there is hardly a granite stone that has not been cleaved in a similar manner, so why is there so much of it around the pyramid? Why did the stone robbers not

[26] Ibid, page 100

process the granite pieces which they had already split, or was so much of it deemed as rejects?

In this view a lot of fractured granite pieces have been restored up against the core (this area is north face by the lower entrance); according to Lehner & Hawass only five granite casing stones remain in place around the whole base of the pyramid.[27] So a vast amount of granite has been subject to the blows of the stone robbers, and yet a huge amount still surrounds the pyramid. Why was the granite not carted away as it was released from the pyramid; it's hard to imagine that the entire granite casing be split first before it was taken away: especially since the time to work this hard stone would be considerable. Maybe Vyse's second granite course[28] could provide a solution, as two courses would generate more waste/reject blocks. Though M&R are against a second granite course, and playing devil's advocate, we can see from Menkaure's pyramid that they were capable of working granite casing to the same height, and so the question of a second granite course remains open. It would be worthwhile to

[27] Giza and the Pyramids, page 193

[28] Perring in his publication, The Pyramids of Giza, from actual survey and admeasurement, Part II, page 1, would state "The lower tiers of this pyramid (about 7 or 8 feet in height) have been faced in granite"

inspect the huge amount of granite remains, for if a second course did exist, the bottom of this casing should have an acute angle, with no vertical foot; and if no such pieces can be found, then it is more likely that we have only the one course of granite.

As the granite casing is given a height of two cubits, and assuming a 3-4-5 angle for the pyramid with one course of granite, then the base length of the pyramid at the top of the granite casing reduces to 408 cubits for a 411 pyramid or 407 cubits for a 410 pyramid. The 3-4-5 angle would be useful for building control, for every 2 cubit increment in height, reduces the base length by 3 cubits: Petrie who took some course levels at the bottom of the pyramid noted how the tenth course equated to the 20 cubit level[29]; at this level the side length of the pyramid would be 381 cubits for 411, or 380 for 410 (Petrie also mentions the fifth course at the SW being at the 10 cubit level).

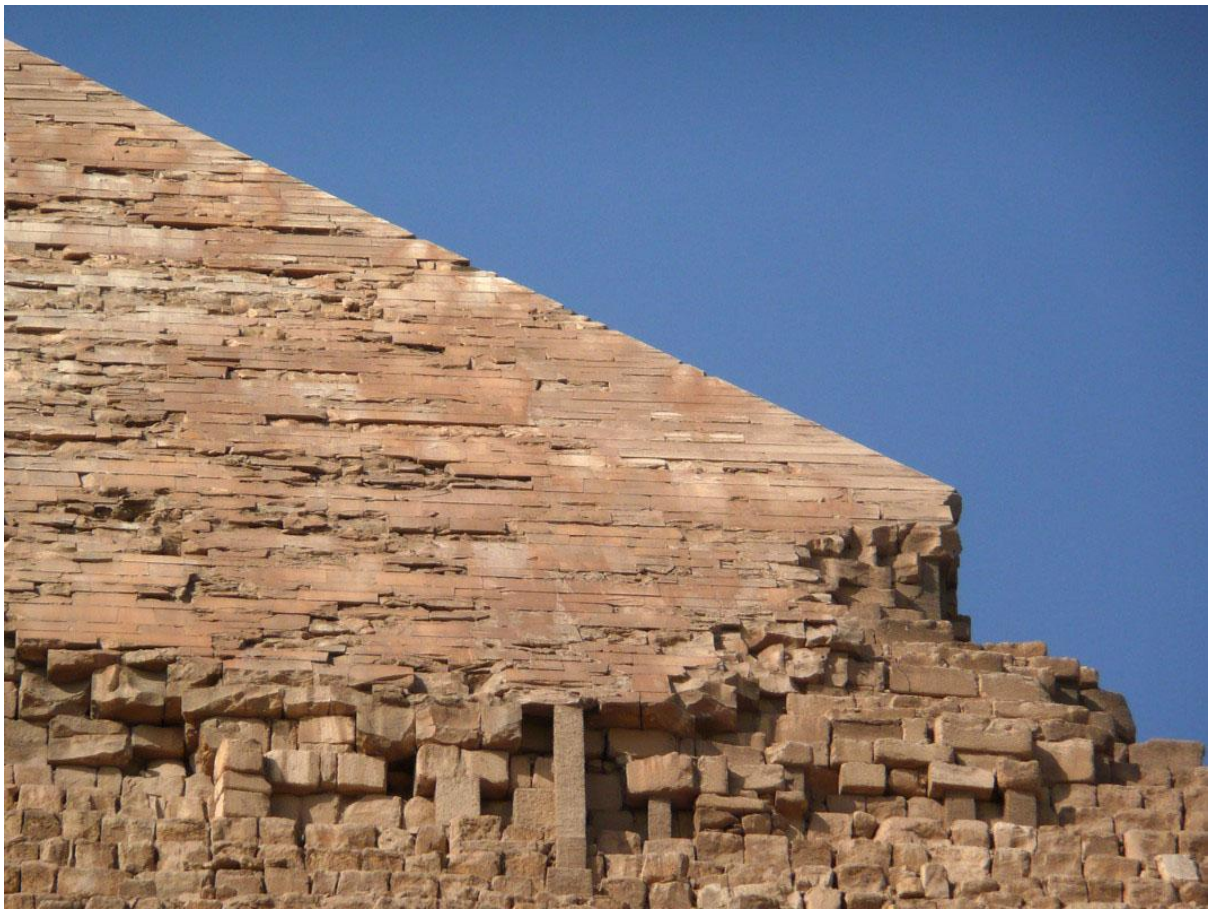


Image courtesy of Jon Bodsworth

[29] Pyramids and Temples of Giza, 1883, page 99

A sizeable mantle of limestone casing remains at the summit of the pyramid, and at places modern piers have been built to support the casing. Petrie would describe the casing; *"The upper part of the Pyramid was cased with Mokattam limestone, of a rather different quality to that of the Great Pyramid; it is grayer, harder, more splintery, and of not such a regular and certain fracture."*[30]

The robbing of the limestone casing is uncertain; Petrie would find a coin of Sultan Hasan, 1347-1361, under the SE corner, and as the mosque built by the Sultan was said to have been built with stones from the pyramid; it suggested that some stones were removed from the base of the pyramid. Though Petrie mentions other early travellers from 1581 and 1591 who suggested that the casing largely remained intact; though Sandy's view of 1611 shows the current state of the structure.[31]

The casing stones at this level are understandably of smaller dimensions; M&R state, *"The casing was laid in horizontal courses: the stones are not always of large dimensions and many are smaller than some of the local limestone blocks of the nucleus."*[32] Lehner & Hawass made the following observation on the casing;

"Looking out across the whole expanse of casing, it is noticeable that the slabs are not in fact flush, but jut in and out by a few millimetres. One explanation might be that at this level the masons cut the slope into the blocks before they laid them in place and so the fit is not exact; alternatively, the slabs might have shifted when people removed the casing further down."[33]

Another possibility to explain this observation is the theory put forward by the engineer Peter James, of thermal expansion.[34] Basically the casing is subject to a large variance in temperature; the sun can beat down at 40 degrees plus, and cool significantly at night. This cycle of expansion and contraction over the vast age of the structure, gradually breaks down the joints, and as more dust and debris fills these joints, the natural outcome is for the stones to undergo thermal movement.

[30] Ibid, page 98
[31] Ibid, page 98
[32] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 50
[33] Giza and the Pyramids, page 194
[34] Saving the pyramids, 2018, see pages 75, 97-101

Just below the intact casing we have an irregular band of what appears to be neat stepped core masonry, and below this, the greater bulk of the pyramid gives a less neat appearance. M&R state; *"Immediately under the surviving part of the casing the nucleus is seen to be formed of regular, clearly marked masonry courses, which form as it were an actual flight of steps. Below this what remains of the faces seems to be very much coarser, as if it had suffered more from the ravages of time. This, however, does not seem to be the case and the irregular superficial layer is perhaps due to detritus or the remains of backing-stones still in situ, while in the regular part these remains have fallen or been removed."*[35]

Lehner & Hawass would further comment; *"This lower band of loose material might be taken for packing material between core and casing, still attached after the casing was ripped away. Indeed, in certain lights the rubble appears to form irregular bands, thinly veiling the more regular stepped courses underneath. However, when we climb the corners of the pyramid we can see that the irregular masonry appears to continue for some depth into the pyramid."*[36] They would go on to add the suggestion that more regular masonry was fitted as they neared the top, to enable better building control. It is hard to form an opinion on this unusual feature, without climbing over the structure or flying drones for a closer inspection, which is not an option for a layperson.

Perring would describe a platform of some 9 feet square (5 cubits?), left at the summit. On the upper surviving stones shallow sockets have been cut to help bond the next course of masonry, and likely the missing pyramidion had a

[35] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 50
[36] Giza and the Pyramids, page 191

square protrusion to engage in one of these sockets left in the course below. If the current platform is 5 cubits square then the top of the pyramid would be 3&1/3rd cubits higher or 1.75m: this would appear to be overly large for a pyramidion. If we assume a pyramidion with a height of 2 cubits (1.05m), its base would be 3 cubits (1.57m), with a volume of 0.86 cubic metres. We do not know what material the pyramidion was made of, but if we take granite at 2700kg per cubic metre, we are looking at a pyramidion of some 2.3 metric tonnes. This may seem like a daunting task to place such a weight, but the granite pyramidion found at the Black pyramid, had a base of some 1.87m and a height of 1.31m[37], or 1.53 cubic metres, or over 4 metric tonnes.

Between the granite casing and the enclosure wall, a fine limestone pavement was laid, which surrounded the pyramid on all four sides. M&R measured the width at various points and concluded that its intended width was 20 cubits (about 10.47m)[38]. Petrie's measures are some 3m more, and M&R state that Petrie had measured to the outside of the enclosure wall.

The above view of the west side looking south, shows some surviving paving. M&R describe the paving as somewhat irregular in size and shape, with a

[37] Der Pyramidenbezirk des konigs Amenemhet III in Dahshur, D.Arnold, page 14
[38] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 72

thickness between 30-45cm. They lay directly on the rock, and seats were made in the rock to receive the paving; the stone enclosure wall has long been robbed. M&R offer the following description of how the wall may have looked like;

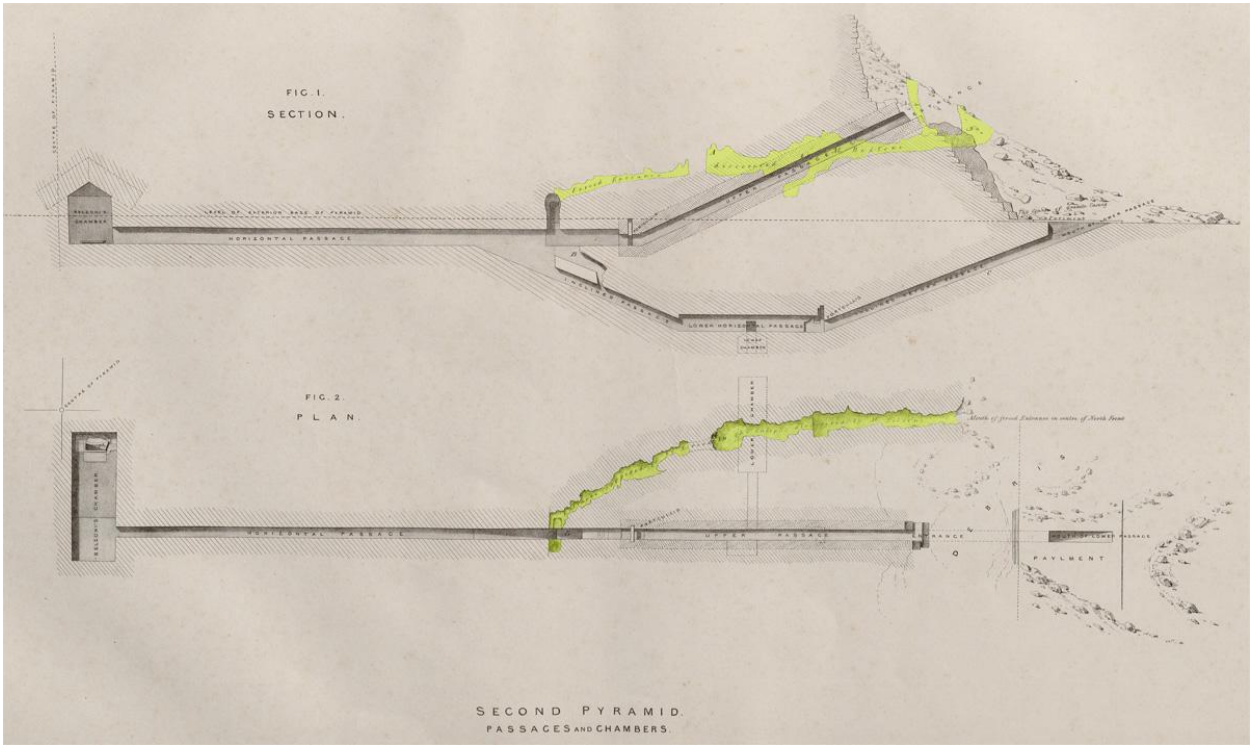
"The enclosure wall of the courtyard was built on foundations which varied in width from 3.25 to 3.60 m. As far as may be seen to the north, east, south and west these foundations are all on rock, except in the SE corner ,where, as we have said, large blocks of local limestone appear on the surface; they also form the foundation of the SE corner of the pyramid. Under the fine limestone blocks of the foundation of the enclosure wall was laid a thin layer of a very hard and pink mortar, large traces of which are still visible on the levelled rock. We think that, as usual, the foundation was a little wider than the wall at the base, whose thickness, therefore, must have been about six cubits (3.14 m.). If we consider the wall faces to have had a slope of 1/7, the wall itself would have been about 8 metres high. Judging by subsequent examples, one may think that the inner nucleus of the enclosure was of coarse limestone and the facing of fine limestone, and that the wall ended at the top with the normal curve joining the two inclined surfaces. More or less fragmentary blocks of this rounded top have been found, especially along the south and west sides of the pyramid."[39]

Where the paving has been removed various holes are to be seen; some would be lever holes to assist in moving masonry, whilst others are thought to be involved as possible surveyor markers for the pyramid. M&R would mention; "*Roughly rectangular or roundish holes, with sides of about 40 cms., were cut in the rock along the four sides of the pyramid and about 9.50 m. from its base. They are regularly spaced (about 5 metres) and were filled with mortar and stones cut ad hoc before the pavement was laid."*[40] A similar array of holes, albeit with different spacing is also to be found at Khufu's pyramid.[41]

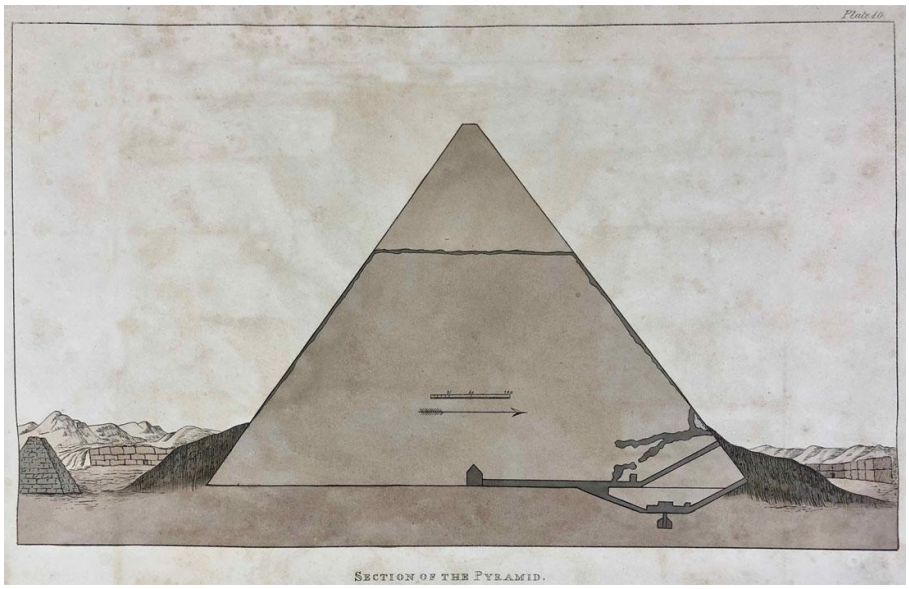
If we accept a pyramid of 411 cubits base, with height of 274, its volume amounts to 85% of that of the Great Pyramid (G.P. is 440 x 280 cubits); and if a 470 base pyramid was intended with a 3-4-5 angle, the G.P. would only amount to 78% of this giant. Perring would give the base of Khafre's pyramid as being some 10.11m higher than Khufu's base, meaning that Khafre's summit would be higher than Khufu's by about 7m (based on a 411 base).

[39] Ibid, page 72
[40] Ibid, page 72
[41] Giza and the pyramids, page 436

The Substructure



The above section and plan of the substructure is courtesy of Perring[42], and I have highlighted the robber's tunnel. We can compare the above with Belzoni's below, were we can see significant difference in the robber's tunnel; indeed, reading the accounts between the various authors, it is difficult to obtain a clear and accurate image of this tunnel: though in plan view it looks like the robber's were confident in their route.



[42] The Pyramids of Giza, from actual survey and admeasurement, Part II, plate II.

Compared to the complicated internals of Khufu's pyramid, Khafre's is a rather low key affair; maybe the movement visible in the Kings chamber of Khufu's pyramid, made them more cautious and avoid building in the superstructure.

The design of Khafre's substructure appears illogical, we have two entrances, which lead to two chambers and because they are connected, it took only one entrance to be discovered to render the security of the other as superfluous. A basic description of the substructure, starting from the upper entrance; we find that the upper passage is constructed of granite masonry, this terminates at a single granite portcullis, and beyond this we have the start of a long horizontal passage, partly cut through the bedrock and partly constructed of masonry. However, because we have a connecting passage from the lower chamber merging through the floor of the long horizontal passage, we have a large void in the floor of some 4.72m, which would need to be bridged, if a funerary procession was to enter by the upper entrance. At this junction no post holes are to be found in the walls to create such a bridge. We could argue that the procession could transit through the lower passage, but then why build the upper entrance, knowing that it would be made redundant? Indeed, why was it necessary to connect the two passages? Security would be better improved if the ascending passage from the lower chamber was omitted, the upper corridor would be intact, allowing a procession; whilst if only one entrance was discovered, at least one chamber would escape the attention of the robber's. The apparent illogical layout raises more questions than answers.

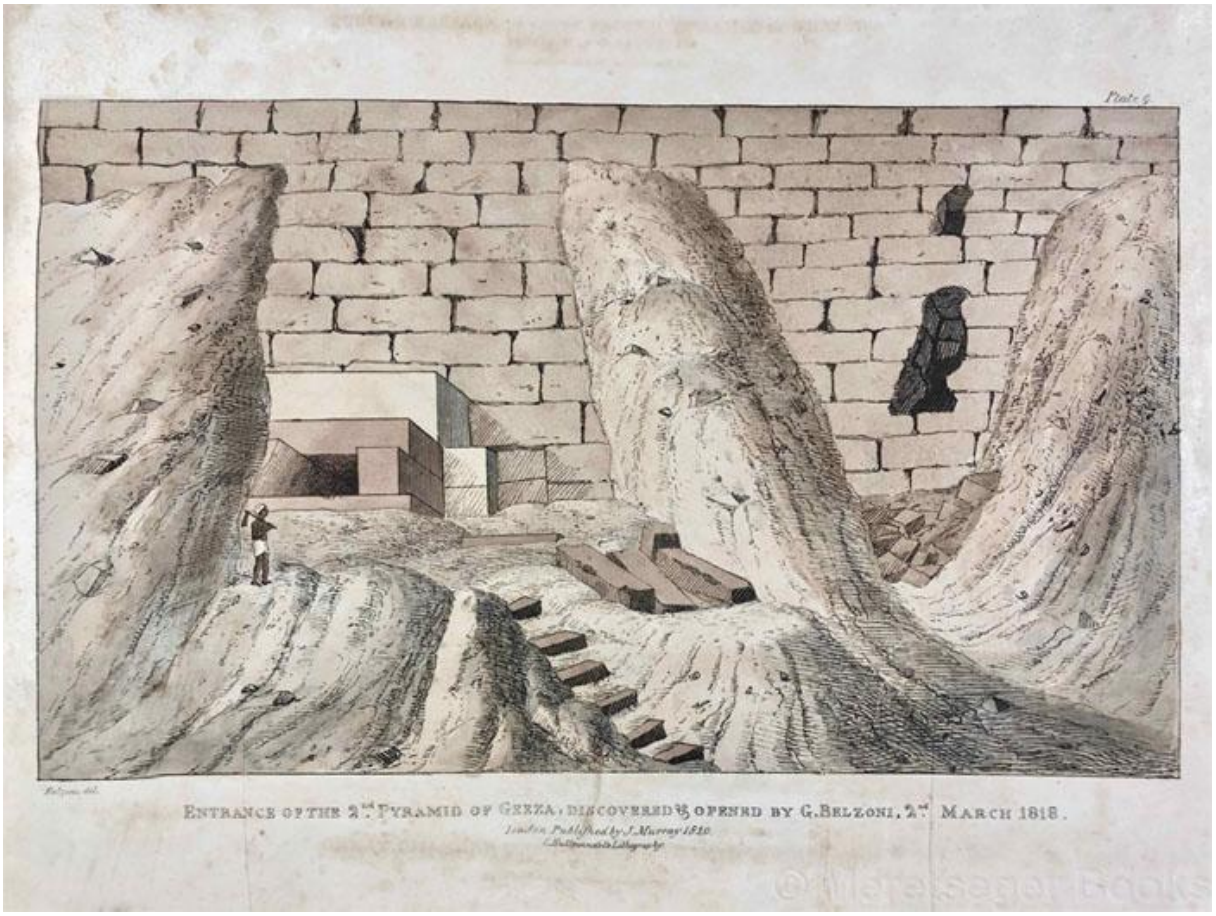
The long horizontal passage continues and enters into the burial chamber; the chamber itself is located in the NE quadrant of the pyramid, and it appears that no part of the chamber encroaches into the southern or western parts of the pyramid. In M&R's TAV 6&10 they show the south wall of the chamber being 1.17m south of the pyramids east-west axis, however, placing their data in AutoCAD, I found the south wall to be over 2m north of the east-west axis. It is a pity that Petrie did not do a full internal survey; but pending a more modern survey it would appear that Perring's drawings on the previous page are more correct.

At the west end of the chamber a fine granite sarcophagus was sunk in the floor, and surrounded by granite blocks. The greater portion of the chambers floor was paved in limestone, whilst at the east end a portion was left in natural rock. The walls of the chamber are largely of rock which was plastered, with the tympana partially constructed of masonry. The pent ceiling was constructed of very fine limestone beams.

The lower entrance cut through the bedrock terminated at another granite portcullis; beyond the portcullis a horizontal passage of similar dimensions to the upper joins with an ascending passage, which exits in the floor of the upper horizontal passage. Midway along the lower horizontal passage an opening on the west wall leads down into the lower chamber (an excavation on the east wall appears to act as a turning space); this chamber is a wholly rock cut chamber.

We will now look at the elements that make up the substructure in more detail.

The Upper Entrance & Portcullis



From Belzoni's publication we have the above plate of the entrance; it is a bit more schematic than accurate, with the robber's breaches placed too high. It is these robber's breaches that Belzoni first discovered after some 18 days of digging. The amount of debris that greeted Belzoni is not known, but when the debris was cleared from the south face of Khafre's pyramid in the 1960's, it amounted to some 15m high (the upper edge of the granite floor stone by the entrance M&R give as 11.54m from the base). Belzoni describes his clearance of the robber's tunnel;

"Having caused the entrance to be cleared of the sand and stones, I found a tolerably spacious place, bending its course towards the centre. It is evidently a forced passage, executed by some powerful hand, and appears intended to find a way to the centre of the pyramid. Some of the stones, which are of an enormous size, are cut through, some have been taken out, and others are on the point of falling from their old places for want of support. Incredible must have been the labour in making such a cavity, and it is evident, that it was continued farther on towards the centre; but the upper part had fallen in, and filled up the cavity to such a degree, that it was impossible for us to proceed any

farther than a hundred feet. Half this distance from the entrance is another cavity, which descends forty feet in an irregular manner, but still turns towards the centre, which no doubt was the point intended by the persons who made the excavation. To introduce many men to work in this place was dangerous, foe several of the stones above our heads were on the point of falling; some were suspended only by their corners, which stuck between other stones, and with the least touch would have fallen, and crushed any one that happened to be under them. I set a few men to work, but was soon convinced of the impossibility of advancing any farther in that excavation."[43]

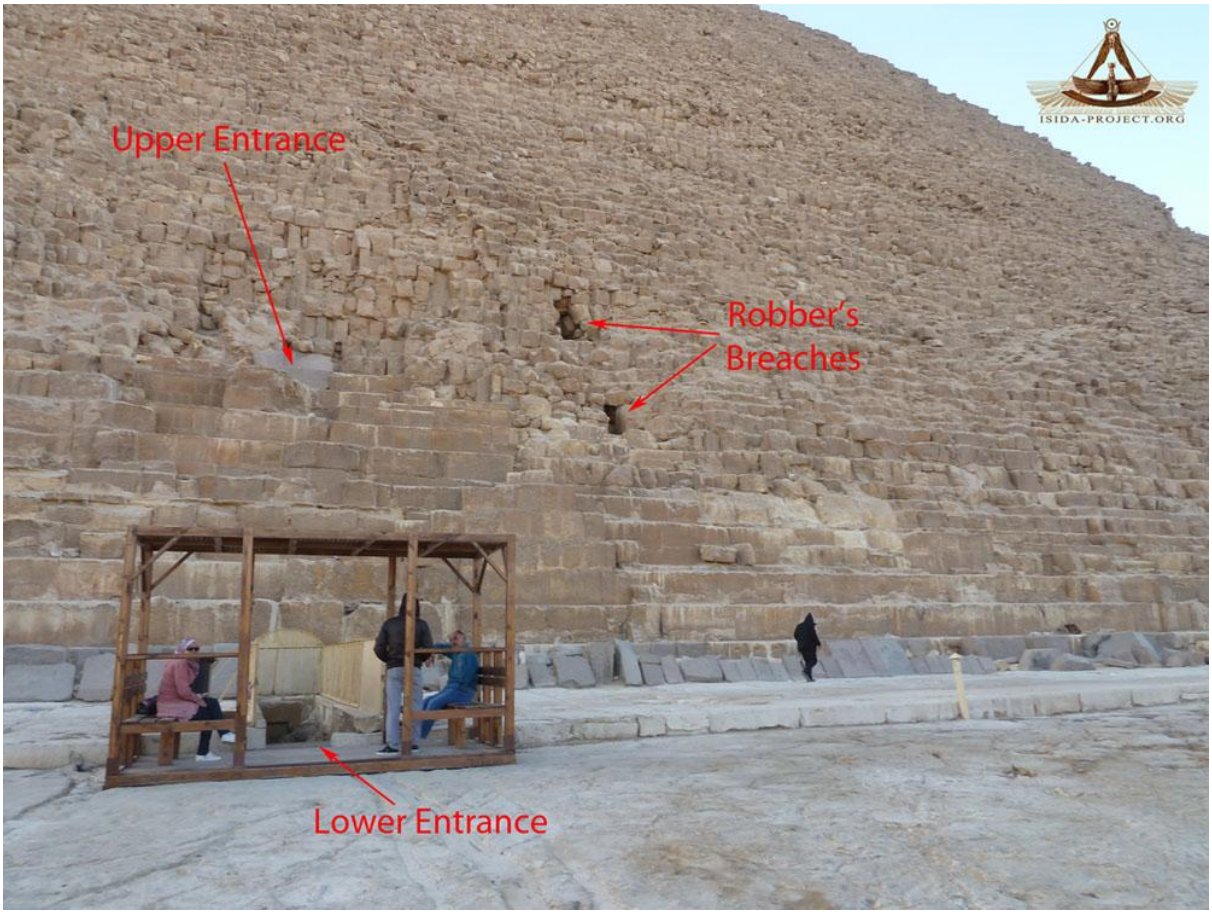
In the previous image we can see two breaches, one above the other; the upper seems strange, as it appears to vertically cut down to join the lower breach (see image on page 27): one wonders if this feature was created by the robber's in the hope of creating a current of air to assist the tunnelers. The question arises as to who made the robber's tunnel? The fact that it curves to the east and fortuitously emerges beyond the portcullis, suggest that the robber's were well aware of the pyramids layout, and if so, had to have been done within living memory of its construction. The actual real entrance would surely be known to them; their eagle eyes would be on the lookout for large lintel stones that protected the entrance: the huge lintel above the Bent pyramid entrance could hardly not be noticed for example. Having removed the limestone casing stone that covered the real entrance, what would greet them? They would definitely see the granite lined descending passage, but was it plugged with granite stones? Perring was under the impression that it was, but this view was probably influenced by the plug stones found inside the lower entrance passage. M&R thought it not likely that the passage was entirely plugged due to the condition of the passage walls; but thought that any plugging may have been limited to a few plugs at the upper part.[44]

So robber's may have been greeted with granite plug stones at the upper part, but would they know how many there was? It may have been the original intention to plug the entirety of the passage; however, an incident such as a plug stone getting stuck fast on its descent may have changed plans to only a few plugs being inserted at the upper end: but robber's would be likely unaware of this fact. Seeing the start of granite plugging they have to assume that the passage was entirely plugged, they are then left with the stark choice of how to circumvent the obstacle. One option would be to bypass the plugging and the granite lined passage by cutting through the limestone masonry alongside the passage. This they did not do but elected to start a tunnel some 8 to 8.5 m above the base and roughly in the middle of the north face.

This location for the robber's tunnel convinced M&R that it was not excavated to permit the first violation of the pyramid, and they state; *"The*

[43] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni, page 263-264.
[44] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 104, observation 10

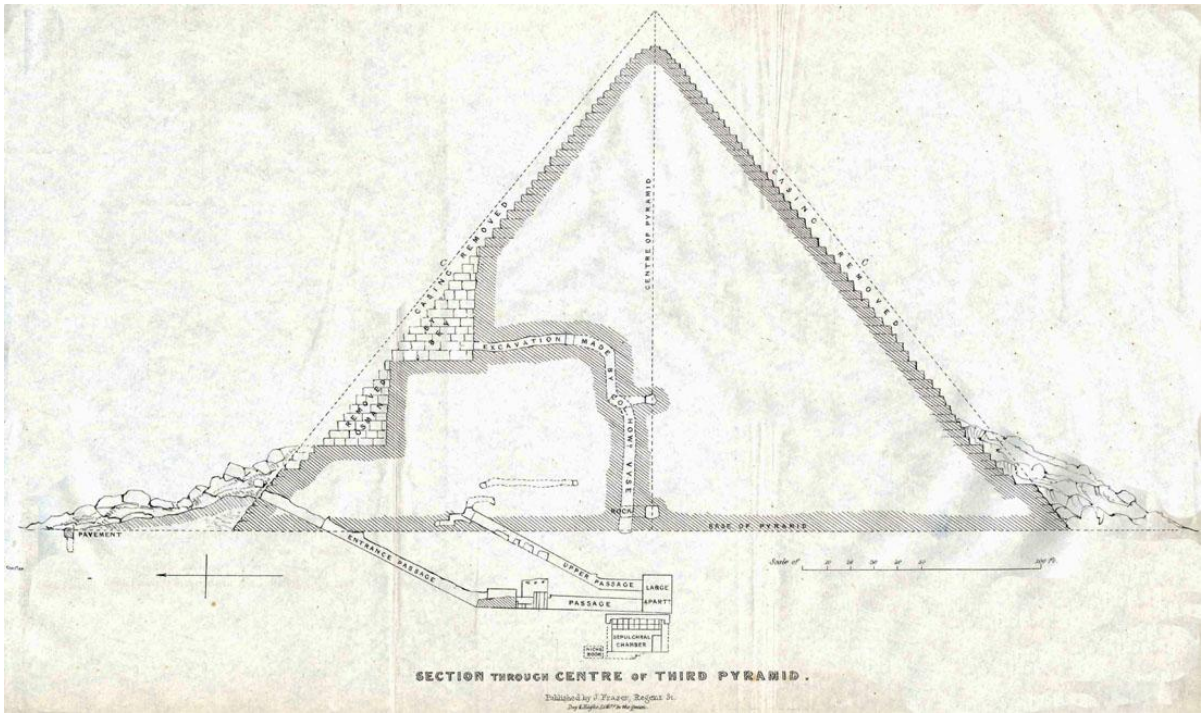
tunnel forced in the masonry seems to have been made by thieves who did not know either where the original entrance was or how to find it."[45] Or did they?



In the above view we get a good view of all the features discussed, and if one looks closely it will be seen that we have a superior laid mass of masonry below the upper entrance; this triangular shaped mass of well laid masonry extends down to the bedrock cut courses. Its function was likely to provide a good foundation for the descending passage. The robber's may have been aware of this feature and elected to avoid cutting through this mass, and instead cut through the loser fill of the core and create a tunnel with a reduced angle, than one determined by following the passage.

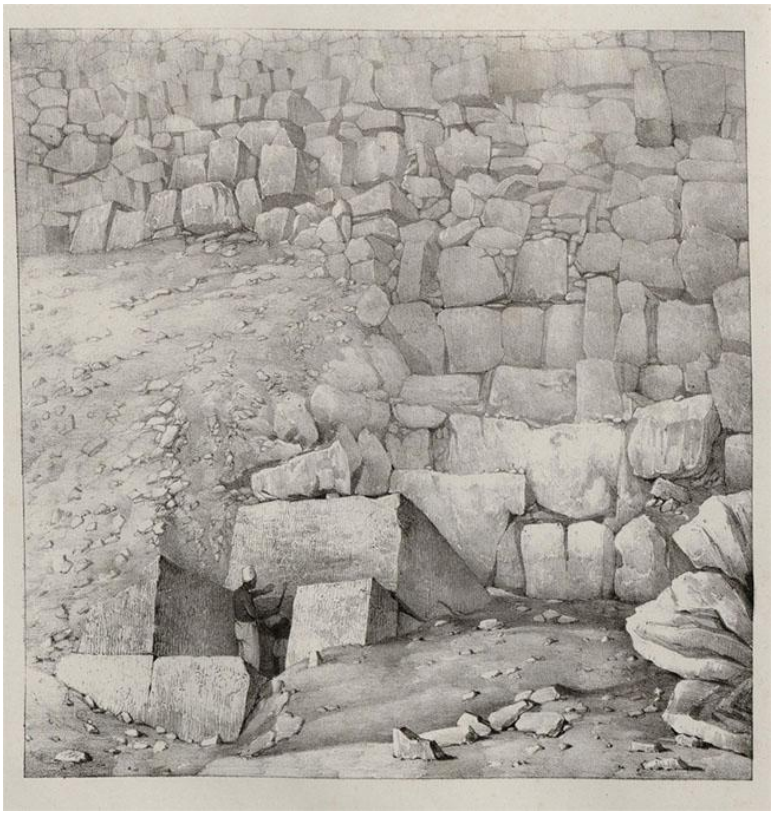
Both Khafre and Menkaure pyramids have a loose fitting core compared to Khufu's, likely because Khufu's internals are largely in the superstructure. Belzoni had to abandon clearing the robber's tunnel due to safety, but would this be the problem encountered by the original robbers? I would suggest not, for if we look at the core of Menkaure's pyramid, it has a similar loose core of masonry and yet Vyse was able to cut and blast a tunnel through the centre; moreover he cut a tunnel through the width of GIII-b, with relative ease.

[45] Ibid, page 104, observation 7



The above image is the start of Vyse's tunnel in Menkaure's pyramid and we can see the loose fill that makes up the core; the route of Vyse's tunnels is shown in his section drawing above. It is likely that the original robber's encountered the same conditions that greeted Vyse; however, Belzoni may have attempted to clear a tunnel created some 4300 years earlier. If this tunnel is the initial violation of the pyramid, these holes would be open for a vast time as the

casing was relatively intact for most of the pyramids history. Rain sheeting over the casing would pour into this tunnel, and along with atmospheric agents, salts form on the core stones, parts start to spall off; we may even have further searchers trying their luck in this tunnel causing more damage, along with untold earthquakes during its vast history. The tunnel may have been open to the elements until the robbing of the casing when debris covered its existence. It is often thought that the tunnel may have been done under the Caliph's and a similar tunnel in Khufu's pyramid is often attributed to Al-Ma'mun in about AD 820; however, there is no hard evidence that the Caliph's made either tunnel.[46]



From Perring's publication we have the above drawing of the upper entrance; floor, wall and ceiling blocks are all constructed of granite for the entire length of the descending passage down to the granite portcullis. Unfortunately Petrie did not provide a full survey, and so he gives no value as to where the floor of the passage would exit on the pyramids casing; M&R on TAV 7 give the upper edge of the floor stone above as being about 11.54m above base (Perring would give 11.48m). Using M&R's TAV 7, the entrance threshold in the cased face by scale rule would be around 12.90m above base; but ideally the pyramid requires a modern survey.

Unable to clear the robber's tunnel, Belzoni gave his workers a rest day why he pondered his next move. This time he spent observing the entrance of

[46] In the case of al-Ma'mun, see 'Al-Ma'mun, the Pyramids and the Hieroglyhs' in Orientalia Lovaniensia Analecta 177, Abbasid Studies II, pages 165-190, by Michael Cooperson.

Khufu's pyramid and observed that the entrance was not in the centre of the pyramid face but displaced to the east; armed with this knowledge he once again attacked the debris which cloaked the north face, and soon discovered the granite masonry of the descending passage. At noon on the 2nd of March, the true entrance was uncovered and the work of clearing out debris from the passage began; this took the remainder of the day and part of the 3rd before they arrived at the portcullis. Belzoni would give the length of the descending passage as 31.83m at an angle of 26 degrees.[47] (Perring gives from the first lintel to horizontal passage as 31.95m, whilst M&R give 31.70m for the ceiling length).

The passage angle first measured by Perring is given as 25˚55′[48]. Piazzi Smyth measured the angle of the passage and its azimuth, which closely agrees to the mean azimuth of the pyramid as recorded by Petrie: Smyth would give the mean passage angle as 26˚30′17″[49], which is what is normally quoted today.

The large lintel above the entrance today is about 2.85m wide (Smyth), 1.50 high and 2.10m deep (M&R), which gives about 9 cubic metres, or about 24 metric tonnes (according to M&R's TAV 7, some of these granite ceiling blocks are as much as 3.5m deep). The ceiling stones were supported by granite wall stones, which lay on a granite pavement. As to the quality of the granite passage, Petrie states;

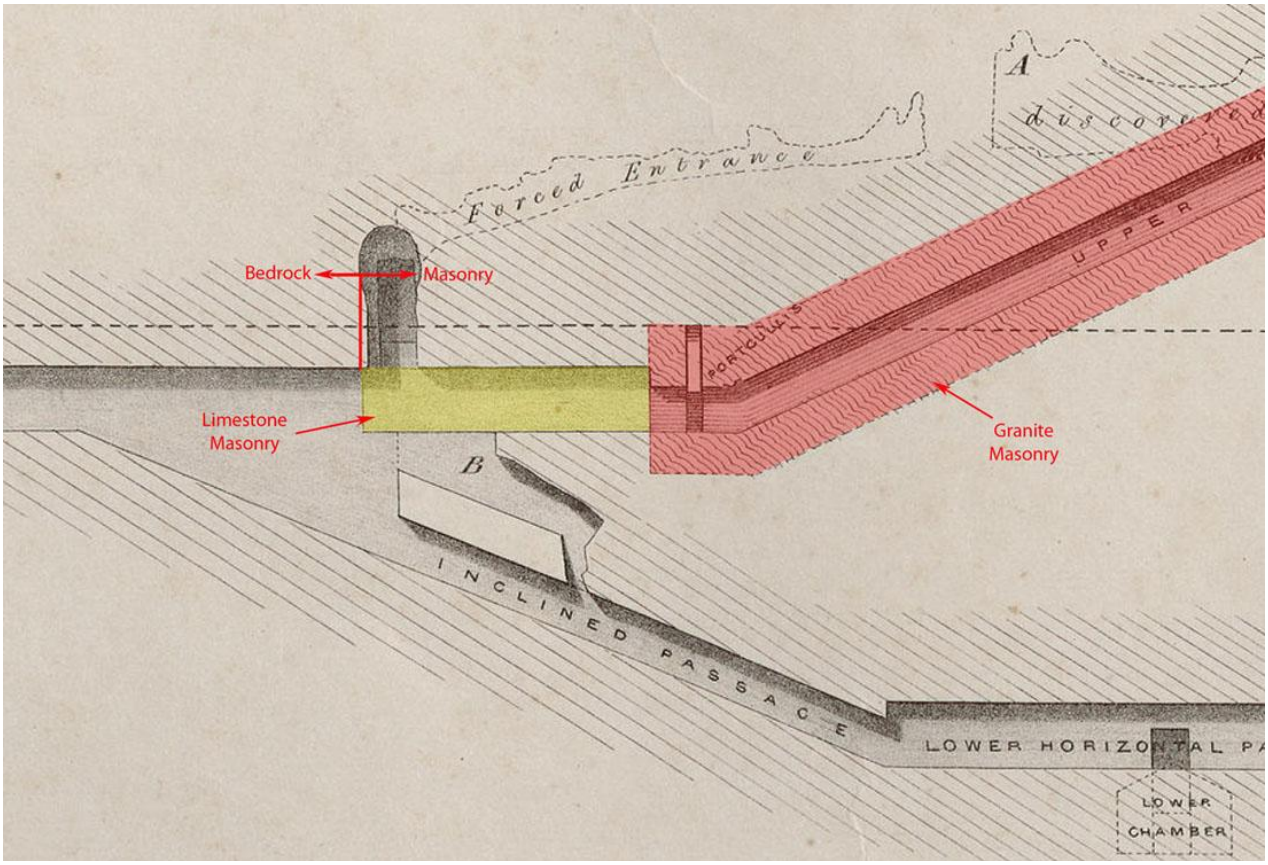
"The entrance passage is entirely of rough dressed granite, none of it polished; like the work of the King's chamber ceiling and the antechamber, and not like the King's Chamber walls in the Great Pyramid. The flaws in it are made good with plaster, much of which is to be seen on the first roof-stone, and all along the side of the roof, sometimes half-way across it. This was laid on with a board or trowel, and afterwards painted red, like the plastering in the Granite Temple."[50]

This passage was measured thus, in height and breadth :—

	E.	W.	Top.	Base.
At mouth . .	47·33	47·32	41·62	41·21
Half-way down .	47·31	47·13	41·08	41·17
Near end . .	47·44	47·23	41·34	41·33
Means . .	Height 47·29±·03		Width 41·29±·05	

The above table by Petrie (in inches) shows the dimensions for the passage; this standard first seen in the Red pyramid at Dahshur is common at Giza, being 2 cubits wide by 2 cubits 2 palms high.

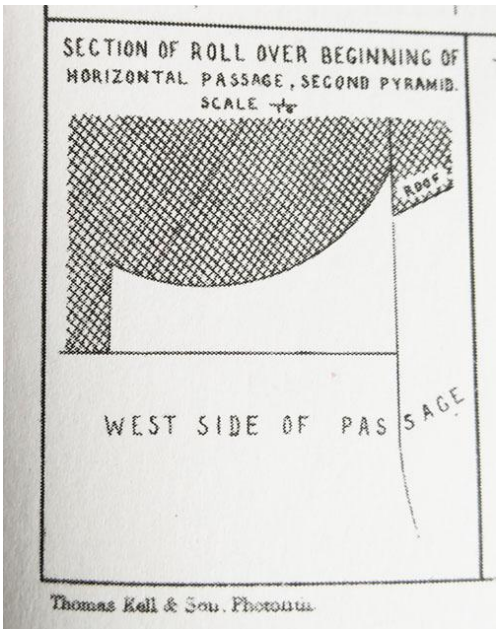
[47] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni, page 268
[48] Operations carried on at the Pyramids of Gizeh in 1837, Vol 2, appendix pages 117-119, for table of dimensions for pyramid
[49] Smyths tables and measures of Khafre's pyramid can be found in his volume 2, 'Life and work at the Great Pyramid 1867', pages 271-278
[50] Pyramids and Temples of Giza, 1883, page 104



From Perring's plate II we can see the granite lined descending passage merge with the horizontal passage; the granite lining continues in the horizontal passage and ends just over a metre beyond the portcullis: here the height of the horizontal passage increases to a comfortable walking height, and here the granite gives way to limestone masonry. This limestone masonry extends for some 8.61m, wherein the passage is cut from bedrock. We recall that a considerable amount of the bedrock forms the lower steps of the pyramid, but how uniform this rock is throughout the pyramid cross-section is unknown, as we could have higher and lower areas of bedrock. The limestone portion highlighted above is also roofed with masonry, though the floor is bedrock.

It appears that in order to create the portcullis housing, a shallow trench was cut in the bedrock, and that said trench terminates at the end of the limestone masonry; to the north of this junction the passage appears to be built on the bedrock, and above the passage we would have core masonry. The robber's tunnel may have been cut to avoid the bedrock, and then when they reached the masonry/bedrock interface they cut vertically downwards to breach into the passage. I could find no detailed information on this part of the robber's tunnel, but it would be worth further investigation, as it might provide information on bedrock height at this location. The construction of the descending passage may have been an additional motive for robber's to place their tunnel where it is, in order to avoid cutting through bedrock.

The original floor length of the descending passage is uncertain, pending a modern survey, but by scale rule from M&R's TAV 7 it is around 36.70m (70 cubits?) this would place its end about 3.6m below base.

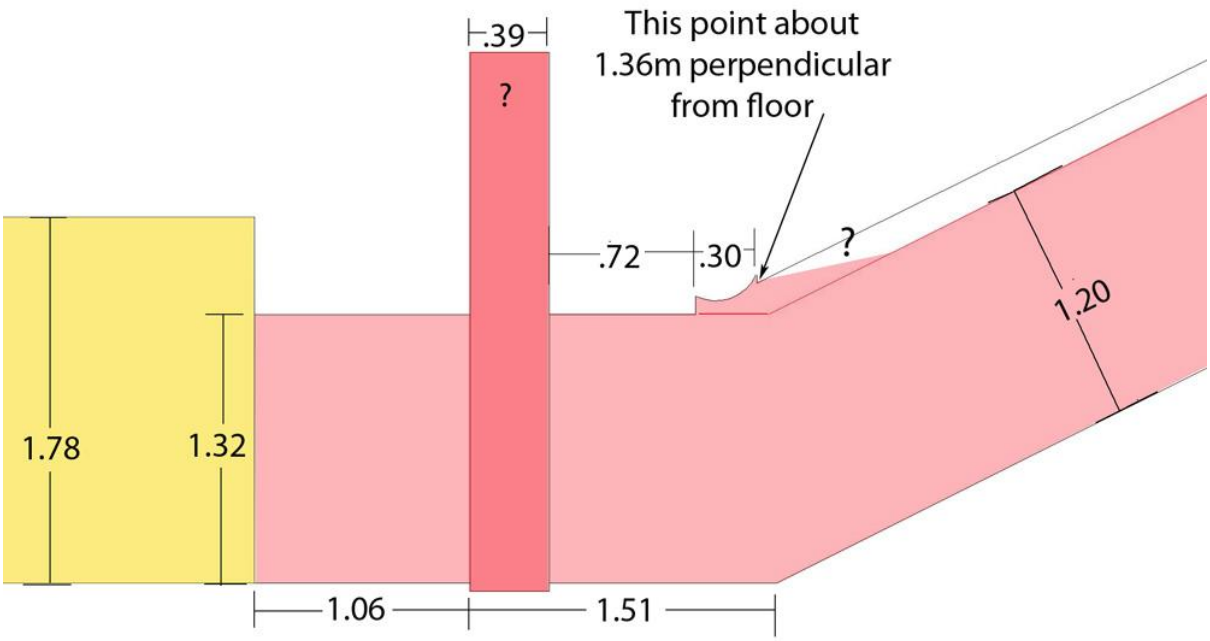


At the southern end of the descending passage ceiling a decorative torus was made in the granite; it is not well drawn in Perring's or M&R's work, but Petrie did a small drawing of it, shown left. M&R would comment; "*A symbolic value might be attributed to it solely because, when the pyramid was closed, it was destined to be seen only by the spirit of the dead king.*

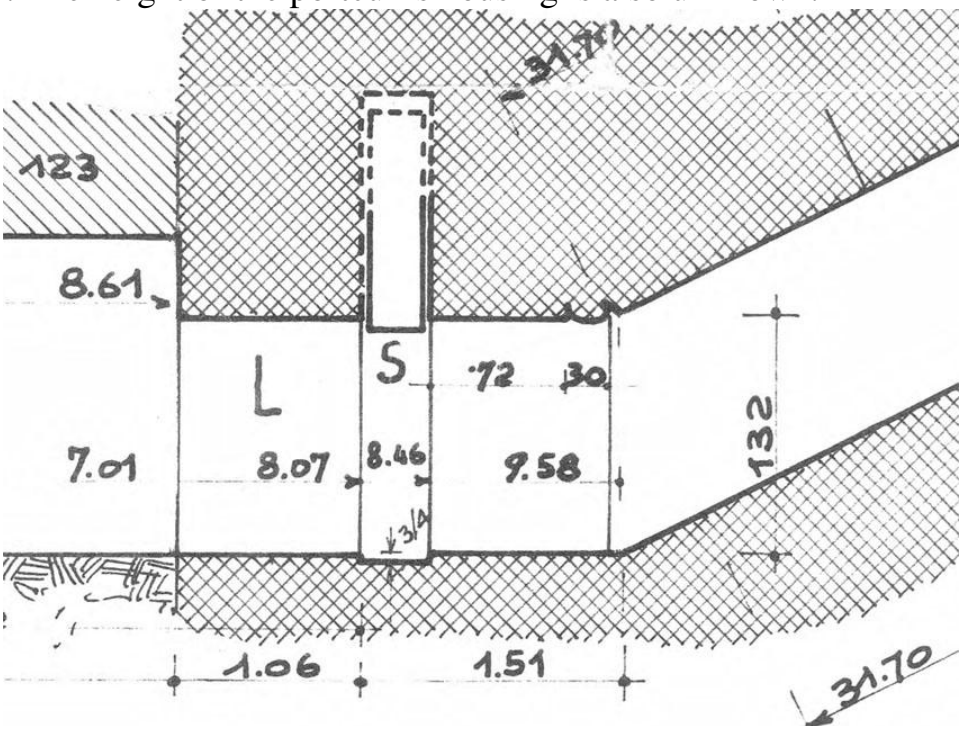
We believe, however, that the ancient architects were obliged (or simply desired) to eliminate the sharp lower edge in the first ceiling block of the corridor at the point where the descending corridor becomes horizontal. The « moulding », therefore, may be only a device to eliminate the sharp edge or to regularise it in case it was broken or chipped during the laying operations."[51]

I would tend to favour a more symbolic role for this decoration, as to create the above profile in hard granite is a considerable amount of outlay, when if they just wished to remove a sharp edge, simpler solutions could have been devised. Another feature of this decorative feature is that it increases the passage height at this location; the horizontal joint line in the image above is the top of the west wall, which M&R give as 1.32m high. This makes the end of the roof line as drawn by Petrie around 1.48m vertically above the horizontal passage floor, or 1.36m perpendicular from the descending passage floor, which is higher than the 1.20m which is given for the descending passage. How this higher roof location merges with the 1.20m height of the passage is not known; but likely it inclines for an unknown distance to join with the ceiling height of 1.20m, as shown on the image overleaf.

[51] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 106, observation 11



The above drawing based on the dimensions supplied by M&R drawings merged with Petrie's drawing, shows the location of the Torus, Petrie gives the width of the roll as 11.7 inches on E and 11.6 on W, or about 30cm. The red line is how the horizontal passage ceiling and descending passage ceiling would meet if the 1.20m height was maintained: the torus increases ceiling height at this location, but how this point connects to the lower ceiling height of 1.20m is not clear. The height of the portcullis housing is also unknown.



The above image is part of M&R's TAV 7, and here we can see how they draw the torus; it differs from Petrie, and they maintain the 1.20m height of the ceiling down to his point: but which is the more accurate of the two?

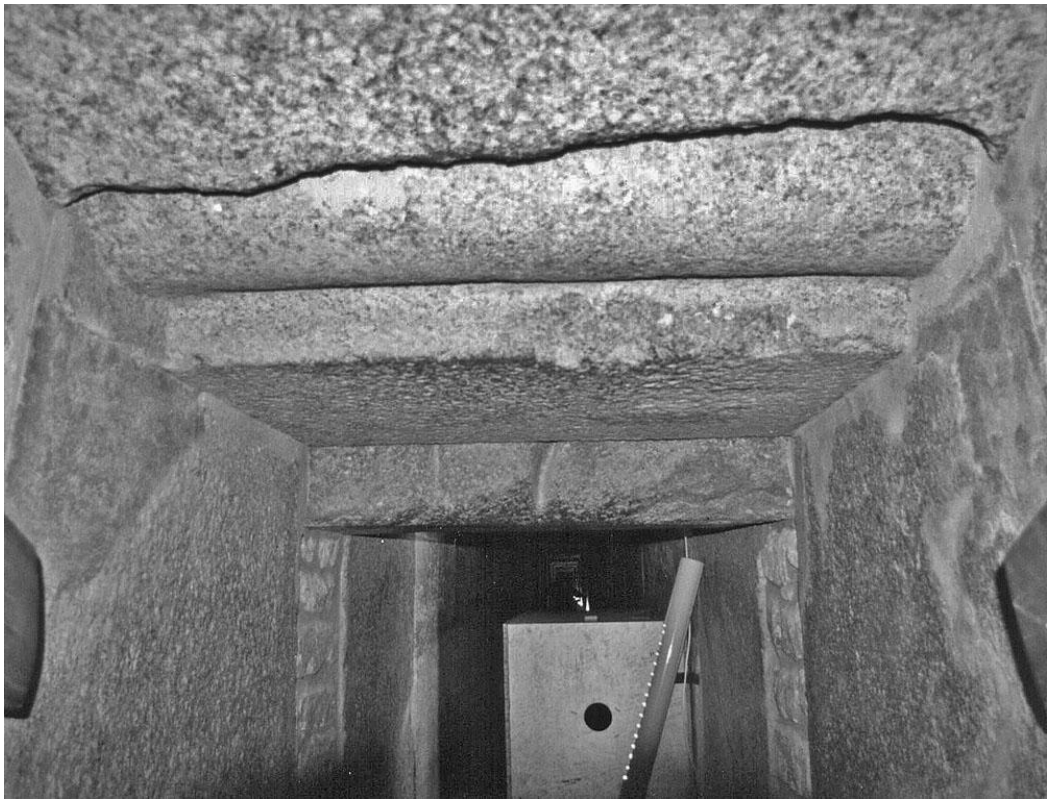


Image courtesy of Charles Rigano[52]

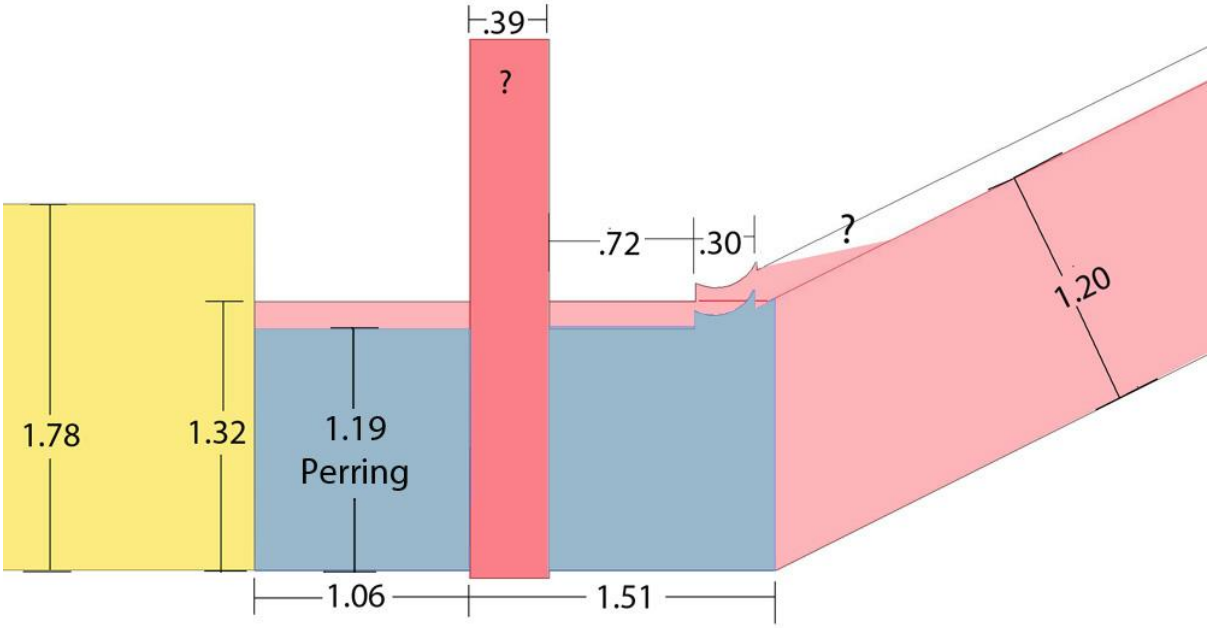
In the above image we are looking south from the end of the descending passage; this area is not open to tourists so I am most grateful to Charles Rigano for the use of his images. Here we can see clearly that Petrie's drawing is the more accurate, in that the torus is placed higher in the ceiling. The horizontal passage ceiling sits on top of the side walls, and beyond this portion of the ceiling we can see the bottom of the portcullis emerging from its housing, complete with grooves cut into its surface: a failed attempt by Perring to smash this portcullis so he could search inside the housing (the available height of this housing for the portcullis is not known). When Belzoni reached this portcullis he found it to be raised eight inches from the floor; today it has been raised to permit access, and is held in position by masonry piers placed inside the portcullis guide grooves. The large box is an air conditioning unit.

[52] This image along with others appears in Charles Rigano's book, 'Pyramids of the Giza Plateau' 2014

Image courtesy of Charles Rigano

In this view looking further back, we can see the line of the ceiling approaching the torus, and though chipped it does appear to terminate at a higher level than the top of the horizontal passage walls, as per Petrie's drawing on page 26. We seem to have mortar repairs at the corners of the ceiling; though I don't know it they are ancient or modern. On the floor of the horizontal passage a shallow groove is to be seen; the portcullis when lowered would sit inside this groove to prevent robbers from trying to lever it up. Raising the ceiling slightly at the torus, would assist in manoeuvring larger items past the junction of the descending and horizontal passages.

As previously mentioned the structure is a surveying mess, with inconsistencies in measures between varying authors, and even in this short granite lined horizontal passage, the height of the passage differs between authors, for example M&R give a height of 1.32m, whilst Perring gives the height as 3 feet 11 inches or 1.19m, which would appear to mirror the height of the descending passage: but again, who is the more accurate?



In the above image I have inserted Perring's passage height (shaded blue); by using this height it is possible to maintain the descending passage height of 1.20m. Did M&R create an error in their drawings, was their 1.32m the height of the ceiling end and they assumed that the horizontal passage maintained the same height? Again it is something a modern survey should be able to clear up, though one favours the neatness of Perring's height.

Though it may be a minor point, it can have consequences elsewhere. It is often quoted that the sarcophagus is too large to be introduced by the passage system; Petrie would point out, *"This coffer being 42.0 inches wide, can never have been taken through the passages, as the upper passage is only 41.3 wide, and the lower is 41.2 and 41.6. Hence it must have been put into the chamber before the roofing was laid over it, and so before the Pyramid was built upon that."*[53] However, this point can be remedied by turning the sarcophagus on its side, as it is only 38.12 inches (97cm) high: in this configuration a box some 2.63m long, by 1.07m high needs to make the turn at the junction. If Perring's measures are right, then the sarcophagus cannot pass; however, if M&R's are correct, it would be a tight squeeze, but given the uncertainties in this area, it may be possible. Corroboration that Perring's passage is more likely, might be found in Belzoni's work, where he gives the passage as four feet high (1.22m)[54]; moreover, Petrie would state that the horizontal passage rises 23.0 inches (58.5cm), once past the granite section, and as he gives the mean height of the higher section near the portcullis as 70.57 inches (1.79m), then minus 58.5cm

[53] Pyramids and Temples of Giza, 1883, page 108
[54] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni, page 269

gives us a granite height of 1.21m.[55] So M&R's drawing has to be treated with caution.

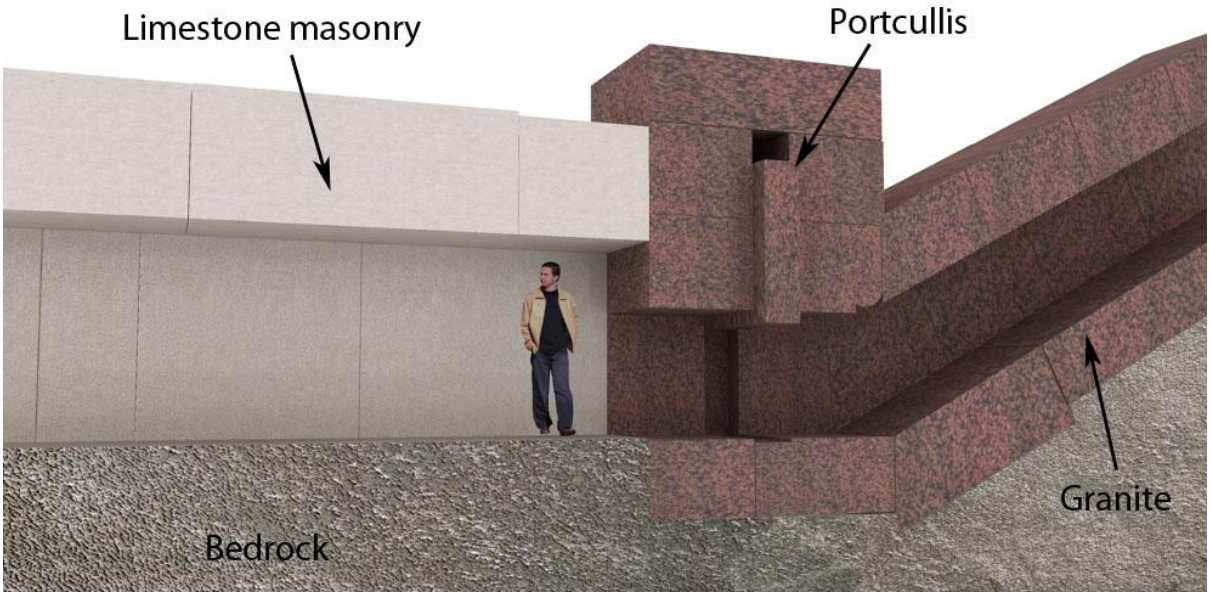
At the end of the granite the walls are of good limestone with finely-picked faces, like the walls of the gallery in the Great Pyramid; and the passage roof immediately rises 23·0, so that it measures thus :—

	E.	W.	Top.	Base.
Near portcullis .	70·76	70·38	41·56	41·78
Beyond gaps in floor	71·53	71·36	41·65	41·55
Near chamber. .	71·27	71·10	41·70	41·30
Means . .	Height 71·06±·13		Width 41·59±·04	

The above are Petrie's measures for the horizontal passage in inches; the width maintains the two cubit standard (1.06m), whilst for the height he suggested; *"The intention in the 71 inch height seems to be to make it half as high again as the ordinary passage"*[56]. As the height of the ordinary passage appears to be 2 cubits 2 palms, then the higher section of the passage would be 3 cubits 3 palms.

The width of the grooves containing the portcullis according to Petrie are 15.77 E and 15.19 W, (mean of both 39.3cm), with the portcullis about half an inch thinner. The depth of the grooves is given as 9.68 E and 10.05 W, making 61.11 inches in all: likely each groove was intended to be half a cubit deep for a total width of 3 cubits. The height of the portcullis is not known, or the housing which would hold it in the stored position; Belzoni noticed a gap that allowed him to insert a bit of barley straw into the housing, upwards of three feet. If we take the height of the portcullis as 1.25m (to cover the height of the passage at 1.20m and the floor groove, we could have a portcullis of 0.75 cubic metres, or around 2 metric tonnes. Until the height of the portcullis housing is determined, we do not know if the stored portcullis was flush with the ceiling or protruded a short distance.

[55] Pyramids and Temples of Giza, 1883, page 105
[56] Ibid, page 105



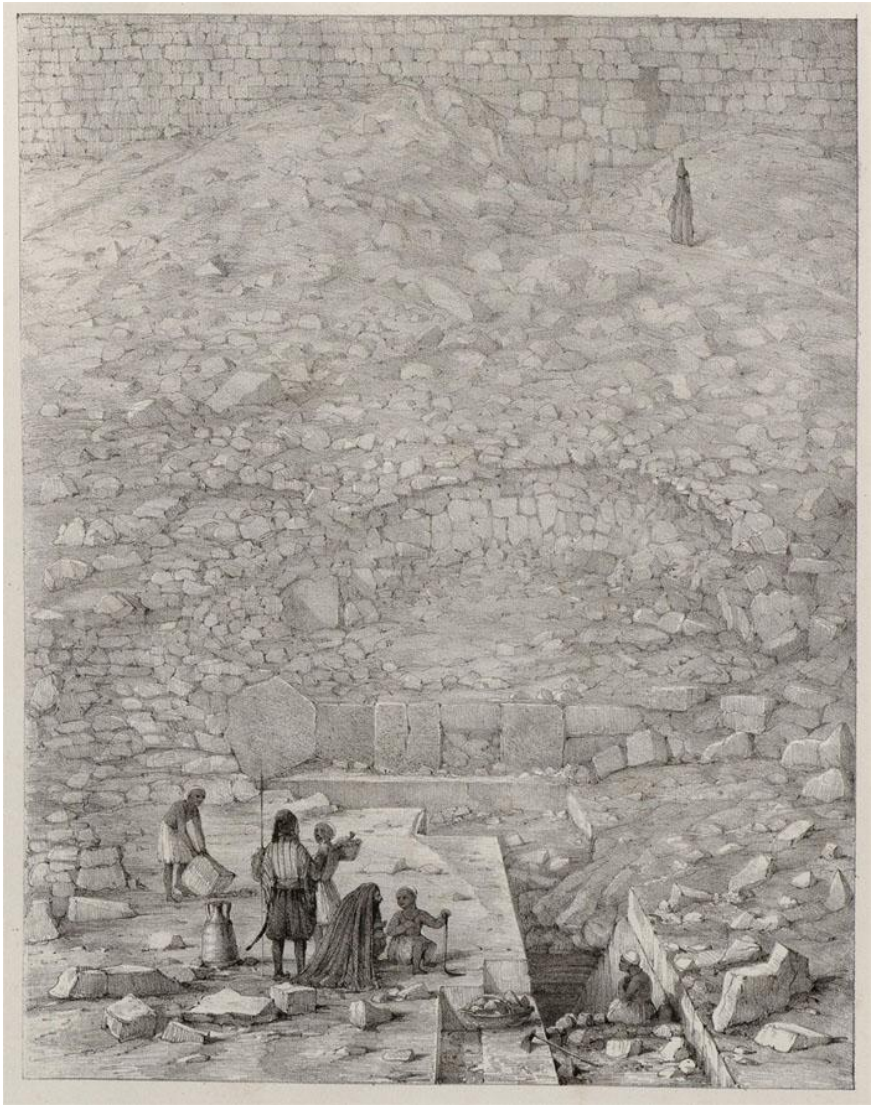
The above schematic image gives a rough idea of the upper portcullis area. The limestone masonry extends south for some 8.61m from the granite. The horizontal passage floor is bedrock, and it's possible the granite floor blocks of the descending passage were keyed into the bedrock. The height of the ceiling stones is unknown, but given that the robber's have cut through the southernmost limestone ceiling stone, we should know the thickness of this stone; but no details are recorded. One wonders why they needed to create some 8.61m of masonry lined passage; we are deep in the bedrock here, as beyond this masonry the horizontal passage continues cut through the bedrock: why not simply abut the granite portcullis against the bedrock? It would seem strange that they required such a large area behind the portcullis to give them access to construct it; could they not simply leave the limestone masonry area as bedrock and introduce the granite elements down the northern trench. They may have hit an area of bad bedrock, such as the grotto that we find in Khufu's pyramid (though the surviving rock floor in this area appears good), which required shoring up. As we will see later, we have another larger area of masonry midway along the long horizontal passage.

The Lower Entrance and Portcullis

The lower passage was never opened by Belzoni, though he calculated that its entrance would run outside of the pyramid at its base.[57] Likely the huge expense in removing debris to locate the entrance discouraged him from searching for it. The search for the entrance was undertaken by Vyse who discovered it under the pavement on the 9th of March 1837. Belzoni could only examine the lower entrance from the inside; here he found the portcullis taken down and under

[57] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni, page 274

debris; beyond this the ascending passage ran some forty-seven feet six inches (14.48m), wherein a limestone plugging stone was found, and he could observe others beyond that.



The above image is from Perring's publication,[58] and shows the lower entrance. Perring states; *"The Lower Passage was opened in April 1837. It was an excavation in the rock, and the Entrance was concealed by the Pavement at the distance of 36 feet from the base of the Pyramid. The whole length of the Descending Passage had been completely filled up with huge blocks, which exactly fitted the aperture, and were laid in cement. The one near the Entrance in the Pavement was 10 feet in length, and the rest were of a great size."*

It's not altogether clear exactly in what state they found the entrance; for example had any of the paving stones been disturbed around the entrance when they found it? A clue from Vyses's publication seems to suggest that the paving was intact, for he states; *"for, although the stones at the base of the Second*

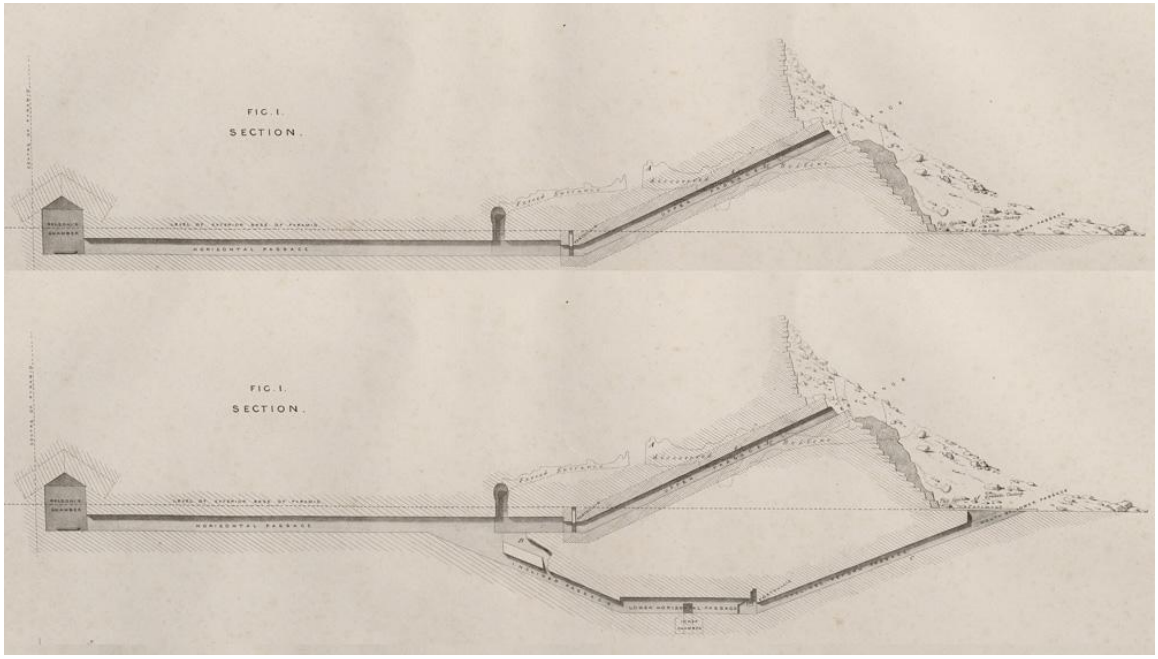
[58] The Pyramids of Giza, from actual survey and admeasurement, Part II, plate VI, fig II

Pyramid had been forced, yet the pavement at that place did not appear to have been attempted notwithstanding that the existence of a lower entrance must have been manifest to all, who examined the interior of that building."[59]

With the help of gunpowder, Vyse cleared a way through the surviving plugging stones and measured the lower entrance; forwarding the details to Perring, Vyse gave a length of 29.36m and an angle of 21˚40´. M&R would use this angle in their TAV 8, but give a floor length of 34.15m. The passage is cut through the bedrock and was plugged with limestone blocks.

The question arises as to why the robber's would not take this route to violate the pyramid? If they were acquainted with the layout of the pyramid they would surely be aware of it, and removing some 30 odd metres of limestone plugs, would appear easier work than the tunnel which was cut through the superstructure: the granite portcullis at its end was no barrier, as they merely had to cut into the softer bedrock to circumvent it or lever it up. In some ways the lower entrance appears alien to the pyramid; the upper passage built of hard granite, and likely plugged for some length of the same stone is a serious obstacle to get over, and yet this hard work is rendered superfluous by the creation of the lower passage, and yet the lower passage was not breached. Either the robber's were unaware of the lower passage, or it was easier to cut through the superstructure, both of which seem unlikely.

Playing devil's advocate, could we suggest that the lower entrance and chamber assembly be a later intrusion, and not original to the pyramid? In the image below I have removed the lower passage assembly to show how the pyramid may have looked if it was a later intrusion.



[59] Operations carried on at the Pyramids of Gizeh in 1837, Vol 1, page 222

The lower entrance passage seems to match the upper entrance passage in being 2 cubits by 2 cubits 2 palms, whilst the lower horizontal passage is of similar size to the upper. This in itself is not evidence that the lower assembly is contemporary to the upper; any later monarch who wished to add to this structure would be well aware of the upper design and taken care to ensure his addition married well with the existing structure.

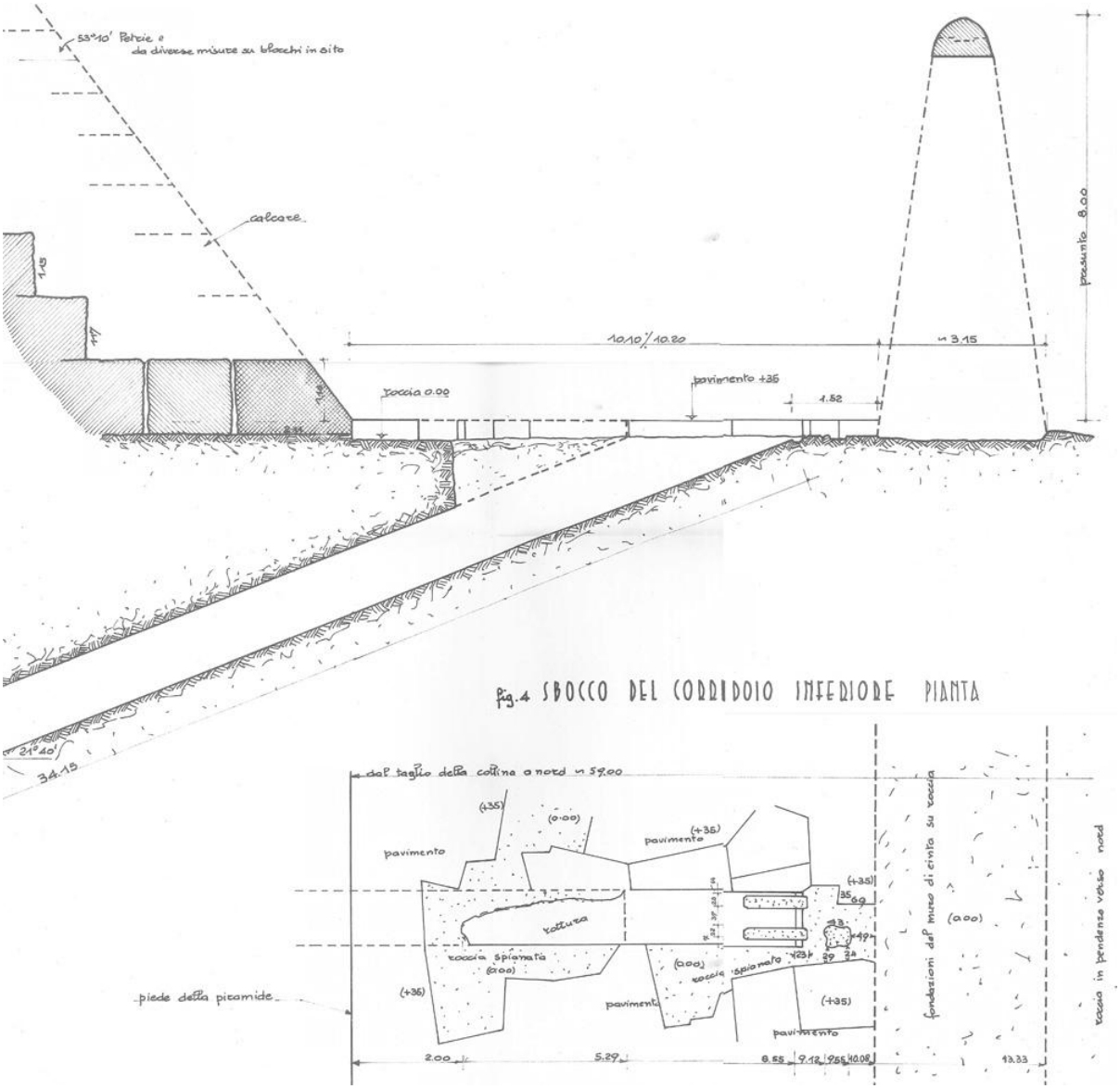


Fig.4 SBOCCO DEL CORRIDOIO INFERIORE PIANTA

The above image is part of M&R's TAV 8, and shows the section and plan of the lower entrance; two obvious features stand out, first, is the close proximity of the enclosure wall, which is only around 1.5m from the passage opening, and yet Perring gives the first plug as being 10 feet long or 3m (Vyse would report that the other plug stones were some six or seven feet long (1.83m -2.13m). This enclosure wall would appear a major obstacle to introducing the blocks from the north, and it would seem unlikely that such a major wall was built after the burial of the king, or a section omitted, to be built after the king was buried.

If it was intended to plug the passage, why was the design not altered to easily allow the introduction of plugging stones by ensuring that sufficient space was made available between the wall and entrance? This way the enclosure wall could be safely completed, and keep prying eyes away from the lower entrance. With the wall built, the only way to introduce the plug stones would be from the side and this may be possible, as by sliding them along the wall, their centre of gravity could be supported by the 1.50m space, with their free ends floating above the passage; then they could be levered up and manhandled into the passage. It would appear a more awkward operation to say a clear approach from the north, which is prevented by the wall.

The second feature that stands out, is the grooves cut in the rock by the entrance; today these are not visible to the public, as the lower entrance is the main entrance into the pyramid and the area is covered in wooden boards. M&R state the following on this feature;

"At the northern end of the floor of (I) may be seen two longitudinal incisions, parallel to each other, which are similar to those in other later pyramids. In the rock below the floor of the surrounding courtyard, apposite the east side of the passage, is a strangely shaped hole the purpose of which we do not know. Its shape and the fact that two protuberances have been left on the bottom seem to exclude that it is the seating of a hinge."[60]

They do not clarify what they mean by later pyramids, but those of you who have read my Middle Kingdom guides will recognise this feature as being quite common in Middle Kingdom pyramids. Commonly referred to as skid poles to assist in the movement of heavy masonry,[61] I have not seen this feature in any other Old Kingdom structure; that's not to say that they do not exist in the Old Kingdom, just that I have not come across any other examples of this feature in the Old Kingdom.[62]

If no other examples of skid poles can be found in the Old Kingdom, could this mean that the lower passage assembly was a Middle Kingdom intrusion? We know from the Middle Kingdom pyramid of Amenemhat I at Lisht that elements of Old Kingdom masonry was being used in its construction; for example a granite architrave with Khafre's cartouche was used in the construction of the entrance passage.[63] It is likely that robbing of stone from the Giza complex occurred earlier than Amenemhat, with the first elements to go being low lying fruit such as temples, walls and causeways; so a situation may arise were a later intrusion was created inside Khafre's pyramid, after the wall had been robbed away: in this scenario introducing large plugging stones from the north would be a possibility.

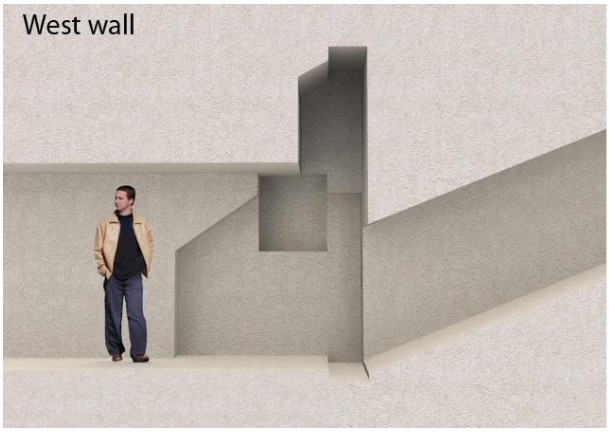
[60] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 62

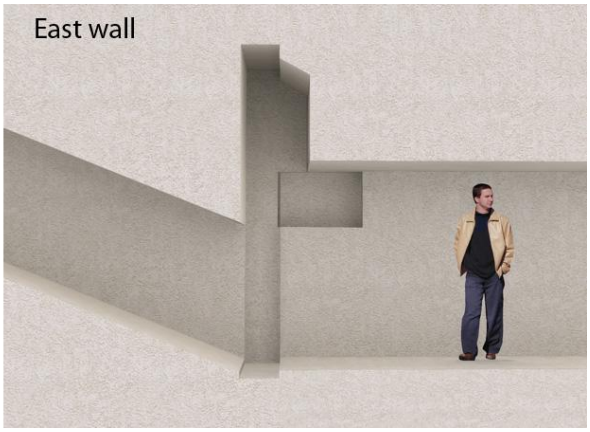
[61] See, Building in Egypt, Pharonic stone masonry, by D.Arnold, 1991, pages 273-275, and fig 6.34 for similar grooves at the Black pyramid

[62] If anyone is aware of this feature in the Old Kingdom, please contact me.

[63] The Pyramid complex of Amenemhat I at Lisht, D.Arnold, 2015, pages 11-12

As previously mentioned Belzoni states that the lower passage was clear of plug stones for some 14.5m; whilst from Perring he tells us that the upper part was plugged for some 36 feet (11m)[64]: this gives a combined total of 25.5m, and as M&R give the floor length of the passage as 34.15m, we have some 8m of passage unaccounted for; maybe further plugs were broken up from the inside in the intervening years between Belzoni and Vyse.





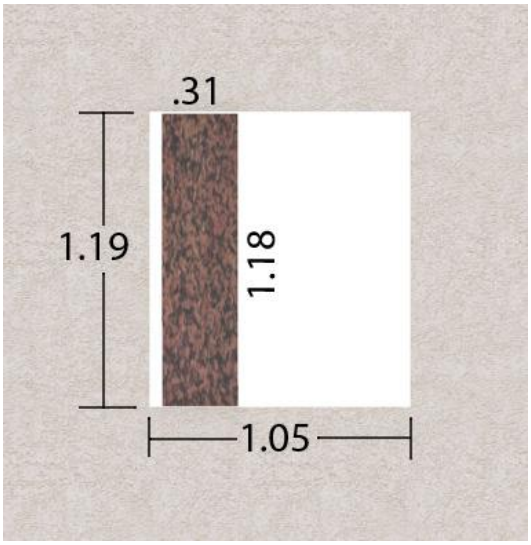
At the end of the descending passage we arrive at the portcullis housing; unlike the upper portcullis, this housing is excavated out of the rock. M&R's Drawings of this area are unclear and inconsistent in measures, so I have tried to use some tourist video to try fill in the blanks; but even then it's not as good as I hoped (The granite portcullis today occupies the cut-out in the west wall, which also obscures things), so the above should be treated as schematic.

M&R give the height of the portcullis housing as 2.85m and we can add 4-5 cm to this for the groove along the floor. The guide grooves are about 33cm wide, which makes the portcullis thinner than the upper portcullis. The portcullis size is largely dictated by the dimensions of the rock cut descending passage, as the portcullis would be transported down the descending passage. M&R's TAV 9 gives inconsistent and confusing measures for the portcullis housing, so for the purposes of this exercise I will adopt the findings of Charles Rigano who provides the following dimensions for the portcullis: 12 inches thick (30.5 cm), width 46.5 inches (1.18m), and damaged height as around 5 feet (1.22m).[65] It is not clear from M&R's work if they actually recorded the dimensions of the granite portcullis, in their fig 8 (TAV 9), the accompanying text suggests that the portcullis was between 1.10 and 1.15m wide, its height between 1.34 and 1.60m and the thickness about 0.31m; but are these theoretical tolerances, based on their dimensions of the housing? (Only in their text do they record the present maximum height of the portcullis as 1.23m). M&R give the guiding groove as some 9cm deep on the east wall, and likely it is similar on the west wall in the upper portion at least, as the lower portion is

[64] The Pyramids of Giza, from actual survey and admeasurement, Part II, page 2
[65] Pyramids of the Giza Plateau, Rigano, 2015, page 119

undercut by the trapezoid shaped cutting, which is about 27cm deep: as the passage is 1.05m (2 cubits wide) and adding 2 by 9cm deep portcullis grooves, we obtain a portcullis housing width of 1.23m (Rigano gives the housing width as 48 inches wide (1.22m) and groove width as 13 inches (33cm).[66] This is in stark contrast to M&R's fig 5 on TAV 9, which suggests that the housing width is only 1.17m, which is less than the width that Rigano gives for the granite block itself of 1.18m. A value of 1.17m would only allow a 3cm deep groove on the west wall, which seems too small; moreover images suggest it is deeper.

A further deeper rectangular cutting is made some 85cm high by 69 wide into the west wall; whose southern end is deeper than its northern end. This rectangular cut-out is 1.05m from the floor (2 cubits; for some reason M&R give the height of the cut-out as 85cm to the ceiling, which would give a height of the passage at this location as 1.90m, yet on their drawing they give the height range of the passage as 1.82-1.84). With the passage at 1.05m wide, this leaves some 6.5cm of the portcullis overlapping each side of the passage.



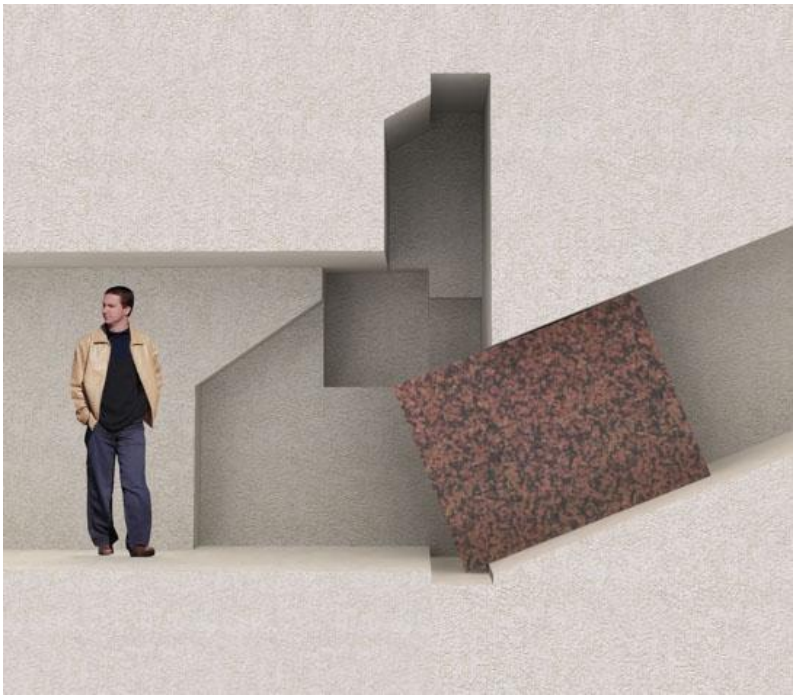
The image left compares the bore dimensions of the descending passage, with that of the portcullis (Metres). The original height of the portcullis is not known, one of its edges is badly damaged and its current height is around 1.23m, though M&R would suggest a possible height of 1.55m.[67] At 1.18m wide and about .31 thick its diagonal would be 1.22m, which is greater than the height of the passage so it would likely be slid down vertically. Today the remains of the portcullis is laid on its side, inside the cut-out of the west wall, see image on next page.

[66] These measures kindly supplied by email correspondence.
[67] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 60 & 62

The manoeuvring of this portcullis would require some thought and design, Petrie would state;

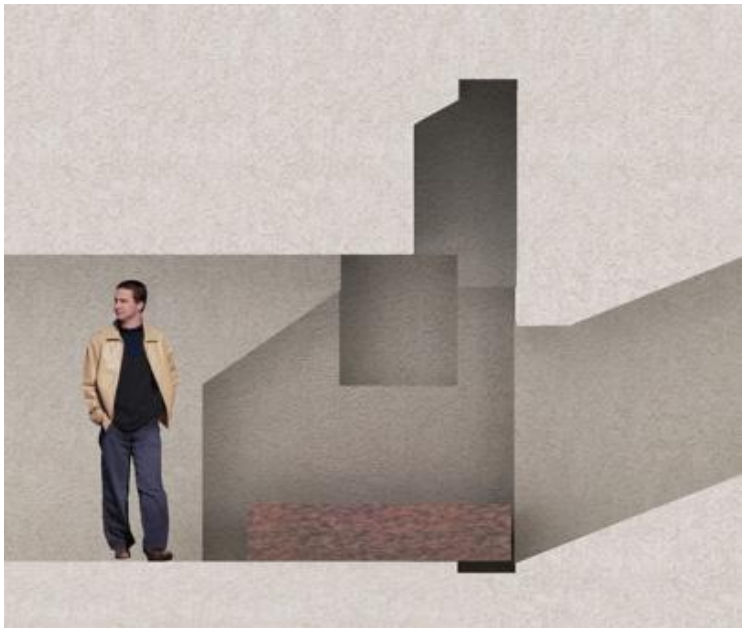
"This passage was closed by a granite portcullis, and it is important to observe how this was introduced. The block of granite was taken along the passage from the southward on edge, and the wall was cut away on one side in a slope, so as to just allow of the block being turned flat across the passage by slewing it round in a complex way. The block was then pushed up into the groove cut in the rock for it, and the cutting in the side required to get it in was filled up by masonry at the back of the block. Thus, to any one forcing an entrance, nothing but rock and the granite slab would meet them. The skill required to turn over and lift such a block, in such a confined space, is far more striking than the moving of much larger masses in the open air, where any number of men could work on them. By measuring the bulk, it appears that the portcullis was nearly two tons in weight, and would require 40 to 60 men to lift it; the space, however, would not allow of more than a tenth of that number working at it; and this proves that some very efficient method was used for wielding such masses, quite apart from mere abundance of manual force."[68]

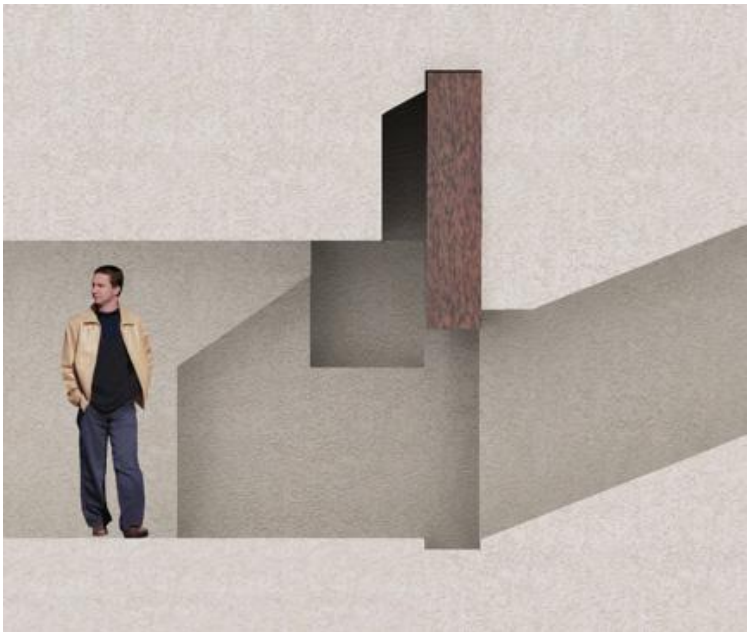
[68] Pyramids and Temples of Giza, 1883, page 108-109



The above image shows a portcullis block some 1.55m long at the junction of the descending and horizontal passages; its height in the passage at 1.18m affords us only 1cm of clearance from the ceiling, whose perpendicular height M&R give as 1.19m (TAV 9). The problem arises on how we make the block turn the corner, and we cannot use the cubic diagonal of the passage, as the diagonal of the block is greater than the passage height. The passage above as currently configured will not allow the portcullis to pass, as the edge of the ceiling prevents us from lifting up the portcullis to access the horizontal passage floor.

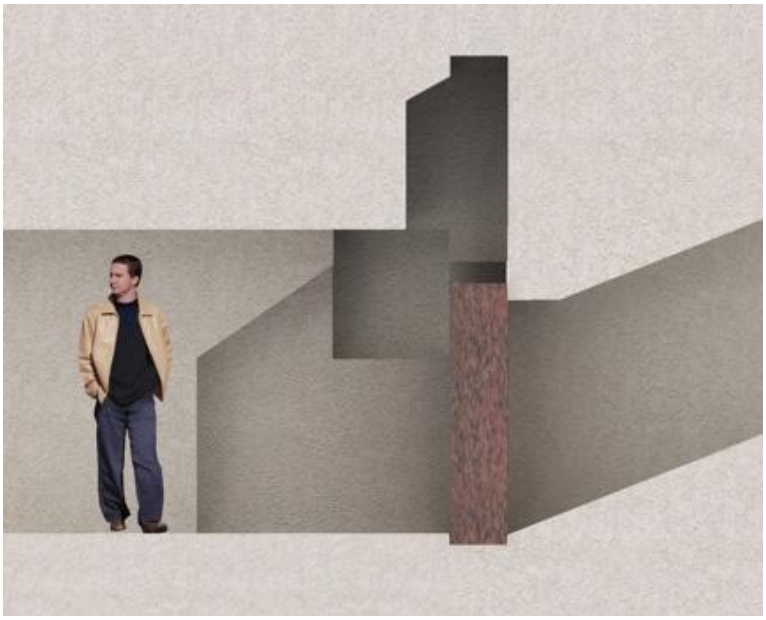
In order to turn the block onto the horizontal passage floor, a part of the descending passage ceiling would need to be raised/chamfered to allow the turn; the ceiling at this location is badly damaged, so it's hard to tell if it was modified to allow a portcullis pass, but a portion of it must have been modified to allow the block to turn the junction. Once on the level floor it can be laid flat, as the trapezoid cut-out is some 27cm deep and the passage at 1.05m wide, we have a total width of 1.32m; greater than the diagonal of the portcullis of 1.22m.





Next the block would have to be raised up from the floor to the vertical and maneuvered into the east grove, which is some 9cm deep (on the west wall there is no southern face to the groove due to the cut-out). They next lever up the portcullis and install the portcullis into its housing; an impressive feat in such a

tight space. A portcullis 1.18 x 1.55 x .31 gives .57 of a cubic metre, and if we take a cubic metre of granite at 2700kg, we are looking at a weight of 1539kg, or 1.54 metric tonnes.



With the portcullis lowered, the current configuration above would have the block only securely engaged in the east wall groove; the west wall offers no support to the south side of the block. As Petrie suggests, this side of the corridor needs masonry support to secure the portcullis.

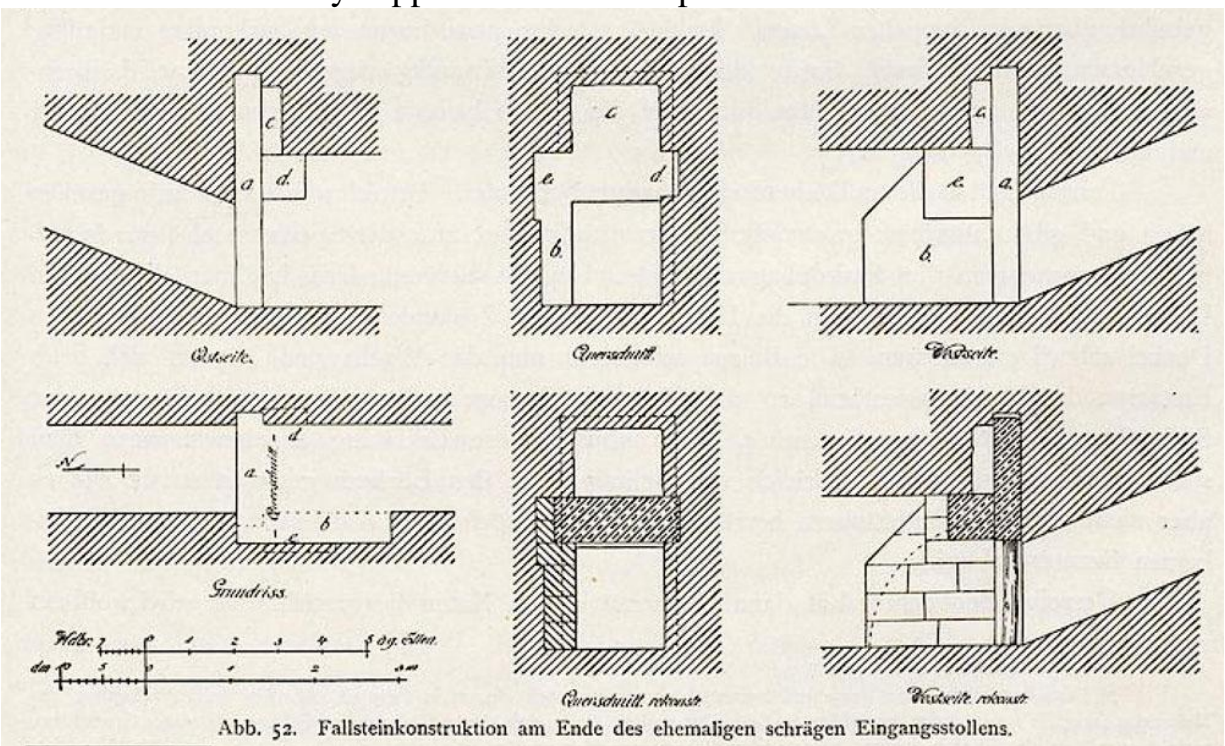


Abb. 52. Fallsteinkonstruktion am Ende des ehemaligen schrägen Eingangsstollens.

The above fig 52 is a reconstruction by Uvo Hölscher[69]; here he utilizes the rectangular holes on both walls to hold a cross beam, and fills the trapezoid cut-out with masonry to create the south portcullis groove: the portcullis is supported by a wooden prop. The western rectangular hole is much larger than that on the east, M&R give the east hole as 84cm by 55cm high, and some 18cm deep (as per the west wall their measures from their drawings seem to have an excess ceiling height here too, the bottom of the hole in their TAV 9, is 1.37m from the floor, with the 55cm being the remainder to the ceiling, for a total of 1.92m)

Any crossbeam was likely introduced into the larger deeper hole on the west wall first at an angle, then straightened and withdrawn into the smaller hole on the east side, and then the cut-out packed with masonry to secure the whole assembly. As a security device it would cause little delay to robber's, who would simply circumvent the granite by cutting through the surrounding limestone, or simply lever it up, much like Belzoni did to the upper portcullis: the groove in the limestone floor of the lower could be easily removed to allow a lever to gain purchase.

The above reconstruction, shows the cross beam and cut-out filled with masonry (though we do not know the material of the cross beam); the beams size is limited to the size of the smallest hole and its distance to the portcullis, but

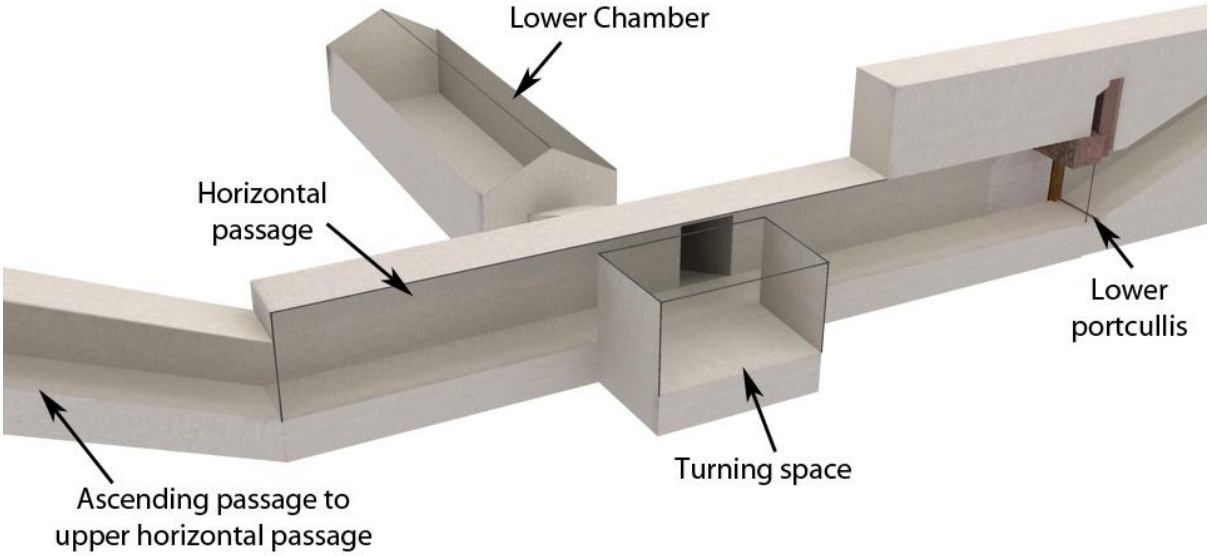
[69] Das Grabdenkmal des Königs Chephren, 1912, page 64

likely no more than 69cm wide by 55cm high: its length if we give the same 18cm depth to the west side could be 1.41m long, or 0.54 of a cubic metre. The cross beam at some 1.37m from the floor, subtracted from the portcullis housing height of 2.85m, leaves us 1.48m, so for a portcullis to match this level, it should not exceed this height; if we accept 1.55m then the portcullis will protrude further and restrict the height size of any funerary items that have to navigate this junction.

The above sequence of events can only be a rough guess; M&R's drawings are somewhat confusing and unclear in this area, for example, in their TAV 9 fig 8 (east wall), they have the horizontal passage height at 1.82m, and then the bottom of the hole to the floor as 1.37m, with the hole to the ceiling as .55m for a total of 1.92m, or 10cm more than they give for the passage height. Then on fig 7 section, 1.37 is replaced with 1.30m, and .55 is reduced to .53m for a total 1.83m, which agrees with the passage height (though in this section they maintain the height of 85cm for the hole on the west wall, which together with its height from the floor of 1.05m gives a total of 1.90m). If fig 7 is correct, then the beam is 1.30m from the floor, and if the portcullis was to be flush with this new location it would be 2.85 – 1.30 = 1.55m high, which is their probable height for the portcullis. This confusion in drawings and measures make for too many permutations for this junction; a modern survey is required to resolve the many ambiguities in this area. As previously noted M&R's drawings for the upper portcullis area are also suspect; indeed, when I placed their dimensions into AutoCAD I found the upper burial chamber to be located north of the pyramids E-W axis (much like Perring's drawing on page 44), yet M&R place the south wall of the burial chamber 1.17m south of the E-W axis. In their defence we must recall that these hand drawn drawings are from the 1960's without the aid of modern computer programs, so more prone to error. Today we live in an era of high technology and 3D scanners which can map to high precision; it would be nice to see such technology update Khafre's pyramid.

The Lower Chamber

Beyond the lower portcullis the horizontal passage maintains the two cubit width (1.05m), but the ceiling is raised to provide a comfortable walking height; M&R give 1.82-1.84m for the ceiling height (Vyse gives 1.80m). M&R give a total length of the passage as 15.75m & 15.70m (30 cubits, Vyse gives 15.67m). Midway along the west wall of the passage a doorway is found, some 1.07m wide by 1.18m high, which appears to be intended to match the descending passage dimensions.



The above schematic view shows the lower chamber layout. Opposite the doorway that leads down to the lower chamber we have a turning space; this space does not take up the whole height of the horizontal passage, as its ceiling is some 19cm lower: moreover, the north wall of this space is about 4cm south of the north wall of the doorway. The size of the turning space is around 3.15m N-S, and 1.71m E-W; Petrie would calculate that a coffin some 40 x 105 inches (1.02m x 2.67m) could be introduced into the lower chamber using this space.[70] The height of any coffin/sarcophagus would have the same problem as the introduction of the lower portcullis, in that it needs to clear the ceiling of the doorway which enters into the lower chamber; here the top of the door has a vertical height of 1.20m.

A short descending passage of some 6.70m with a similar shallow angle as the lower two passages, 20˚30´ M&R (Vyse 20˚50´), leads into a long narrow chamber. M&R give the length of the chamber as 10.43m S and 10.41 N (Vyse 10.39m: Petrie 10.44m S and 10.46m N). The width M&R give as 3.12m E, and 3.10m W (Vyse 3.10m: Petrie 3.13m E & 3.14m W) in cubits it may have been intended to be 20 cubits long by 6 wide. Wall height is given by M&R as 1.84m (Vyse 1.83m), a possible 3.5 cubits; whilst the somewhat irregular roof is given an apex height of 77cm by M&R (Vyse 74cm).

M&R report that a possible double leaf door existed in the upper doorway of the passage which leads to the lower chamber, as they found two holes at the bottom corners of the doorway and mortar traces along the top which may have secured a wooden lintel.[71]

[70] Pyramids and Temples of Giza, 1883, page 108
[71] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 62

Image courtesy of Charles Rigano

In the above image we are looking down the short descending passage to the lower chamber; today this area is normally off the tourist map, and locked by a steel door. M&R would describe the passage as *"of rather coarse workmanship, does not appear to have been plastered and some gross errors in working or faults in the rock were filled with mortar, especially in the ceiling."*[72]

[72] Ibid, page 62

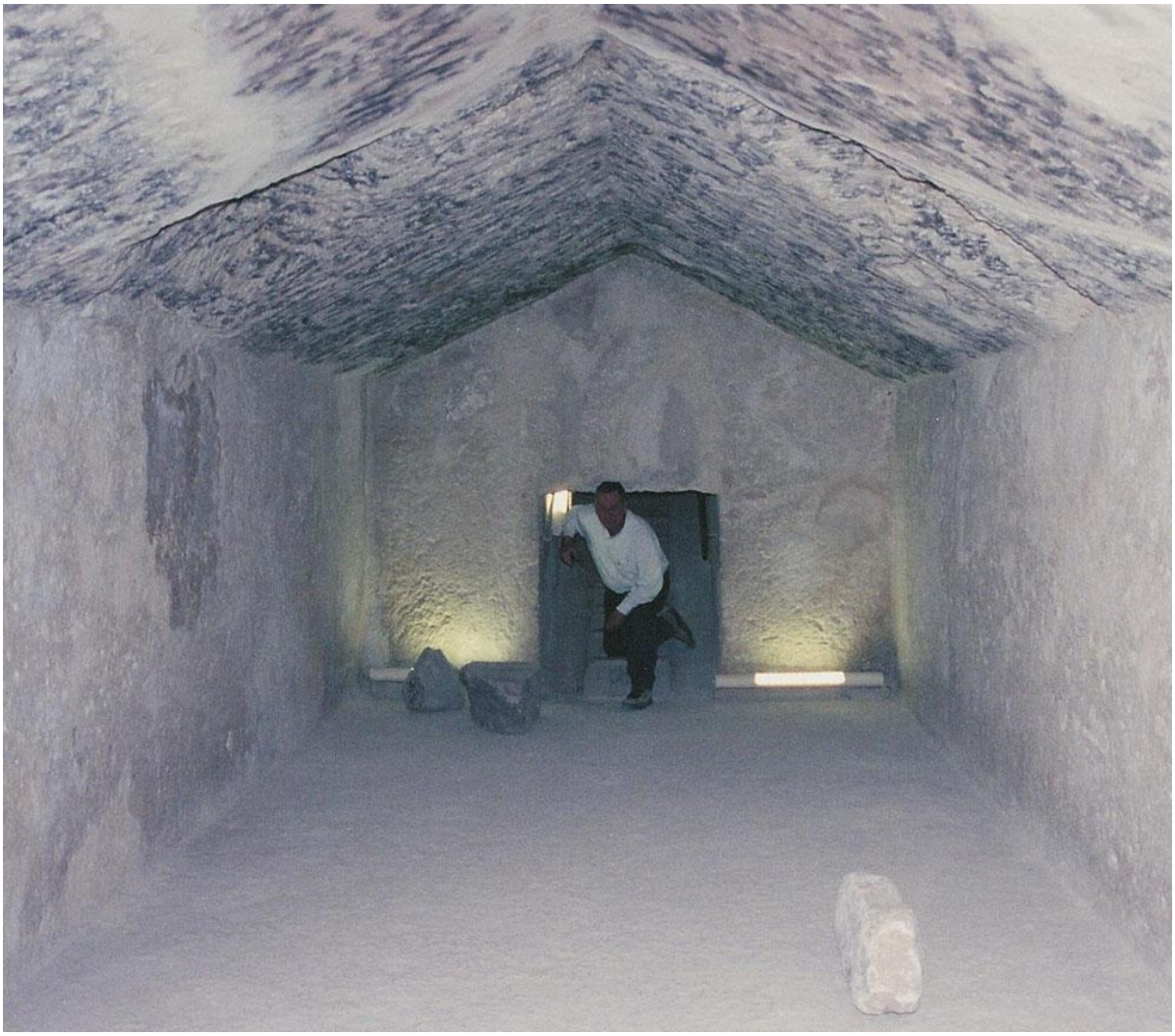


Image courtesy of Charles Rigano

In the above image looking east, we can see the author Charles Rigano entering the lower chamber; the ceiling finish appears quite rough. Petrie would state;

"The lower chamber is also plastered, and is cut very roughly in some parts; on the roof even 6 inches too much having been taken off, and then plastered up; this great deficiency is, however, the same on both sides of the roof, and it looks as if some different form had begun, and then abandoned."[73]

[73] Pyramids and Temples of Giza, 1883, page 108

Image courtesy of Charles Rigano

In this view looking west, we can more clearly see the deeper cut in the ceiling. M&R would generally describe the workmanship of this chamber as rather coarse; indeed, they mention that the pavement was very rough and levelled with mortar.[74]

When Belzoni first entered this chamber he reported; *"This chamber contains many small blocks of stone, some not more than two feet in length."*[75] Unfortunately, no more detail is given on these blocks, and Perring would only comment that *"The apartment contained a quantity of square stones"* though they may have gone by Petrie's time, as he makes no mention of them. Belzoni would also report inscriptions found on the walls and ceiling, which he thought might be Coptic; though these appear to be no longer visible.

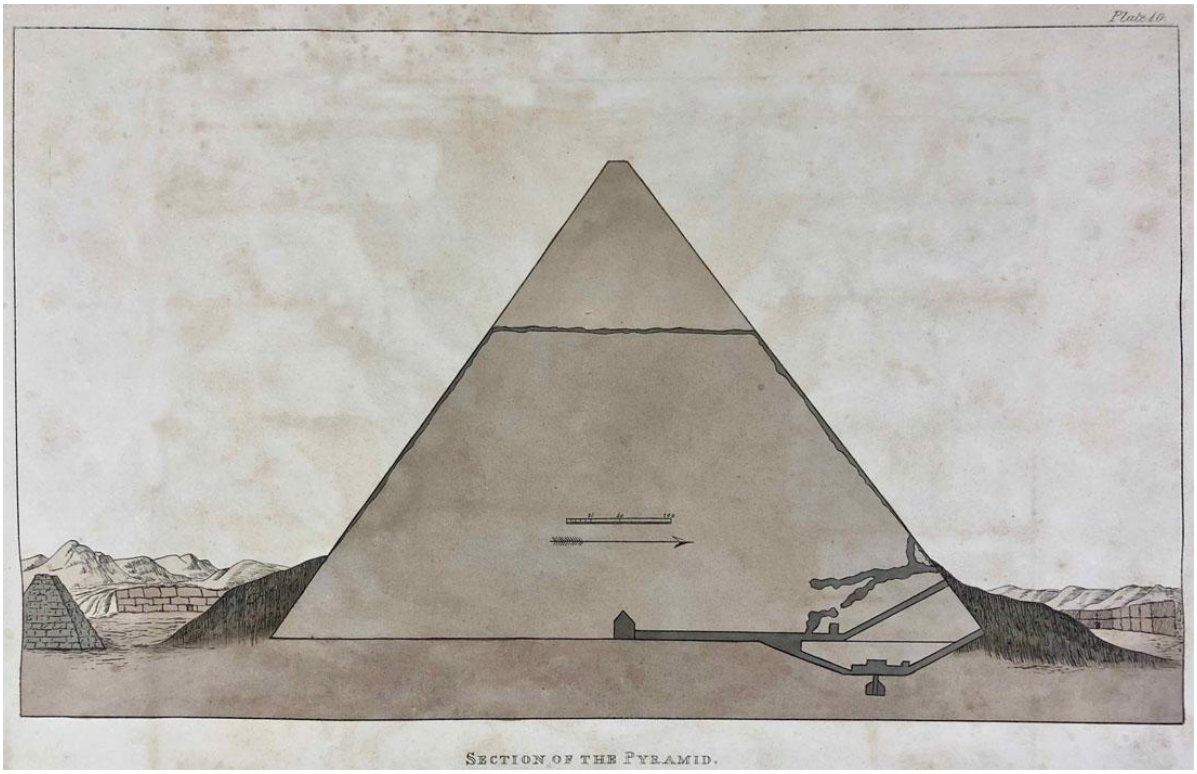
Perring would comment, *"It is evident, from a stain upon the walls, that the rain water has penetrated in such quantities, that it has been 12 inches deep in this chamber."*[76] M&R would further report that the ascending passage that

[74] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 62
[75] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni, page 273
[76] The Pyramids of Giza, from actual survey and admeasurement, Part II, page 3

leads to the upper horizontal passage *"was once scoured by running water"*[77]. It is unlikely that this water came from the plugged lower entrance passage, but from an open upper entrance passage, or robber's tunnel, or combination of both.

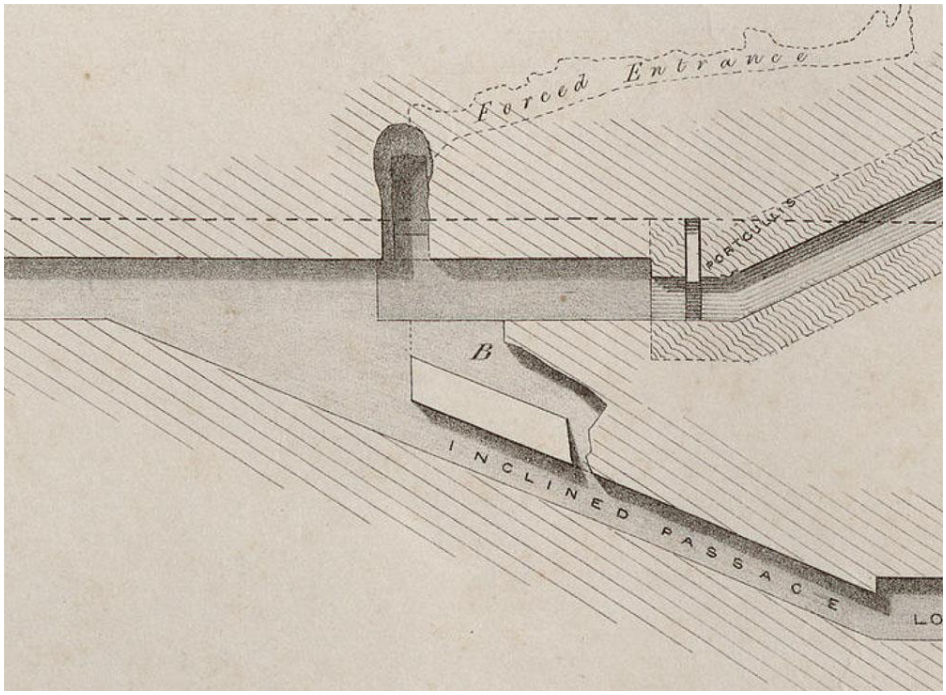
The ascending passage to the upper horizontal passage & junction

At the southern end of the lower horizontal passage, we have an ascending passage which joins the floor of the upper horizontal passage. Unlike the north end by the portcullis were the ceiling is badly damaged, the ceiling here is relatively intact; M&R give the top of the doorway as 51cm below the ceiling, and as they give the height of the ceiling as between 1.82-1.84m, then the vertical height of the door would be circa 1.31-1.33m. M&R noted that the inclination of the passage was not constant, varying from a low of 21˚30′ to a high of 25˚ (TAV 9), this gave a fluctuating vertical height of 1.30 to 1.34m, and a perpendicular height of 1.21 to 1.235m. (They would gave an average angle of 21˚40′)[78] The total floor length given the uncertainties, they give as around 24.40m (TAV 6); the passage width maintains the 2 cubit value, which we see throughout the substructure.



[77] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 62
[78] Ibid, page 60

In Belzoni's drawing above we can see the ascending passage connect to the upper horizontal passage; this left a sizeable vertical precipice if one approached this junction from the upper entrance passage, which Belzoni called a shaft.
Belzoni would descend down his perpendicular shaft by rope, and found that the entrance to the lower inclined passage, was largely choked up with stones, but the route of the passage could be made out.[79] Belzoni would miss one feature at the junction between the two passages, which was discovered later by Caviglia during debris clearance work of the passages under Vyse.

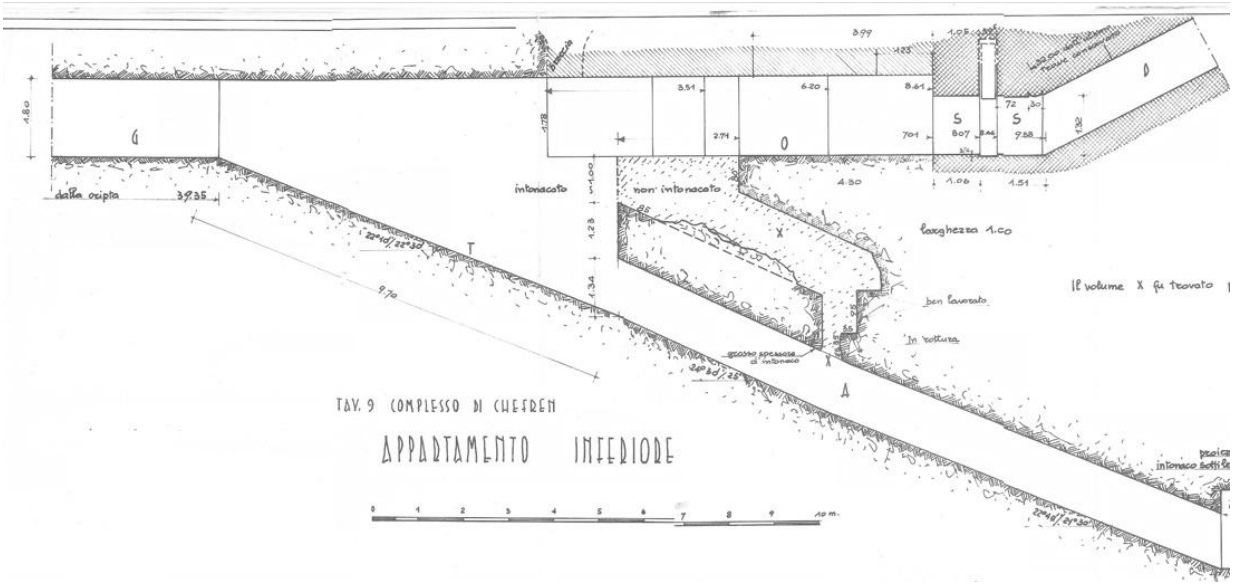


What Belzoni missed is the area B in Perring's drawing above, Vyse would state; *"It appeared that, in clearing the horizontal passage, he found that a part of the floor was composed of masonry, near the chasm formed in that communication by the descending passage, which returns beneath it to the northward; and that, when this masonry was removed, he discovered another descending passage, above, and parallel to the lower one, which terminated at a short distance in the rock, and was connected by an hole with the other passage. It might therefore be supposed that it had been made for the sake of ventilation in forming the subterraneous passages before the pyramid was built, or that an alteration had, for some reason or other, taken place in the original construction of the pyramid."*[80]

One might forgive Belzoni for missing the masonry floor, but it seems strange that he and others missed the hole in the ceiling in the inclined passage; unless

[79] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni, page 270 & 273
[80] Operations carried on at the Pyramids of Gizeh in 1837, Vol 1, page 138-139

this was made by Caviglia, or the hole had been filled and plastered over during Belzoni's time, and opened by Cavilgia.



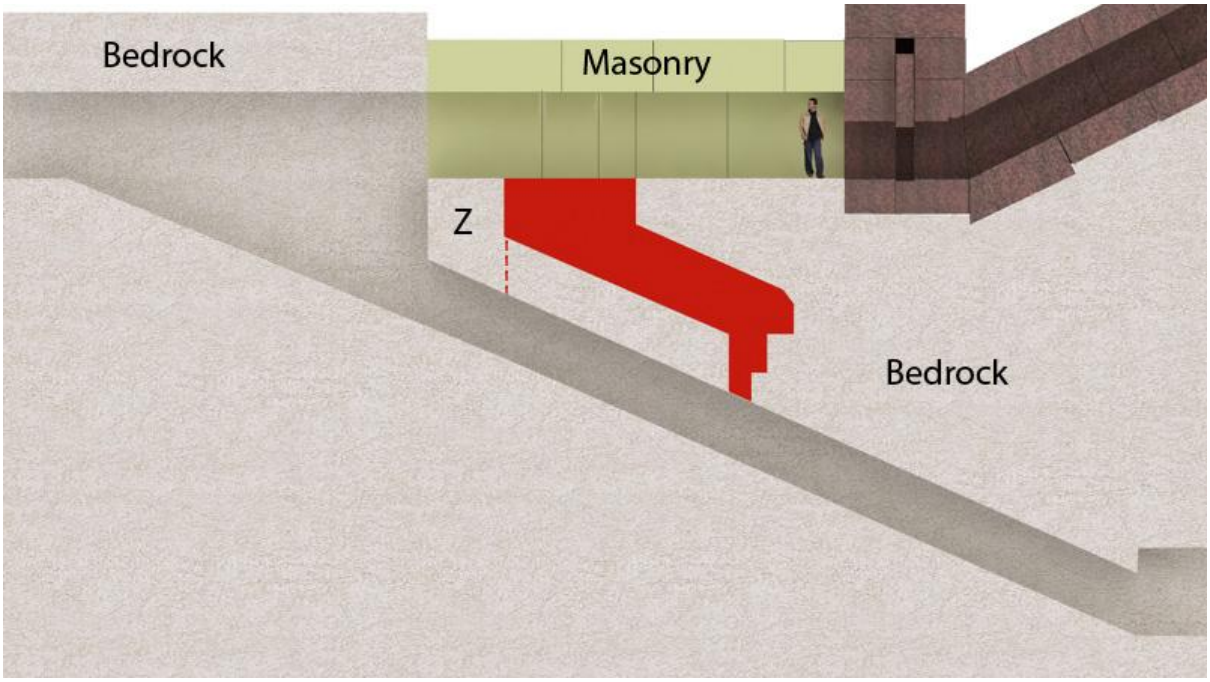
In the above partial scan of M&R's TAV 9, we get a more detail look of Caviglia's void; here the area is labelled 'X'. Unfortunately we have very scant data on this void; for example in M&R's drawing above, we appear to have either debris or uncut rock on the floor of the void, but there is nothing in their text to clarify this. All M&R report is; *"From the hole a small inclined corridor (X) runs northwards which passes under (O) and very quickly becomes a vertical shaft which comes out into the ceiling of the lower ascending corridor (A). The walls of the shaft are well-worked except in the lower part, which is roughly hewn in the rock and very coarse."*[81]

I could find no detailed images looking inside the void, as this area is off limits to tourists, so it's hard to come to any conclusion as to its function. M&R would suggest; *"All things considered, it is our impression that the excavation of the short corridor (X) was caused by a banal error of measurement or calculation committed by the ancient architects."*[82]

While this may be the case and playing devil's advocate, there are a few issues which concern me. First, if this was an error in starting the inclined passage too far north, why do we have the shaft at the end of this cutting, and why do we appear to have a horizontal portion beyond it? Second, we can see from the above image that we have 8.61m of limestone masonry at the start of the Horizontal passage (O); starting the passage X here undermines the support for the masonry superstructure in that the masonry here is merely sitting atop a bedrock ledge: and third, why is passage X practically full size from the beginning; indeed, by scale rule passage X is higher (1.3m) than the inclined passage A. The task at hand is to connect the lower horizontal passage to the

[81] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 60
[82] Ibid, page 114

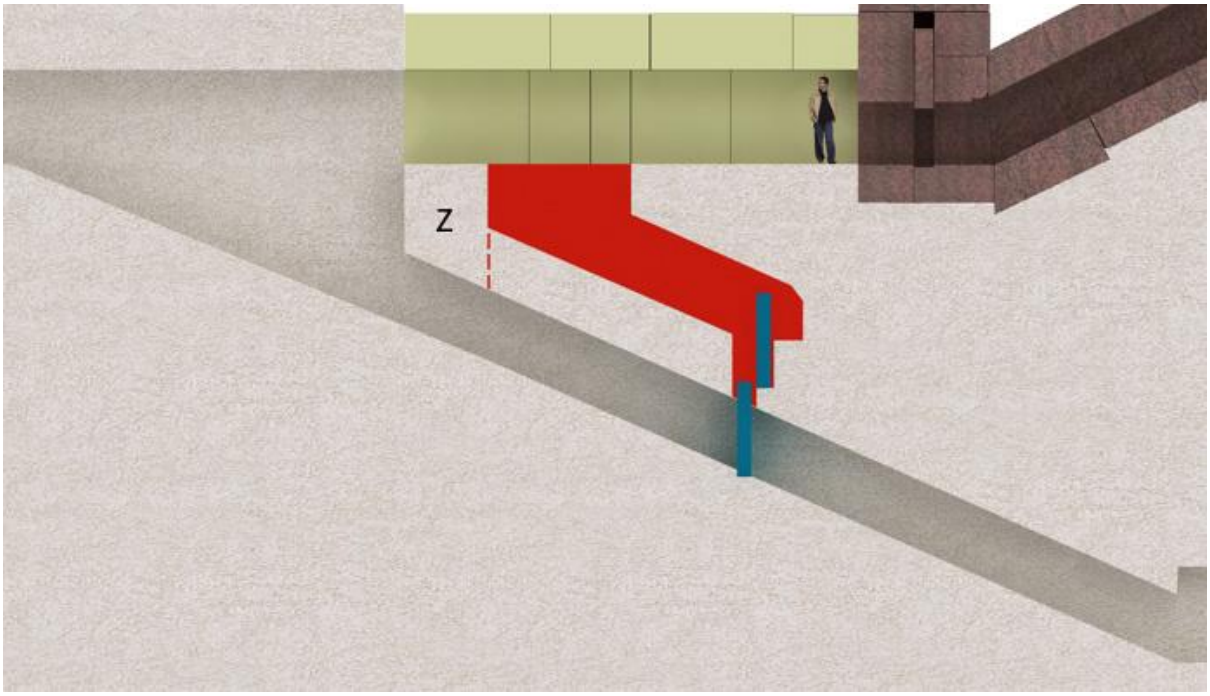
upper; and whilst the builders will take upmost care in their calculations, there is always slight room for error; for example, the azimuth of the lower entrance passage might be slightly out compared to the upper entrance, so I would expect the builders to dig a smaller guide tunnel to connect the two sections. Where the tunnel would break out at the other end would always be uncertain, so a small tunnel would allow for some error; for example it might break out, slightly higher or lower than intended, or more east/west than intended, but an initial smaller tunnel allows some tolerance for error. Once the two sections were connected they could create central axis lines on the ceilings, and enlarge the passage referring to these reference lines.



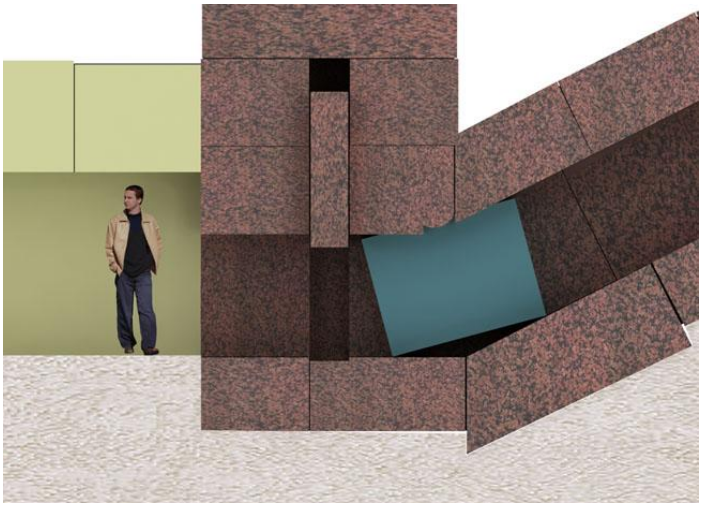
Regardless if the lower section was original or intrusive, one would have thought that the builders would leave the bedrock intact under the limestone masonry: in the image above this is the portion 'Z' (such a scenario would also reduce the bridging gap).

Gilles Dormion and Jean-Yves Verd'Hurt (D&V) published a book on Khafre's pyramid in 2018[83], and in this publication they were not convinced that Caviglia's void was caused by an errant passage, and developed the idea that the void was created to introduce another portcullis to the inclined passage.[84]

[83] La Chambre De Khephren, Analyse Architecturale, 1918
[84] Ibid, see fig 23, page 85



D&V would suggest that the vertical shaft was to allow a portcullis to seal off the inclined passage; it would be stored on a ledge inside the void, and at the time of closure, lowered through the hole in the ceiling. Though the idea appears to have been abandoned, as the hole in the ceiling is very irregular, and no guide groves exist in the lower passage walls; moreover, there are no cuttings in the void, like we see in the lower portcullis to allow a portcullis to fit. Of course these could all be ascribed to the unfinished nature of the excavation, but it does seem strange that they should cut into the bedrock below the masonry walls; further, it lengthens the already considerable floor gap to the remaining horizontal passage.



If we tried to introduce a portcullis of the size found in the lower portcullis, by sliding it down the passage on its side it would fail to make the turn. IN D&V's work, they have used the dimensions of M&R for the height of this junction, which I have shown to be suspect.[85] Of course they could use the cubic diagonal of the passage to bring the portcullis down, though it would have to be introduced diagonally at the very start of the

[85] Ibid, see fig 21, were they use M&R's height value of 1.32m

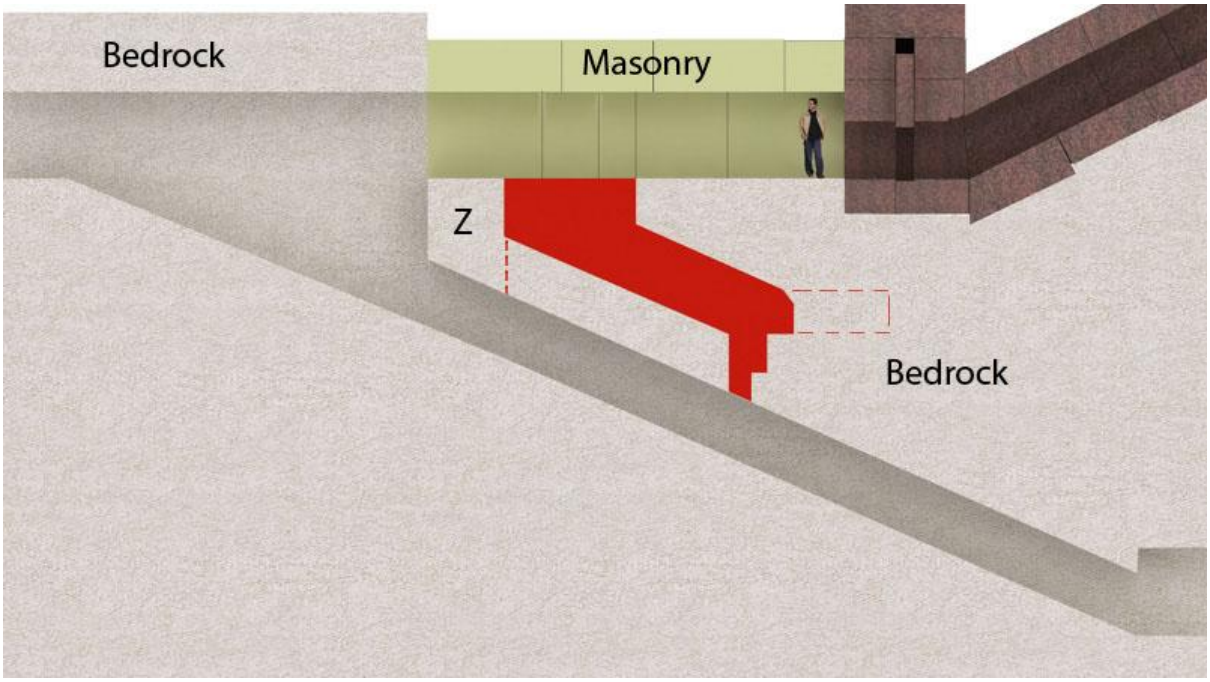
passage; as has been highlighted previously the diagonal of the portcullis is greater than the height of the passage, so it could not be introduced vertically and then turned into the diagonal position.

Inserted diagonally, the upper edge is about 13cm below the passage ceiling, and given the uncertainties at this junction, the block could likely pass (for this experiment I have used the lower ceiling height as shown on page 40). Of course this method could be used on the lower entrance passage, and it's even possible that a portcullis for the void was transported also down the lower entrance passage, along the lower horizontal passage and up the ascending passage; there being many variables.

However, the whole design appears messy and awkward; was there even a need for a portcullis in this location? There is so little data on Caviglia's void that it's hard to come to any conclusion, but the suggestion that it could be an errant passage or unfinished portcullis housing are not that convincing to me. Pending further data, the only alternative I can suggest is an intrusive burial; it might sound ludicrous, yet in the Black pyramid of Amenemhat III at Dahshur we have several intrusive burials, including two which were made in the entrance passages:[86] here, because the entrances faced east and west, two transverse cuttings were made across the passages to enable a north south orientation for the body; though such cutting would not be required in Khafre's as the entrance passage is orientated north.

The void clearly has an unfinished nature about it, a work stopped in progress, but what was intended? If a burial was intended was the horizontal portion at its north end to be carried further north to allow storage for a coffin? Was the neater part of the vertical shaft, intended for canopics or other items, and the rough hole at the bottom, used to dump debris from their excavations?

[86] See my Black pyramid guide.



In the above image I have extended the void north to allow a coffin. Whatever the intended function of the void, it seems to have been carefully packed with masonry to make good the passage floor above; though we have no idea if this was contemporary to Khafre, or a later restoration. We do not know if area 'Z' ever existed; it is directly under the robber's breach in the ceiling, and today the vertical face of the bedrock is where the red dashed line is above. The gap distance from this point is just over 9m, whilst the 'Z' extension in line with the wall masonry would reduce the gap to around 7.5m.

Looking up into the breach from the ceiling of the ascending passage

In this view we can see a faint line marked on the rock, which probably denotes the axis; a small part of this line can be seen at the very bottom of the previous image. Below is an image of robber's breach in the upper horizontal passage ceiling. Chisel marks can be clearly seen[87]

[87] It would be interesting to closely examine these chisel marks, as chisels and the markings left by them, evolved somewhat over Egyptian history as materials improved from copper to bronze and to iron. For example see Building in Egypt by D.Arnold, 1991, pages 33-35

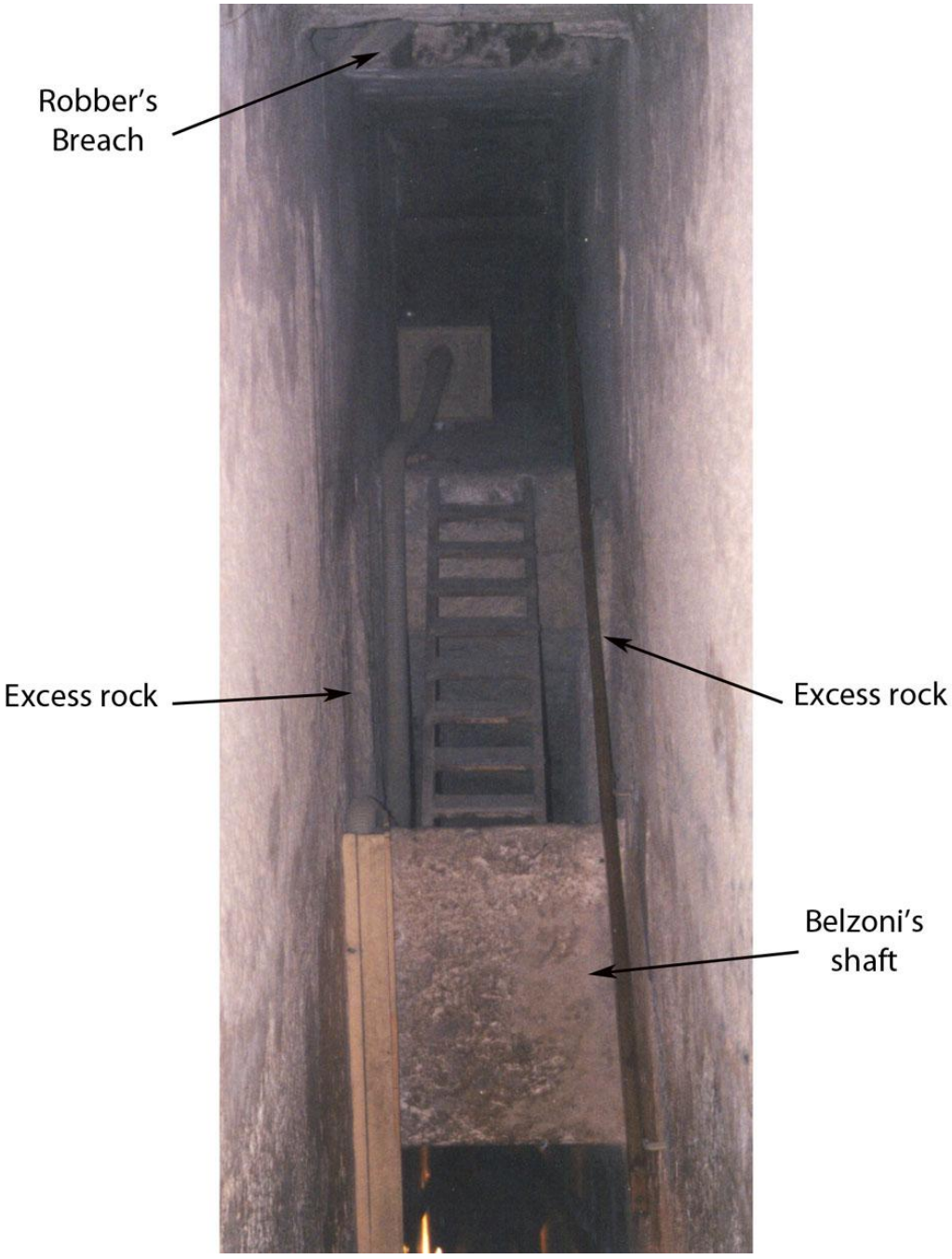


Image courtesy of Charles Rigano

This view looking north, we see the robber's breach in the ceiling (which is shown on the previous image); below it the front of the air conditioning unit, which is just in front of the upper portcullis (see images on pages 38&39). The wooden ladder leads down to Caviglia's void; this area covered by the ladder in Belzoni's time was concealed with masonry. When Belzoni lowered himself down his shaft by rope, the upper part, some 1m high was the masonry fill; today only the bedrock portion remains and is about 1.23m high. The above image shows excess rock on both east and west walls of the void, which reduce the width of the void to around 90cm.

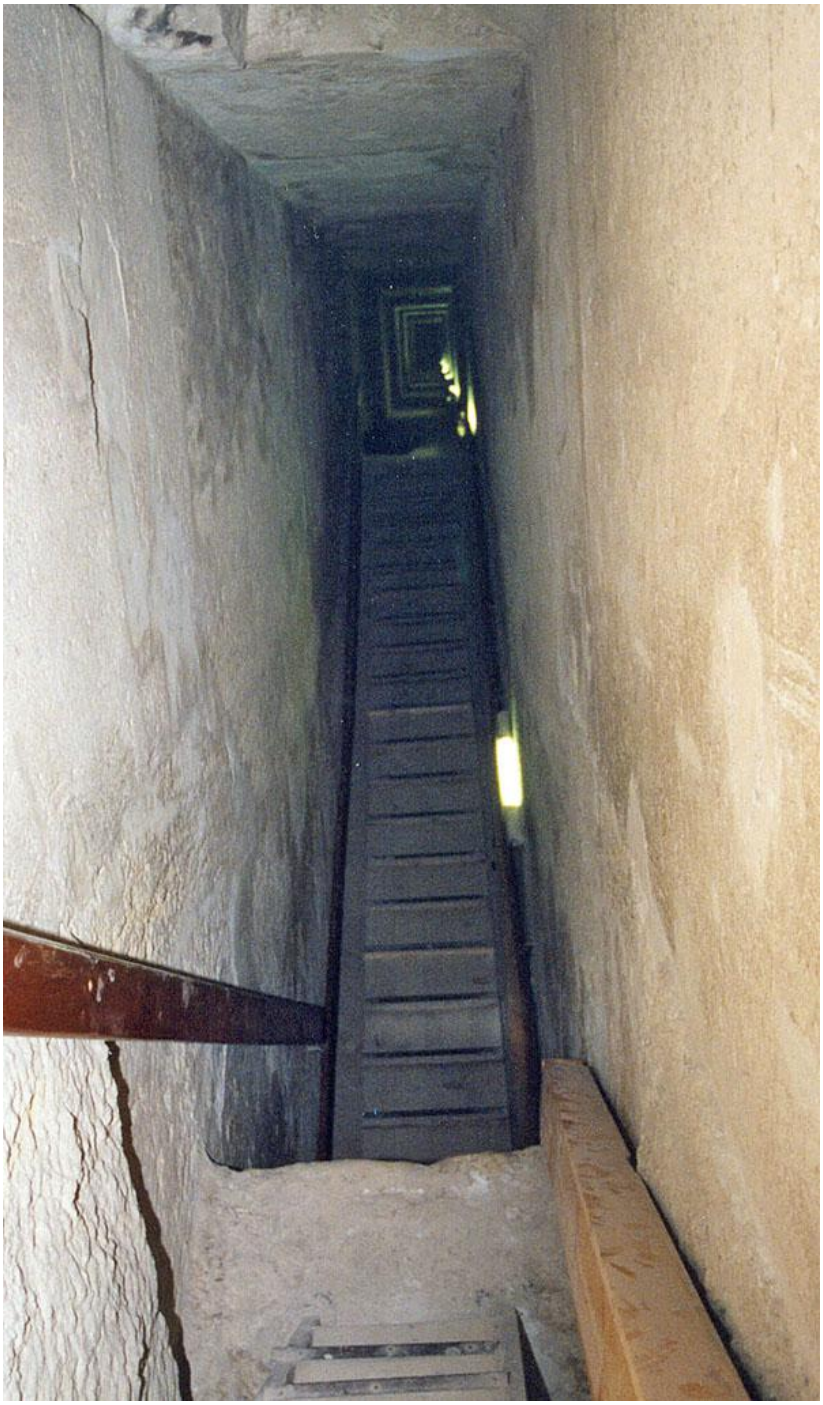


Image courtesy of Charles Rigano

This view looking south, we see the long horizontal passage leading off towards the king's chamber; the bottom of the wooden ladders visible on the previous image are visible, as is the robber's breach in the ceiling: the excess stock of rock is more clearly visible here on the east wall.

Looking north from the horizontal passage, showing the lower inclined passage, which is the route tourists take today; the upper entrance passage and the lower chamber are off limits.

Looking south along the long horizontal passage, with the wooden boards of the ascending passage visible in the previous image, terminating at the bottom of the image. The junction of the two passages is largely cut from the bedrock, M&R would state; *"The sides here are all rock-hewn and the corridor has regained its original width of 1.05 m. The sides of (T) have been excavated with a certain care and plastered with pink plaster while faults in the rock were walled up or filled with mortar. This makes it certain that the structure is original."* ('T' is the area of the junction; whilst regaining the width of 1.05m (2 cubits) is reference to the extra stock of rock left in Caviglia's void, which they give as some 5cm on west and 8cm on east wall.)[88] Though I would add caution that this shows that the junction is original to Khafre's design; any future addition would be capable of doing a careful job at this junction.

The Upper Horizontal passage

Where the lower ascending passage meets the level floor of the horizontal passage above, we have a further distance of 39.35m (75 cubits? (Vyse 39.12m) to the doorway of the burial chamber; this makes this section 2.5 times longer than the lower horizontal passage. To this we have to add the distance, for the northern section, which includes the gap and level floor to the end of the upper

[88] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 54

entrance passage which is about, 16.11m to the start of the granite or the end of the tall passage; which gives a total length for the tall passage of around 55.46m: and to this we can add the level granite floor by the portcullis to the inclined floor of the entrance passage, of 2.57m, for a total level distance of around 58.03m

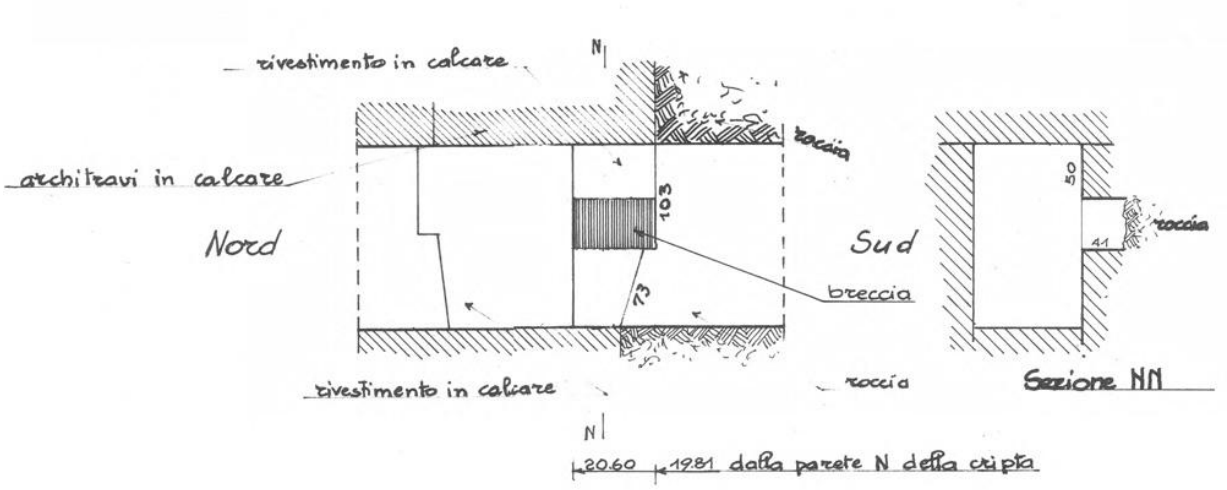
M&R would describe the quality of the long horizontal passage; *"The passage appears to be entirely tunnelled in the rock, the quality of which shows some natural faults and was not fine enough to allow more than a fairly rough dressing: so it was considered necessary to finish off the walls and ceiling with slightly pinkish gypsum plaster. The passage is not perfectly horizontal but slopes down almost imperceptibly to about halfway, to rise again at the same angle to a level almost equal to that of its northern end. In its central part, for about 11 metres, walls, ceiling and floor are faced with limestone blocks. It is clear that the work was made necessary by the bad quality of the rock which the corridor cut through here, and this is confirmed by a breach opened in the masonry of the east wall. The vein of bad rock is diagonal to the course of the corridor and so the facing begins and ends, on each wall, on the floor and on the ceiling, without relation to the neighbouring sides. Some blocks of this facing are of inferior quality and the stone appears much corroded and flaked"*[89]

In Belzoni's time he would report on the condition of the passage; *"As we advanced farther on we found the sides of this passage covered with arborizations of nitre; some projecting in ropes, some not unlike the skin of a white lamb, and others so long as to resemble an endive-leaf."*[90] Given the above conditions of the walls it would be difficult for Belzoni to recognise the extent of the masonry section in this passage, though he does state; *"Half-way up the horizontal passage, which leads into the large chamber, is some mason's work; but I believe it to be only the filling up of a natural cavity in the rock."*[91]

The breach in the east wall mentioned by M&R is a small affair, with the rest of the masonry of the 11m section intact; so it's difficult to agree with the confidence shown by M&R, that a vein of bad rock would run the entire length of this masonry section; for the simple reason that it is not visible, and thus can only be a suggestion; as there may be other reasons to explain this feature.

[89] Ibid, page 54 & 56
[90] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni, page 270
[91] Ibid, page 274

In the above image looking south, we can see M&R's breach on the east wall; according to their TAV 10, this is the southern limit of the masonry section, and starts at some 19.81m from the burial chamber (this distance also applies to the masonry start on the west wall and the ceiling). The depth of the block which fitted into this space appears to be 41cm.



In M&R's fig 4 above (from TAV 10), we can see the location of the breach, and how the southern end of the masonry section abuts against the bedrock portion of the passage. The walls and ceiling have a similar start point, but the masonry floor starts slightly further north; unfortunately I could find no data as to whether the masonry floor is inserted between the walls or if the walls rest on the floor: though section NN above gives the impression that the floor is inserted between the walls, I could find no confirmation of this.

View inside the breach; it's difficult to extrapolate the condition of the bedrock from such a small breach, and it would be beneficial for a geologists report. Certainly many fissures run throughout the Giza plateau, along with poor areas of rock, such as the Grotto in Khufu's pyramid; there is hardly a tomb at Giza that is not effected by such defects; for example a sizeable fissure runs down the length of Queen Khentkawes inner chapel; the builders would come across such features regulary; in Khentkawes case, the fissure was hidden by the masonry lining of the chapel. In other cases, the fissure could be just filled with mortar and plastered over, or even left unrepaired.

According to M&R's drawings both east and west walls have an equal length of masonry, some 11.02m in length, with the masonry floor largely matching this; though the masonry ceiling extends a further 1.25m north for a total length of 12.27m. Other than the masonry joint lines shown on fig 4 (previous page), the manner of masonry construction for the walls are unknown; in D&V's work, they mention that plaster on the masonry section makes it difficult to ascertain the masonry joint lines; though it's unclear if such plaster is modern restoration repairs. Likewise, no joint lines are given for the floor masonry, though measurements for ceiling joints are given in TAV 10, which show ceiling blocks varying in length from 67cm to 2.18m.

However, the above measures by M&R have to be treated with caution, for in D&V's publication, fig 39[92], we have major differences for this masonry section; here they have the walls closely agreeing with M&R, in being 11m long and starting at 19.77m from the burial chamber: but for the ceiling, it starts at 21.96m from burial chamber and runs for only10.08m, with the ceiling blocks ranging from 65cm to 1.53m. Whilst the floor section starts 22.34m from the

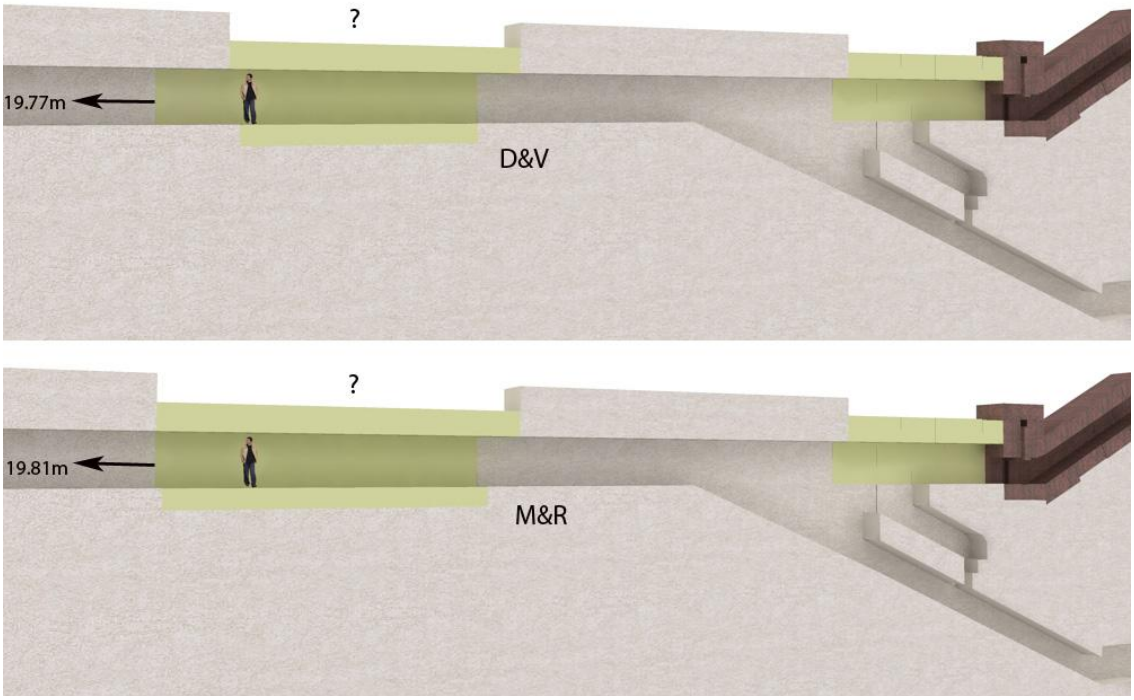
[92] La Chambre de Khephren, 2018, page 141

burial chamber, with a length of 7.51m for the regular squared stones, however, a large irregular floor stone, extends beyond this, and pass the northern limit of the masonry walls: so it's all a bit of a mess.

M&R seem to be under the impression that the masonry for the passage was introduced from above, and further masonry of the superstructure would be placed on top of this ceiling.[93] Indeed, I have seen some authors draw a vertical shaft from the top of the bedrock, down to this level. The level of the bedrock is unknown at this location; M&R would suggest that the ceiling was at least 1.20m below the pyramid courtyard, with a possible two or three metres of rocky core above that.[94] However, given that we know so little about the makeup of the masonry in this passage, I feel it cannot be discounted that the masonry section was lined from the inside and that no shaft was required; the builders were certainly experienced in lining rock cut chambers, and one can certainly admire the skill in the creation of Menkaure's granite chamber.

To add to the mystery, in D&V's publication they give the results of microgravimetric and radar scans of the horizontal passage and burial chamber carried out in 2000, which suggested to them that a lower descending passage might be found under the masonry floor of the passage, which could lead down to a concealed chamber.[95] As far as I am aware, no further work has been done on this anomaly. Pending clarity on the masonry makeup of this passage, it's hard to come to any conclusion; drilling small holes into the masonry of the ceilings, walls and floors, should provide valuable data, and such things have been done in the past, be it inside the Meidum pyramid, where D&V discovered the relieving chambers, or even in the queens passage inside Khufu's pyramid; though today the tendency is for non destructive testing, which has its limitations.

[93] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 108, observation 15
[94] Ibid, page 54
[95] La Chambre de Khephren, 2018, The full scan report is available in the annex of this publication, pages 174-185

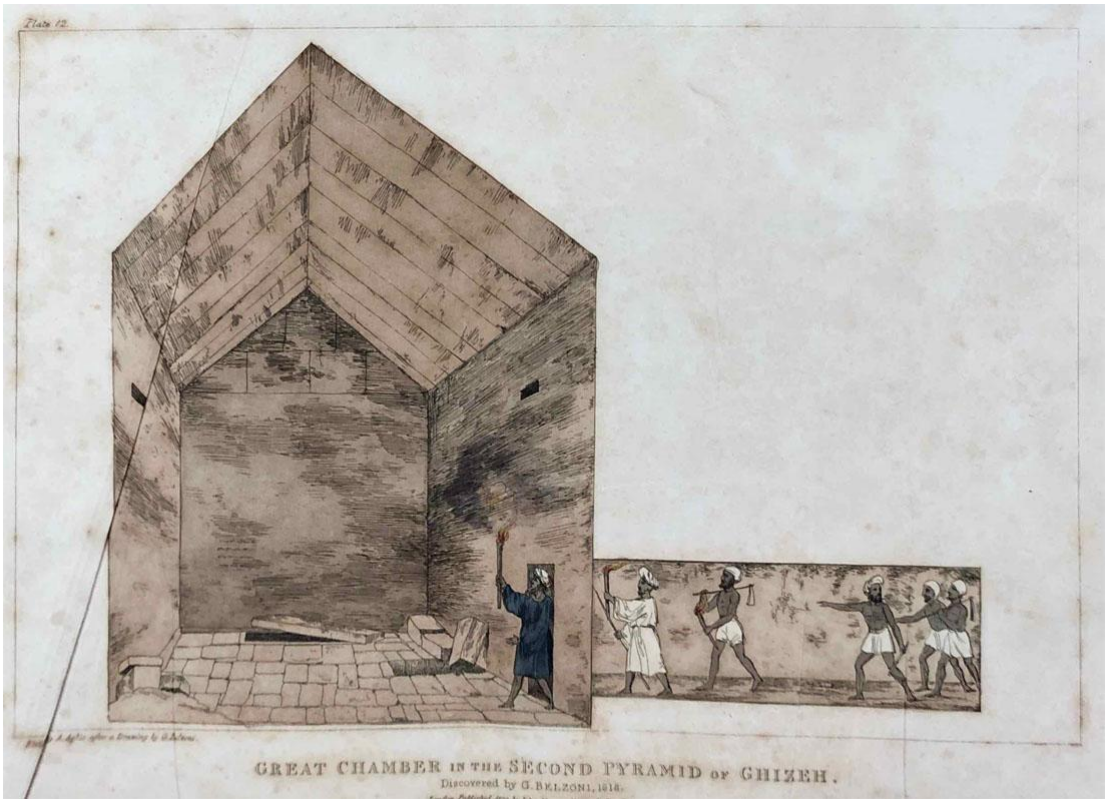


The above schematic views roughly show the location of the masonry built portions of the horizontal passage, and highlight the differences between the two sets of authors; though they generally agree on the 11m length of the walls, which place the south ends as some 19.77-19.81m from the burial chamber: this would make the north ends as some 24.65-24.69m from the north end of the high passage, by the granite.

The Burial Chamber

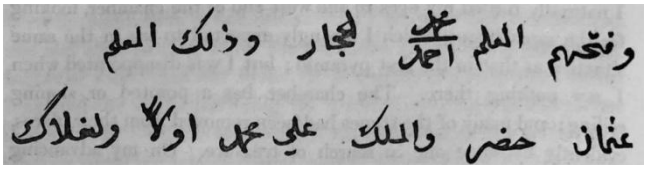
The burial chamber is a sizeable affair and entirely hewn from the bedrock, though it is roofed by fine limestone beams. M&R give the dimensions of the chamber as some 14.15m long by 4.97m wide and 5.24m high at the walls, or a possible 27 by 9.5 cubits and 10 cubits high. Petrie would report; *"Stone has been let into the walls to make good defects; and the whole surface was stuccoed. The floor is partly of rock and partly paved; the paving is of fine limestone 9 to 14 inches thick, except around the coffer at the W.end, where it is of deep granite blocks."*[96] The finish appears to be of a superior quality than that of the lower chamber. There is some confusion to the chamber's apex height, Petrie did not measure it, but accepted Perring's drawings and tympanum height of 38 inches; however M&R highlighted error in Perring's drawings and have accepted Vandier's value of about 6.84m, as likely more correct, which would give the apex height as about 3cubits higher than the walls.[97] (Perring would give an Apex height of 6.83m, but an errant wall height of 5.87m)

[96] The pyramids and Temples of Gizeh, 1883, page 105
[97] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 80



The above plate from Belzoni's publication highlights the condition that Belzoni found in the chamber; the paving is largely intact, with the lid of the sarcophagus ajar. The fine limestone ceiling beams are noted as well as the masonry tympanum of the west wall (the east tympanum is a mix of bedrock and masonry). Also visible is two holes high up on the north and south walls; however, the limestone pavement is incorrectly drawn here as it starts some 1.2m west of the doorway; in reality the figure above should be walking not on pavement, but on the bedrock portion of the chamber floor, which extends some 4.89m from the chambers east wall, whilst the doorway axis is 3.17m (6 cubits) from the east wall.

In the horizontal passage some 15cm from the doorway; M&R report two small holes in the walls and traces of mortar, though nothing was found on the architrave or threshold that would suggest a door.[98]



Belzoni would report many scrawls on the walls with charcoal, which rubbed off into dust at the slightest touch. The Arabic left was found on one of the walls at the west end of the chamber; by the time of Vyse's arrival these inscriptions no longer survived.

[98] Ibid, page 56 and TAV 10 fig 1.

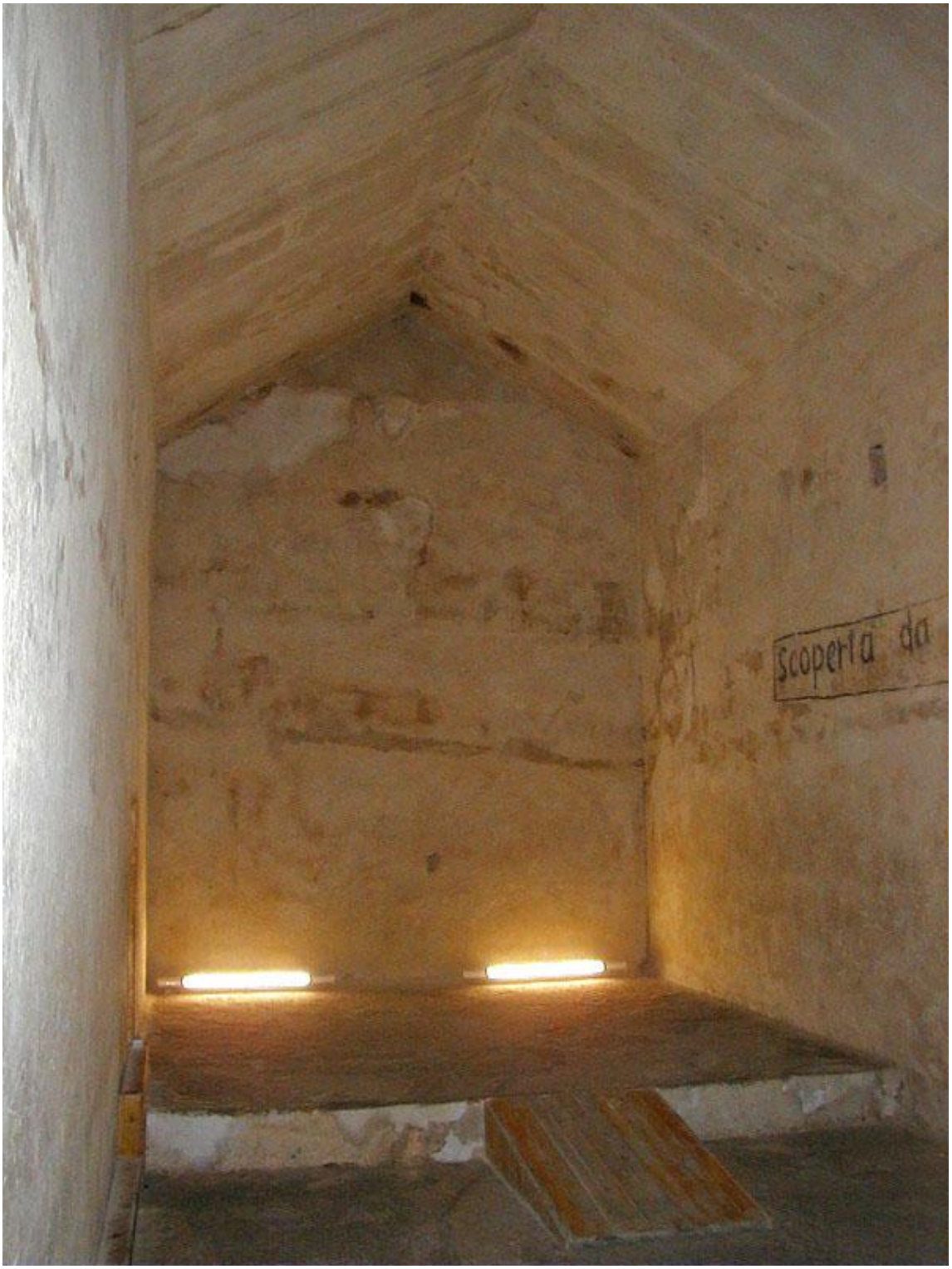


Image courtesy of Jon Bodsworth

Looking at the east wall, with doorway just visible on left; here we can see the bedrock portion of the chamber floor, at some 40cm high the limestone paving would abut against this face. The hole high up on the south wall is also visible; these holes are roughly in alignment to where the two floor types meet.

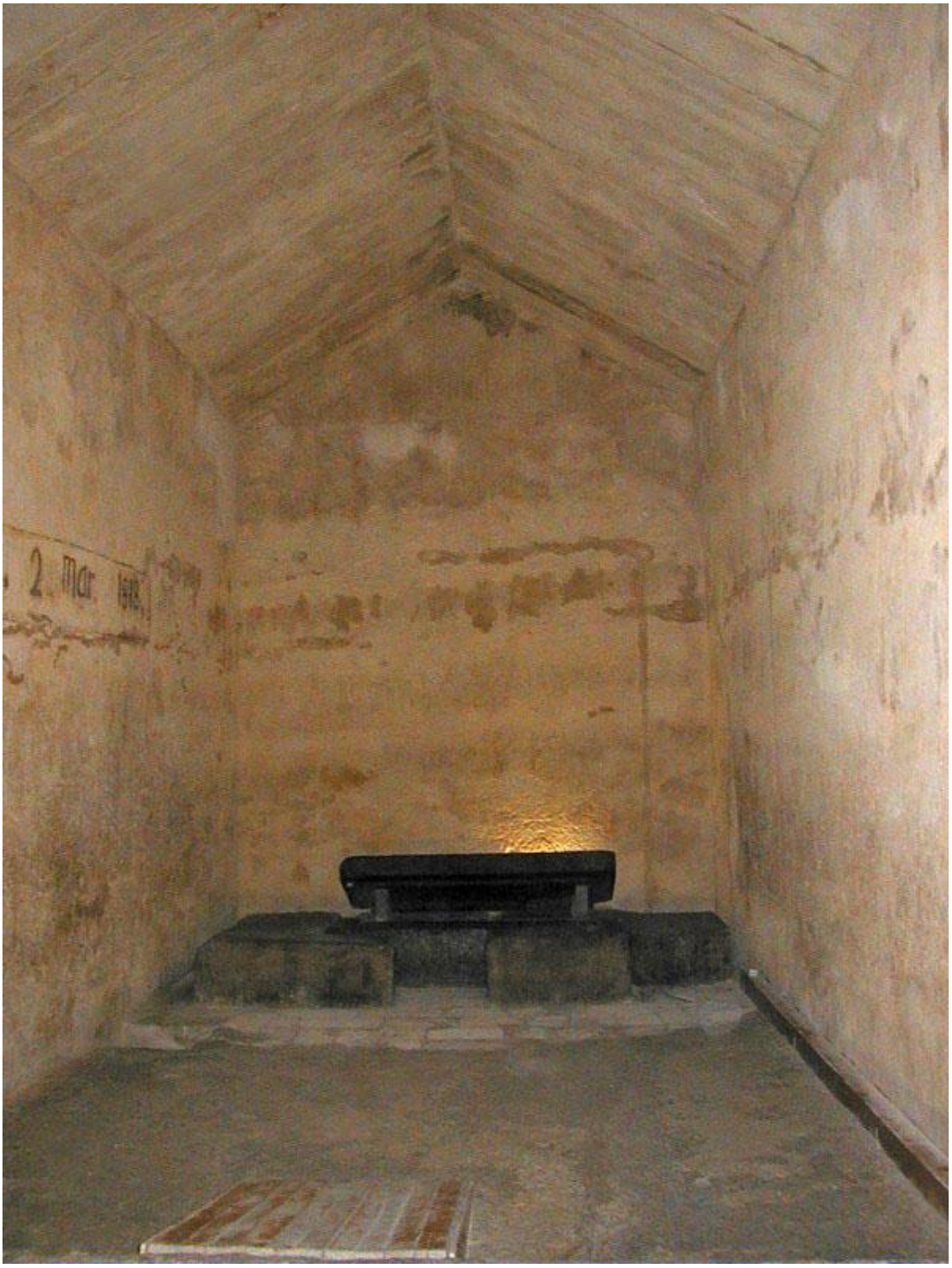


Image courtesy of Jon Bodsworth

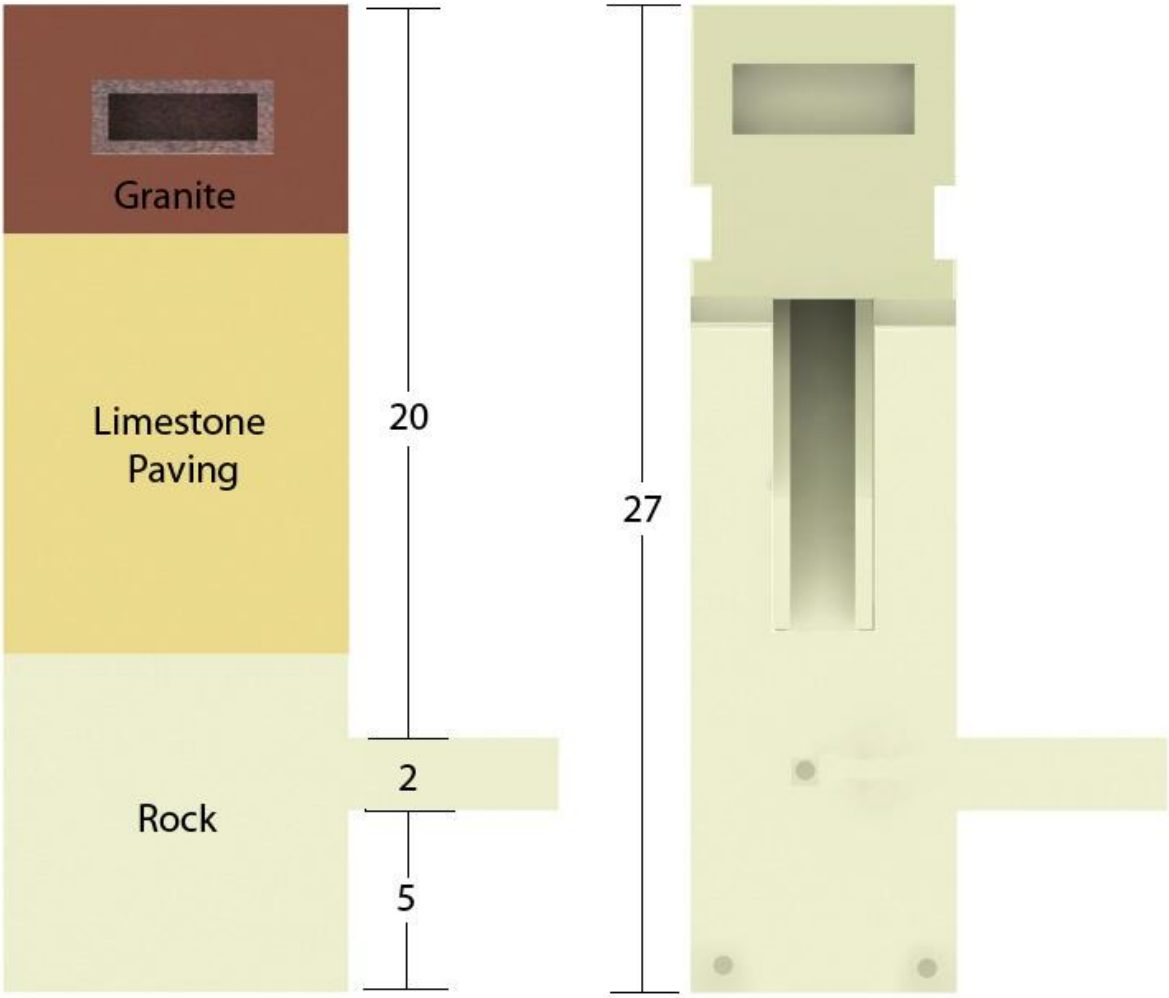
Looking at the west end, we can see that the sarcophagus is sunk into the floor and surrounded by granite blocks; modern masonry repairs have been done around this area to repair damage done by Perring, who ripped up the limestone paving and excavated under the sarcophagus. Against the south wall, a neat pit can be seen sunk into the floor, it is thought that this pit may have held a

canopic box, and would be covered by the limestone paving. The banner on the south wall by Belzoni commemorates his opening of the pyramid on the 2nd of March 1818: though he would not reach the burial chamber until the 3rd.

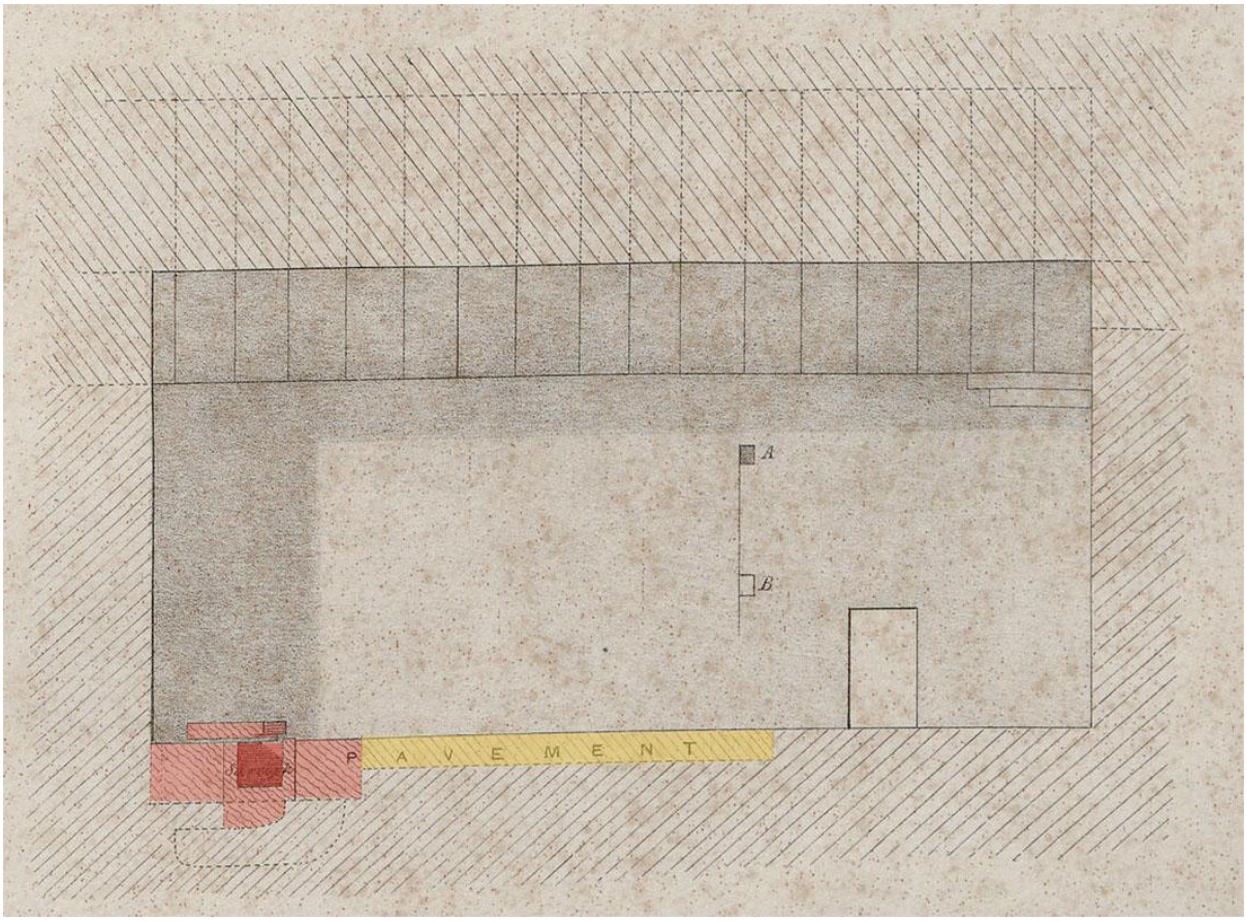
Looking towards the east end, we can see the doorway more clearly, and the hole on the north wall. Also visible is a sizeable breach by the ceiling made by Perring on the north wall, and a close up view below.

The previous image shows the exceptionally fine quality of the ceiling beams and the very fine joints; when Belzoni first entered the chamber with his torch made of a few wax candles, he commented that the chamber had a painted ceiling.

The design of the chamber is somewhat similar to the upper chamber in Menkaure's pyramid; the two floor layouts are shown below, Menkaure on right.



Both chambers share a similar length, and both have their entrances located 5 cubits from the east wall (this passage displacement is also to be seen in queens' pyramid GIII-a, which also had a sunken sarcophagus at its west end). Perring's rationale for removing the pavement was due to the descending passage in the floor of Menkaure's chamber, which led to the granite lined burial chamber. Perring remained convinced that Khafre's chamber was not the main burial chamber.



In Perring's section of the chamber above I have coloured in the limestone and granite portions of the pavement; the dotted line is his excavation under the sarcophagus. Dimensions in this area are uncertain, though Perring reports that the sarcophagus was 1.09m from the west wall, and as the sarcophagus appears to be 2 cubits wide at around 1.07m, it may have been intended that the granite portion of the pavement extended some 6 cubits (3.14m) from the west wall.[99]

The sarcophagus was cemented onto an irregular block of granite some 12 to 18 inches thick, whose rough bottom was mortared onto the bedrock. The sarcophagus was protected on all four sides by granite blocks; though if Perring's figures are correct, the sarcophagus is not centred to the chamber's axis, for he reports that the sarcophagus was 1.32m from the south wall (2.5 cubits) and as the sarcophagus is given as 2.63m long (5 cubits), the north end of the sarcophagus, would be 2 cubits from the north wall.

[99] M&R's drawing TAV 10, fig 2 only give an approximate 3m due to the damage in the area, though in their reconstruction fig 8, they suggest 3.3m. A closer inspection of the surviving granite blocks, should give a more reliable figure.

The sarcophagus is in fairly good condition; Petrie's description:

"The coffer is well polished, not only inside but all over the outside; even though it was nearly all bedded into the floor, with blocks plastered against it. The bottom is left rough, and shows that it was sawn and afterwards dressed down to the intended height; but in sawing it the saw was run too deep and then backed out; it was, therefore, not dressed down all over the bottom, the worst part of the sawing being cut .20 deeper than the dressed part. This is the only error of workmanship in the whole of it; it is polished all over the sides in and out, and is not left with the saw lines visible on it like the Great Pyramid coffer. The finish is about the same as on the walls of the King's chamber, and the horizontal polishing lines can be seen inside the N.end.

The lid is lying on the floor of the chamber, unbroken; it was slid on to the coffer, and held by a projection on its base, which fitted into undercut grooves along the N., E., and S. Sides of the coffer, the W side being cut away to the depth of the groove. The grooves in the coffer are not parallel, but are wider apart at the W., so that the lid should have no chance of jamming in being put on. When finally slid into place, two pins (probably of bronze) dropped down out of the holes in the lid, into corresponding holes in the W. Side of the coffer.

The designers were evidently afraid, however, of the coffer being turned over, so as to let the pins drop back into the lid; they therefore sunk the coffer into the floor. To make it still safer they put resin in the pin-holes, where it may still be seen; then the pins, being ready heated, were put into the holes in the lid, which was quickly closed; thus the pins sank ½ inch to 1 inch, melting their way into the resin, and probably forcing it up their sides. This process made sure that there could be no way of getting the lid off without breaking it, and the

design answered perfectly; the lid was never drawn off. On one side of the groove in the coffer may be seen a little scrap of cement, this shows that the lid was cemented o in the grooves, and that it never was slid back, or it must have rubbed off such a fragile scrap. This cementing on of the lid was also of use to prevent any shake; so that the labour of wrenching it up and down must have been enormous. This seems, however, to have been the way of forcing it, as the undercutting is much broken, and the cement in the groove, and the melted-in pins, make it impossible to suppose any other mode of removing the lid. There is a good deal of crystallized salt on the inside of the coffer."[100]

The widening of the grooves towards the west side can just be made out on the previous image. The lid is relatively intact apart from damage resulting from its removal; however, I have noticed a recurring account by Egyptologists that the lid was broken in two pieces; for example, in Lehner and Hawass's publication, Giza and the Pyramids, page 198, they state; *"The masons no doubt hoped that those features would prevent the sarcophagus ever being opened again once the king's body was sealed inside. But someone managed it, breaking the lid into two pieces, as Belzoni found it."* Similar statements exist elsewhere, for example, I.E.S. Edwards states; *"The lid itself, which lies nearby, is broken into two pieces a condition in which it was found in 1818 by Giovanni Belzoni, the first European explorer to enter this pyramid in modern times."*[101] Clearly the lid is intact, other than the damage inflicted during its removal.

Belzoni himself does not provide much information on the sarcophagus, he states; *"It is surrounded by large blocks of granite, apparently to prevent its removal, which could not be effected without great labour. The lid had been broken at the side, so that the sarcophagus was half open. It is of the finest granite; but like the other in the first pyramid, there is not one hieroglyphic on it. Looking at the inside, I perceived a great quantity of earth and stones, but did not observe the bones among the rubbish till the next day, as my attention was principally bent in search of some inscription that would throw light on the subject of this pyramid."*[102] On the following day Belzoni elaborates a bit more.

"A young man of the name of Pieri, employed in the counting house of Biggs and Walmas in Cairo, came the next day to visit the pyramid, and having rummaged the rubbish inside of the sarcophagus, found a piece of bone, which we supposed to belong to a human skeleton. On searching farther, we found several pieces, which, having been sent to London, proved to be the bones of a bull."[103]

[100] The pyramids and Temples of Gizeh, 1883, page 106-107
[101] The Pyramids of Egypt, revised edition 1985, page 145
[102] Narrative of the operations and recent discoveries in Egypt and Nubia, 1820, by G. Belzoni, page 271
[103] Ibid, page 275

It's difficult to visualise what Belzoni found, but given the good condition of the chamber, where we have no evidence of excavations other than a few upturned paving stones, one wonders where the '*great quantity of earth and stones'* that Belzoni found inside the sarcophagus, came from? The quantity of bone found is also uncertain, and the evidence is so superficial that one could hardly suggest a bull burial; a simpler solution might be remains of offerings that found itself inside the sarcophagus with the other debris, whose makeup is also uncertain. As the bones were sent to London, they may yet exist in some museum, and if they could be found, dated, so as to determine the era of their introduction. It has to be borne in mind that the pyramid has likely been entered many times in its history; as we can see from Menkaure's pyramid some restoration efforts from the Saite period.

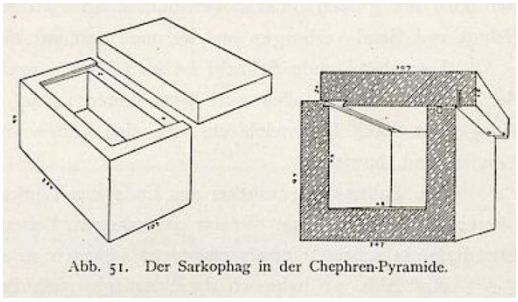


Abb. 51. Der Sarkophag in der Chephren-Pyramide.

The section left by Hölscher shows how the lid would be slid on from the west, and at some 1.07m wide, it could be stored on top of the granite blocks behind the sarcophagus; as Perring gives a distance of 1.09m for the sarcophagus from the west wall: moreover, the lid could utilise some of the wall thickness of the sarcophagus, of some 19.4cm, which would allow more space behind the stored lid, for levers or ropes. M&R report some shallow holes around 10cms in diameter on the upper faces of some of the surrounding blocks;[104] unfortunately their locations are not marked on their drawings, so it's difficult to come to a conclusion; but they may be connected with the installation of the lid.

The exterior dimensions of the sarcophagus box are 1.07m wide, 2.63m long and 0.97m high; as previously mentioned the box is too wide to traverse the passage, though placing it on its side, would solve this problem. As it appears that M&R's measures for the passage height by the upper portcullis are incorrect, then the sarcophagus could not be introduced this way. Neither does it look possible for the sarcophagus to traverse the lower entrance route, as the good condition of the south doorway at the end of the lower horizontal passage appears to be not high enough; always assuming the published measures are without error. This means that the sarcophagus would have to be placed inside the chamber before it was roofed, or if the masonry in the mid section of the upper horizontal passage was part of a construction shaft it could be introduced through here; though it would have to be early in the build so as not to interfere with superstructure construction.

[104] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 56

77. The size of the coffer was measured thus :—

		E.	Mid.	W.		Mean.	Mean error.
Outer length	Top	103·62	103·64	103·69		103·68 ±·02	·04
	Mid.	103·73	Inaccessible.				
	Base	103·72	„				
		N.	⅓ along.	⅔ along.	S.		
Outer width	Top	41·96	41·97	41·96	41·99	41·970 ±·006	·015
	Mid.	41·95	Inaccessible.		42·00		
	Base		All inaccessible.				
Outer height	E.	38·12	38·12	37·98	38·07	38·12 intended.	
	W.		All inaccessible.				
Sides thick at the top	E.	7·65	7·66	7·59	7·61	7·645 ±·01	·03
	W.	7·62	7·64	7·70	7·69		
		E.	Mid.	W.			
Inner length	Top	84·63	84·68	84·63		84·73 ±·02	·07
	Mid.	84·74	84·80	84·91			
	Base	84·69	84·76	84·80			
		N.	⅓ along.	⅔ along.	S.		
Inner width	Top	26·66	26·68	26·73	26·67	26·69 ±.01	·04
	Mid.	26·73	26·74	26·79	26·76		
	Base	26·70?	26·71	26·70	26·73		
Inner depth	East	29·51	29·58	29·62	29·57	29·59 ±·01	·03
	Mid.	29·59			29·58		
	West	29·68			29·61		
		N.	Mid.	S.			
Ledge depth	East	1·72	1·76	1·60		1·70 ±·02	·04
	West	1·73		1·69			

Ledge wide, 1·20 to 2·30 on N., 1·08 to 1·90 on S.

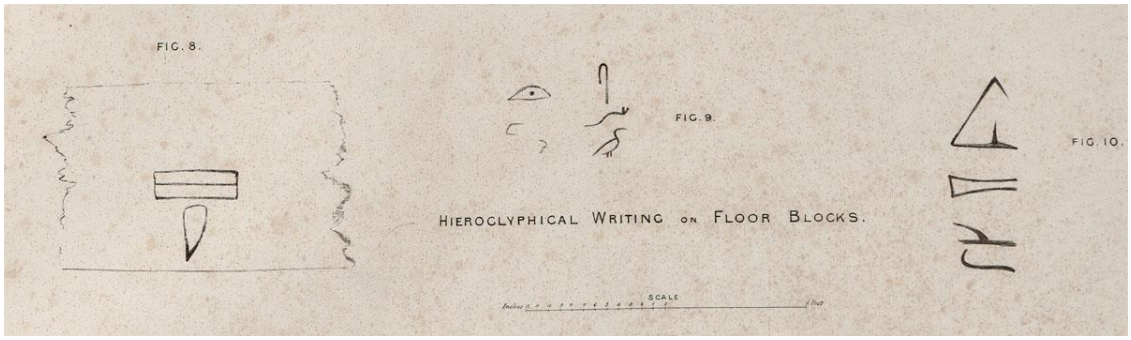
Lid, 103·73 on W., 42·03 on S. Thickness, 9·89 W.S.W., 8·20 S.S.W., 8·22 S. 8·24 S.E.

The above table are Petrie's measures for the sarcophagus (in inches). The other feature of interest in the pavement is a possible canopic location against the south wall; here we have a neat pit, M&R state; *"Against the south wall of the room a small pit may be seen that is certainly original because it is cut with great accuracy. It measures 76 cms. in an east-west direction by 72 north-south and is at least 70 centimetres deep from the· level of the rock. It is perhaps a receptacle for the canopic vases and was originally covered with a limestone slab which formed part of the floor. In Belzoni's drawings it is shown that the receptacle was already without its cover when its discoverer entered the room in 1818."*[105] According to M&R's TAV 10, this pit starts some 3.99m from the west wall.

In Vyse's work he suggests that the limestone paving of the chamber was made of two courses of stone;[106] though given the shallow depth for this section it would seem unlikely; moreover, Vyse was not present when the floor was ripped up by Perring, as he was on his journey back to England: likely it was the depth of the sarcophagus, which made him think that there was two courses.

[105] Ibid, page 58

[106] Operations carried on at the Pyramids of Gizeh in 1837, Vol 1, page 180. (a similar statement is made in Perring's publication; but a lot of the text here appears to have been lifted out of Vyse's publication, so it is difficult to ascertain who is the real author of the statements in these publications.)



When Perring ripped up the limestone paving of the chamber he came across several markings on the stones; shown above from his plate III.

The two holes high up on the south and north walls, have been suggested by some as the beginnings of air channels similar to what we see in Khufu's pyramid, though it's hard to see how such small shafts could be cut through solid bedrock; more likely given their alignment with the limestone pavement, they had something to do with a possible partition of the chamber, and a further doorway into the paved part of the chamber. Petrie's description; *"On both N. and S. walls there is a vertical red line drawn, on the N. at 198.3* (5.04m) *from E., and on the S. at 198.6 from E. These red lines on both walls run up to .5 or .1 on the W. Side of a blind hole in the rock, which looks like the beginning of an air-channel; and there is a square of the same size marked adjoining the line some way below the hole, as if it had been at first intended to cut the hole lower down."*[107]

Today these red construction lines are no longer visible, and below we have Petrie's dimensions of the holes and marked out squares.

	Hole.					Square.				Base of Hole.	
	E.	W.	Top.	Base	Deep.	E.	W.	Top.	Base.	To Ceiling.	To Square.
N. .	11·5	11·2	8·8	9·1	11·5	12·2	11·8	8·7	9·0	53·6	62·8
S. .	10·5	10·2	7·4	8·1	13·4	11·6	11·5	8·7?	9·0	55·2	62·1

The backs of the holes are quite irregular and unfinished.

Given the width of the holes, it may have been intended to partition the chamber starting at 10 cubits (5.24m) from east wall. The bottom of the holes appears to be 2.5 cubits from top of wall, whilst we have a further 3 cubits to the top of the marked out squares; the bottom of the squares is about 2m above the floor, or about 20cm higher than the doorway. Given the red construction lines, it appears to be an unfinished construction; two such cross beams could support a lightweight wooden partition, or one of mats; the lower squares if intended to

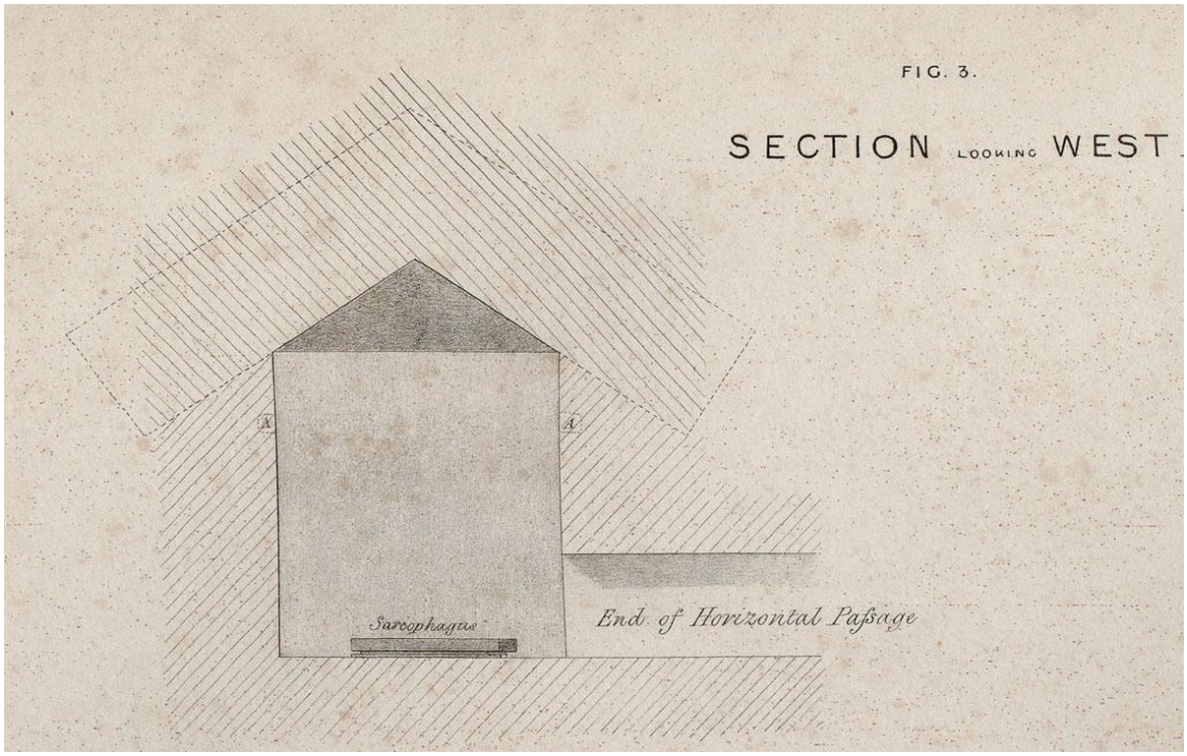
[107] The pyramids and Temples of Gizeh, 1883, page 106

support a cross beam would offer sufficient head height for a doorway in the partition.

Above we have the doorway to the burial chamber, and at top of picture we can see the hole in the north wall; the red construction lines are no longer visible, so the red imposed lines give a rough idea: M&R state; *"In the north and south walls two vertical lines are clearly visible traced in red and as high as the walls themselves. The eastern one is in line with the edge of the rock floor and the other is 23 centimetres further west. At a certain height from the floor two horizontal lines about 30 centimetres apart form a small square with the others. Moreover, higher up can be seen another identical square which subsequently, in both the walls, was incised and excavated to a depth of about 33 cms to the south and 43 cms. to the north. The bottom of these holes is rough.*[108]

Given that this chamber would be constructed relatively early compared to the rest of Khafre's complex, one would have thought that the chamber would have been completely finished; the construction lines left on the wall would suggest it was a very late unfinished addition to the chamber, or even a later intrusive addition that was unfinished.

[108] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 58

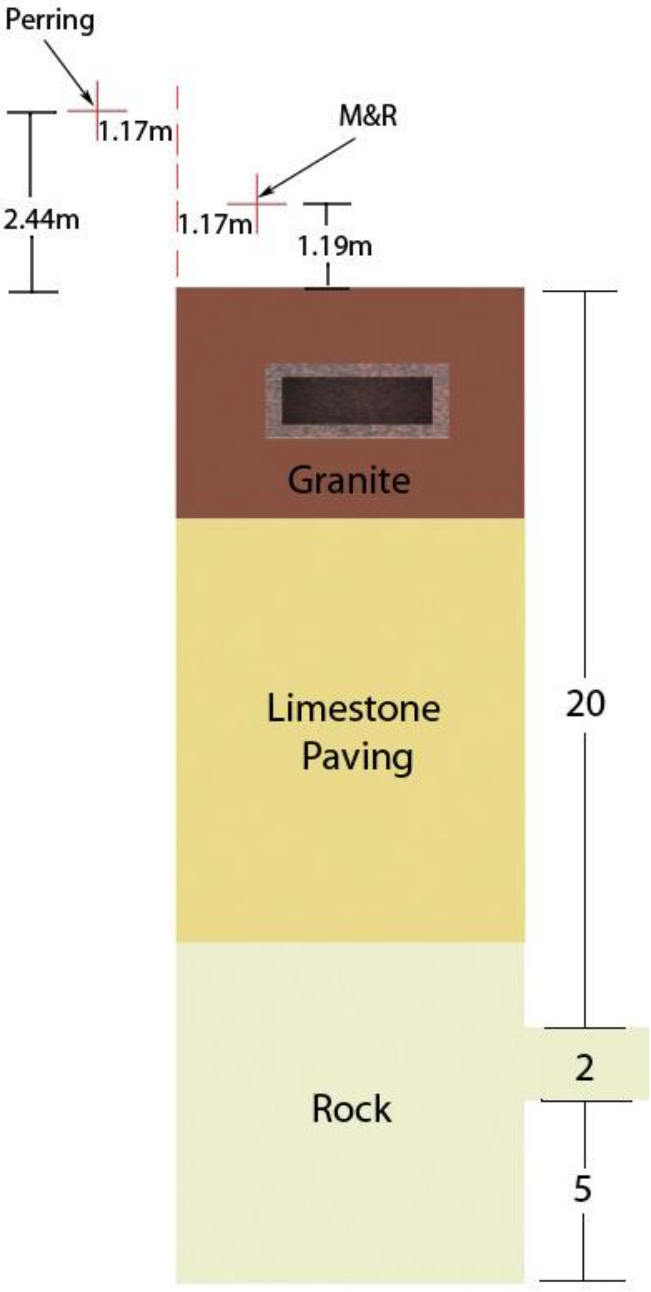


In the above section by Perring[109], we can see how far the ceiling beams extend into the bedrock; I could find no measures in Vyse's or Perring's work which give the value for the depth of the ceiling block; though Perring spent a considerable effort excavating along the beam to determine its depth; but by scale rule it is about 2.67m. In his drawing he has placed the two holes on the north and south walls; clearly any shaft such as we see in Khufu's pyramid would conflict with the ceiling beams. It is not known if further similar beams were placed on top of these, which likewise could be abutted against the bedrock.

As there is inconsistencies in published measure's it's difficult to determine the levels of the substructure; but using M&R's drawings the burial chamber floor is around 3.5m below pyramid base, which makes the top of the walls 1.74m above pyramid base. The chamber's location in respect of the pyramids centre also differs greatly between M&R and Perring; the major difference being whether the chambers south wall extends beyond the pyramids east-west axis. M&R state; *"The position of the crypt with respect to the vertical axis of the monument was calculated by Petrie, who corrected Perring's measurements. It is to be found in the NE quadrant of the pyramid and its west wall is 1.19 m. from the north-south axis of the pyramid itself. It does not appear to us that Petrie corrected the measurement of 1.17 m. given by Perring as the distance of the south wall of the crypt from the east-west axis. So we shall accept this datum with the necessary reserve."*[110]

[109] The Pyramids of Giza, from actual survey and admeasurement, Part II, plate III
[110] L'Architettura Delle Piramidi Menfite, Parte V, 1966, page 60

However, it should be recalled that Petrie did not do a full survey of this pyramid, and only measured a few elements of the substructure. Having calculated the size of the pyramid and updated the upper entrance passage axis east of the pyramids N-S axis, and assuming the azimuth of the long horizontal passage matched that of the entrance passage, then the burial chambers west wall would be some 47 inches (1.19m) east of the pyramid centre.[111] Petrie could not calculate the location of the chambers south wall, as he provides no measures for the long horizontal passage other than the height.



IN M&R's TAV 10, and TAV 6 they show the pyramid centre as shown left, with the south wall of the chamber at 1.17m south of the E-W axis. Perring's centre in contrast has the south wall 1.17m north of the E-W axis. It appears that M&R have used Perring's 1.17m value but confused its location; this can be confirmed by using M&R's measures for the rest of the structure in AutoCAD which show the chamber's south wall to be closer to 2m from the E-W axis.

Today many modern publications still show the pyramids centre as displayed by M&R above; granted the structure still awaits a modern survey, but the available evidence does suggest that no part of the burial chamber is outside the northeast quadrant of the pyramid.

John Legon would create an article on the Design of Khafre's pyramid,[112] and he provides a table of measurements in which he provides a table of his own measurements, along with a design scheme for the structure in Egyptian units.

[111] The pyramids and Temples of Gizeh, 1883, page 104
[112] GM 110 (1989), pages 27-34

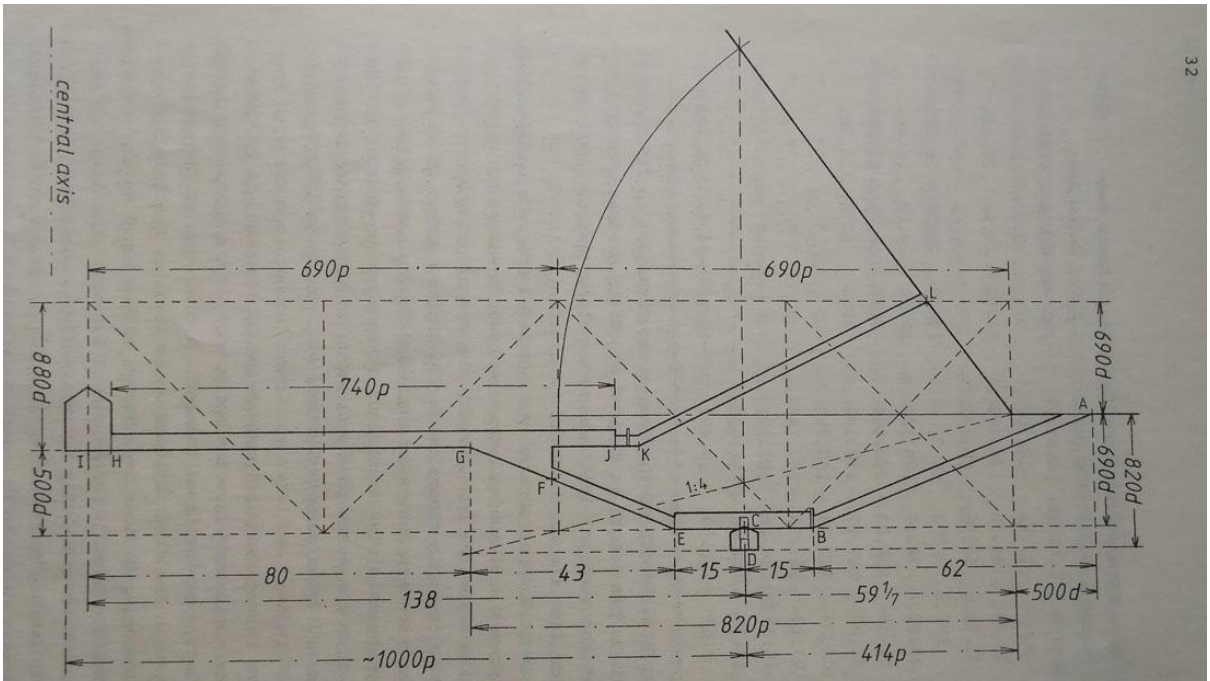


Fig.2 Dimensions of Second Pyramid in Cubits, Palms (p) and Digits (d).

Table I **Dimensions of the Passages in Metres**

	Line	Length	Angle	Vertical	Horiz.
Lower Entrance Passage	AB	34.94	21° 40'	12.90	32.47
Lower Horizontal Pass.	BC	7.88	-	-	7.88
" " "	CE	7.88	-	-	7.88
Lower Chamber Passage	CD	6.71	21° 19'	2.44	6.25
Connecting Passage	EF	14.65	23° 0'	5.72	13.49
" "	FG	9.69	22° 0'	3.63	8.98
Upper Horizontal Pass.	GH	39.37	-	-	39.37
" " "	GI	41.86	-	-	41.86
" " "	GJ	16.02	-	-	16.02
" " "	JK	2.58	-	-	2.58
Upper Entrance Passage	KL	36.95	26° 28'	16.47	33.08

The above images show Legon's table of measures and his scheme for the design of the pyramid. In this study we can see that the south wall of the burial chamber does not go beyond the central axis. If we take the entrance passage axis as an intended 24 cubits east of the pyramids N-S axis, and ignoring the azimuth, then our 27 cubit long chamber would have its west wall some 3 cubits (1.57m) from the pyramids N-S axis. In Khufu's pyramid the entrance passage axis was 14 cubits to the east, and as the King's chamber was 20 cubits long,

only 5 cubits of the chamber was west of the N-S axis, and an area in which the kings sarcophagus was found (the queen's chamber is east of the N-S axis). In Khafre's pyramid, if it was intended that the sarcophagus was located in the west, then they appear to have made an error; unless we follow the view of Perring who remained convinced that the real burial chamber was yet to be found or D&V's view that a passage leading to another chamber might exist under the long horizontal passage floor.

Concluding Remarks

It is sad to see yet another structure in such a mess; in an era of hi-tech and laser scanning there should be no ambiguity on what we see; in many ways we are not much further forward in our investigations than from Vyse's time. Architectural study has always been poorly served by Egyptology; not many in the history of Egyptology have given it serious study, and fine works such as Dieter Arnold's publications are often the exception, not the rule. Too much of what we know is wholly reliant on old dated reports, which sadly pose more questions than answers. Simple things should be able to be resolved, such as whether the Caliphs made the robber's tunnel for example; the Caliphs would have the use of iron tools to cut this tunnel, whereas if it was created in the Old Kingdom, we should expect cut marks consistent with copper: the breach in the ceiling of the horizontal passage should furnish some clues.

One hundred years ago Somers Clarke would state;

"Archaeologists have devoted much energy to the study of pots and pans, a study undoubtedly of much value; but why should things structural be so neglected, when they are of equal importance with the others alike archaeologically, historically and ethnographically?"[113]

Though this statement was made a century ago, it is sadly still pertinent today.
To keep the guides to a manageable size, it is hoped that separate guides will be made for Khafre's temples.

[113] Journal of Egyptian Archaeology, Vol 7, 1921, El Kab and the Great wall, 75.