THE BENT PYRAMID

The Bent Pyramid at Dahshur is one of Egypt's oldest pyramids, and still one of the least understood. Why the bend? Why the two entrances? **Colin Reader** seeks to find some answers.

Local lads enjoy the water's edge of Lake Dahshur, one of a series of sacred lakes that once allowed quarried stone to be carried by boat to the edge of the pyramid precincts. In the background is the Bent Pyramid and its subsidiary pyramid.

The Bent Pyramid at Dahshur was built for King Sneferu, the founder of the 4th Dynasty, around 2600 B.C. Its name comes from the marked change in angle of the superstructure, with the lower half of the pyramid built at about 54° and the upper half built at 44°. This change in angle, however, is not the Bent Pyramid's only unusual feature.

In addition to a conventional entrance near the centre of the northern face, some 12 m above ground level, the Bent Pyramid has a second entrance high on the western face, more than 30 m above the surrounding desert. These two entrances connect to quite distinct elements of the internal chambers. Some researchers have taken this (together with evidence for movement of the structure that may have occurred during the building works) to conclude that difficulties were experienced during construction.

According to these theories, the design changes that were taken to address these difficulties led to a structure that departed significantly from what had been intended. The pyramid could no longer be regarded as suitable for the burial of Sneferu and was abandoned—although not before it was hurriedly finished by reducing the angle of the upper slopes. Not all commentators agree with this interpretation, and unfortunately, any attempt to understand the Bent Pyramid is hampered because existing surveys conflict with one another in a number of key respects.

In the absence of any consensus, I was privileged to be granted rare access to the interior of the pyramid in early 2018 to try and resolve some of these issues. On the basis of the inspections I have been able to undertake, I have reached two broad conclusions: 1) it does appear that movement of the structure occurred during construction, and 2) some of the Bent Pyramid's unusual features may have been introduced in response to these construction problems.

By working through the building sequence and considering the challenges that presented themselves from the standpoint of the individual responsible for building the structure—who I will call the Construction Manager—I attempt in this article to gain a clearer understanding of this enigmatic structure.

The Substructure

Although the wide, open plateau at Dahshur appears eminently suited for the building of a large pyramid, there is evidence that ground conditions may have been less than ideal. The strata at Dahshur are considerably younger than the limestones exposed at other pyramid sites, and the geological map of the Greater Cairo area describes the ground conditions as "sands and sandstones and gravels". If as this description suggests, the bedrock at Dahshur contains lenses of sand and gravel, these ground conditions may have contributed to the difficulties experienced during the construction of the Bent Pyramid.

In addition to potential issues resulting from adverse ground conditions, the project at Dahshur also faced a series of technical challenges associated with the intended layout of the internal passages and chambers. The preceding pyramid at Meidum featured an innovation: for the first time, the pyramid entrance was placed on the pyramid face. Rather than tunnelled through the surrounding bedrock, a passage descends through the Meidum Pyramid's superstructure to a depth of around 7 m below ground level. This approach was also adopted for the Bent Pyramid, however the plans for Dahshur were far more ambitious, with the lower end of the Northern Passage extending more than 22 m below ground level (see Fig 1.).

It also seems reasonable to assume that for the internal chambers of the Bent Pyramid, the intention had been to follow the pattern attempted at Meidum and seen at the subsequent Red Pyramid at Dahshur. Here the descending passage leads to a pair of near-identical antechambers separated by a short section of horizontal passage. The antechambers and horizontal passage thus shared a common floor level—convenient for bulky funerary equipment.

It is likely that construction of the Bent Pyramid started with the excavation of a deep rock-cut trench similar to the example we see at Abu Rawash (Fig. 2). Initially, the

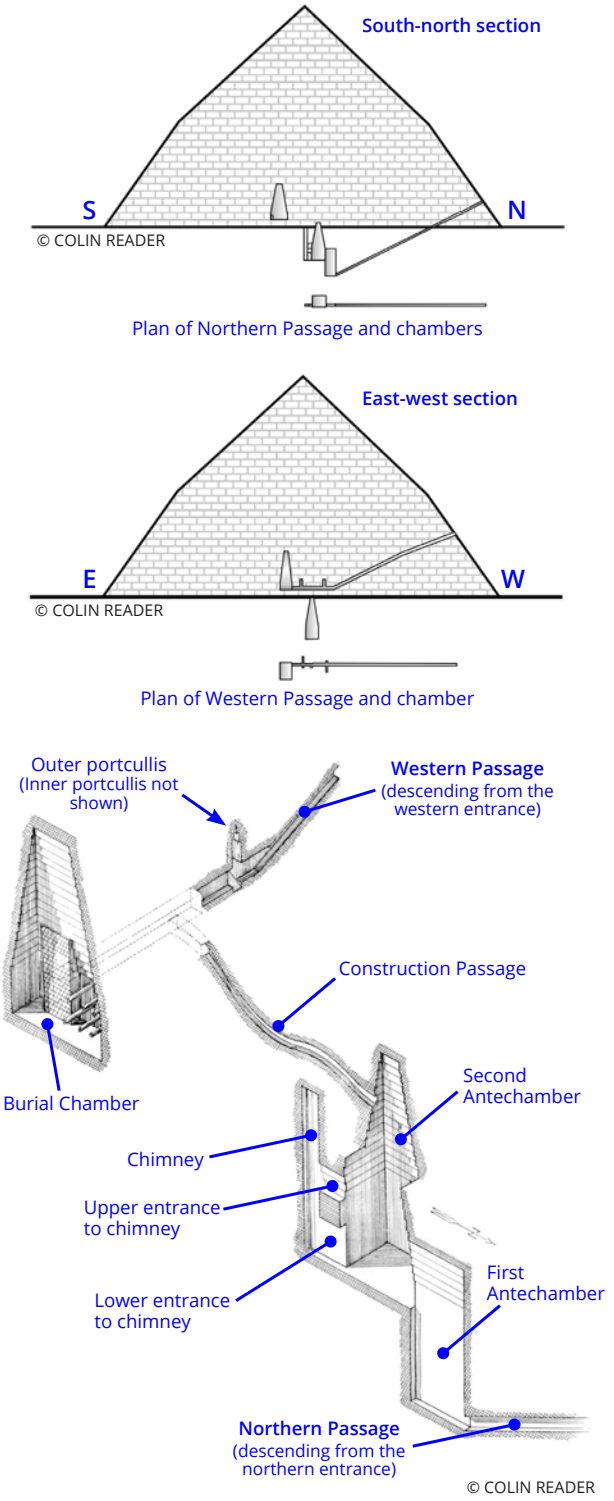


Figure 1. *The internal layout of the Bent Pyramid at Dahshur (isometric view, after A. Fakhry).*

excavation would have been a narrow sloping trench into which the carefully-worked floor, walls and ceiling of the entrance passage were to be built. At the lower end of the sloping section of trench, the intention would have been to widen the excavation to accommodate the underground chambers, but it is here that we see the first evidence to suggest a change to the design of the Bent Pyramid.

As illustrated in Figure 3 (page 32), at the lower end of the Bent Pyramid's Northern Passage, a very short length of low horizontal passageway (A) opens up into the

Figure 2. *The pyramid at Abu Rawash was built for the 4th Dynasty's King Djedefre around 2560 B.C.—some 40 years after Sneferu's Bent Pyramid at Dahshur.*

After centuries of quarrying, the rock cut trench that formed the pyramid's substructure is now exposed. In the background is the sloping Northern Passage. The foreground shows the widened section for the underground chambers. Also visible are the lower sections of core masonry for the pyramid superstructure that were placed around the open trench (arrowed).

unusually tall and narrow First Antechamber (B), which is no wider than the Northern Passage itself. Beyond the First Antechamber, rather than the horizontal passage we see at Meidum and the Red Pyramid, all we find is a short section of rough excavation (*c*) which appears to project towards a vertical shaft (*d*), the base of which has not been located. Both the vertical shaft (*d*) and particularly the short, rough excavation (c) look very much like exploratory works. Were these excavations abandoned because they encountered difficult ground conditions, perhaps a lens of sand and gravel such as that implied by the geological map? If so, this may explain why the layout of the underground chambers in the Bent Pyramid differs from what we see at Meidum and the Red Pyramid.

When the inside of the Bent Pyramid was first documented in the 1830s, it was found that oddly, ancient masonry steps had been added retrospectively to accommodate the different floor levels between the First and Second Antechambers (Fig. 3, B and E). I believe that the need for these steps was a consequence of the first major change to the design of the Bent Pyramid that was introduced by the Construction Manager.

In the original plan, it is likely that the low horizontal passage (A) had been longer and had perhaps extended as far as c, where the abandoned excavation suggests adverse ground conditions had been encountered. If additional exploratory work at d had confirmed that the difficult ground conditions were not localised, one of the few options available to the Construction Manager was to raise the floor of the Second Antechamber (E) to avoid the difficult ground. The masonry steps were therefore introduced to accommodate the unplanned 6.75 m high difference in floor levels between the two antechambers.

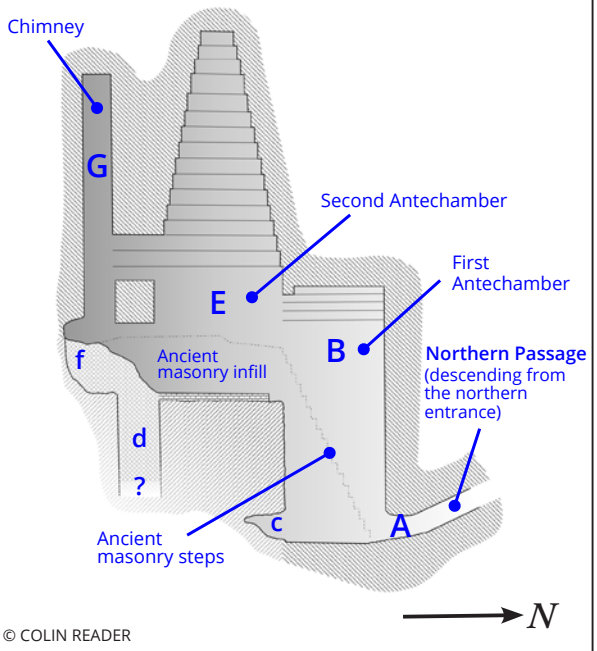


Figure 3. *Details of the underground chambers of Sneferu's Bent Pyramid (after Maraglioglio & Rinaldi).*

In order to construct the steps however, it was necessary to raise the ceiling of the horizontal passage between A and c to provide the necessary headroom, hence the unusually high and narrow First Antechamber (B). Although not what had been intended, the mismatching antechambers that resulted from these enforced design changes satisfied at least one of the requirements of the 'standard' pyramid

layout that we see at Meidum and the Red Pyramid—a pair of antechambers that preceded the Burial Chamber. Although it is not clear whether the Burial Chamber was also intended to form part of the Bent Pyramid substructure, another length of abandoned excavation (Fig 3., f) suggests that perhaps these plans were changed in favour of a Burial Chamber in the pyramid's superstructure which was to be reached via a vertical shaft known as the chimney (G).

The Burial Chamber: Lessons from Meidum?

I have always felt that the chimney that connects the inner antechamber at Meidum to the space referred to as the Burial Chamber, was odd (see Fig. 4, right). Even if we assume that the Meidum sarcophagus was placed in the Burial Chamber before the ceiling was complete, the mummy and coffin still had to be introduced (with difficulty) via the narrow vertical chimney.

In a paper published a few years ago, I argued that the corbelled ceiling of the inner chamber at Meidum indicates that this was intended to be a relieving chamber and that the original intention had been to excavate a Burial Chamber in the underlying bedrock. Although probably never built, the original plan would have placed the Burial Chamber at the same floor level as the passage and antechambers, making the chimney unnecessary and the introduction of the funerary equipment far easier.

We may never fully understand the reasons that led the ancient builders to change the internal arrangement at Meidum, however given that this was the first pyramid with internal passages and chambers that lay partly below ground

The Pyramid of Meidum viewed from the southwest.

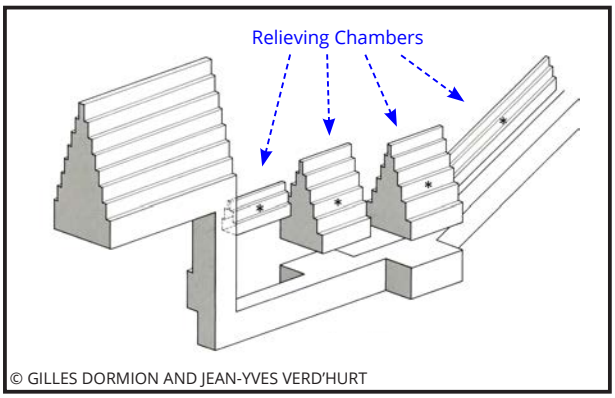


Figure 4. *The internal layout of the Meidum Pyramid. The relieving chambers (marked with an asterisk) were discovered by amateur archaeologists Gilles Dormion and Jean-Yves Verd'hurt between 1998 and 2000.*

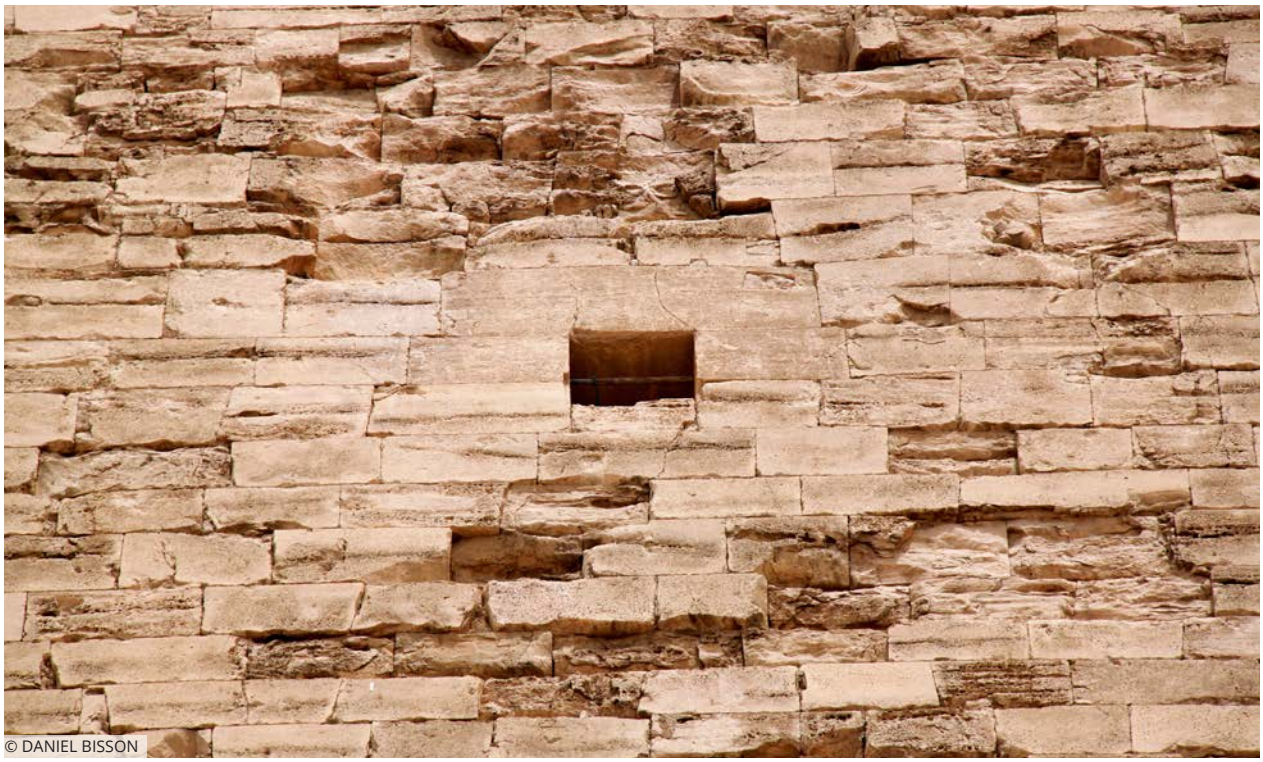


Figure 5. *The western entrance to the Bent Pyramid. When the interior was first explored in 1839, this western entrance was deliberately blocked. At some 30 m above the desert surface, it would have been very difficult to access.*

Figure 6. *The ancient cedar timbers in the Burial Chamber of the Bent Pyramid. It is likely that these timbers were introduced as braces during the construction of the Burial Chamber, and never removed.*

and partly in the superstructure, it is entirely possible that the chimney was introduced in response to unforeseen technical issues that developed during construction.

The introduction of a chimney in the Bent Pyramid suggests that the Construction Manager may have faced similar technical challenges to those encountered at Meidum. Given that the floor of the Burial Chamber is located close to original ground level, lower than the outer sections of the Northern Passage (Fig. 1), it is clear that the decision to place the Burial Chamber in the superstructure was taken at an early stage. This would have been before the masonry of the superstructure had reached any appreciable height and before the Northern Passage had been completed. Although it is not clear why the Burial Chamber was placed so far south and east of the centre of the pyramid, if ground conditions had become a significant issue by this stage, the Construction Manager may have decided that the chamber needed to be placed well away from the main excavation to protect against instability of the deep trench.

It wasn't necessary to wait until work had been completed in the deep trench before starting on the pyramid superstructure and Burial Chamber. Once the location of the Burial Chamber had been fixed and the extent of the trench was known, the first courses of core masonry for the superstructure could be placed in the area surrounding the trench, just as we see at Abu Rawash (Fig. 2).

Given the vast footprint of the Bent Pyramid, it would have taken some time to place these first few courses of masonry, and it appears that during this period another change was introduced into the pyramid's design: the chimney was abandoned close to ground level and a new western entrance and passage introduced to provide access to the Burial Chamber (Fig. 5).

We can also be sure that the decision to include the Western Passage was taken at a relatively early stage in the construction of the pyramid because, like the floor of the Burial Chamber, the horizontal section of the Western Passage also lies close to ground level (Fig. 1).

The Burial Chamber of the Bent Pyramid was the first to include vertical walls of any significant height in the masonry superstructure of a pyramid, and it is likely that the masonry used to build these walls was carefully positioned before core masonry was placed around the outside of the chamber. It is my view that the large timbers in the lower section of the Burial Chamber (Fig. 6) were placed at this stage to provide temporary bracing as the walls were raised and the surrounding core masonry was added. These timbers would have been removed once structural stability had been provided by the completion of the corbelled ceiling.

At this stage however, we appear to have another change of plan, and the Burial Chamber was partly infilled with masonry. Initially, this masonry infilled only the lower vertical-walled section of the chamber, burying the timbers, perhaps in an effort to provide additional stability. The lowest courses of the corbelled ceiling were then re-cut to provide vertical walls above the newly raised floor, however this work was not completed before the decision was taken to raise the floor level yet again. Once this final floor level was reached, further attempts were made to re-cut the corbelled ceiling. The amount of re-cutting required was so great, however, that it ran the risk of adversely affecting the structural stability of the entire chamber, and it seems that work in the Burial Chamber halted at this point.

The Core Masonry and the Northern Passage

Prior to Dahshur, all Egyptian pyramids were built as stepped structures. Originally, the Meidum pyramid had been completed as a step pyramid by Huni (probably Sneferu's father), and when Sneferu attempted to convert it to a true pyramid, part of the northern face collapsed.

Although none of the later pyramids were intended to be completed with a stepped profile, it is evident from the remains of structures such as the 5th-Dynasty Pyramid of Neferirkare (Fig. 7), that in some cases, a stepped core formed a major element of the superstructure, and it is possible that the Bent Pyramid was built in this way.

Figure 7. *The stepped core of the 5th-Dynasty pyramid of Neferirkare at Abusir, ca. 2470 B.C. The pyramid was later transformed into a true pyramid shape, and it may be that the Bent Pyramid was constructed in a similar way.*

By the time the Northern Passage, antechambers and chimney of the Bent Pyramid were complete, the lowest courses of masonry for the superstructure would have been placed in the area surrounding the open trench, and work to the above-ground Burial Chamber would have been well underway. With the substructure complete, the trench would have been infilled to ground level and core masonry placed over the infilled trench to complete the lowest tier of the pyramid core.

In order to maintain access to the substructure, the above-ground section of the Northern Passage would have been extended through this newly placed core masonry. It is difficult to determine when work would have begun to infill the steps and to place the outer casing, but it would also have been necessary to extend the Northern Passage further as this outer masonry was added.

This construction sequence suggests that the Northern Passage of the Bent Pyramid has three distinct elements: the underground section within the trench, the mid-section built within the core masonry, and the outer section built within the outer masonry and extending to the pyramid casing (Fig. 8).

Some 12 m from the northern entrance, at the point along the Northern Passage where the core and outer masonry meet, is the major dislocation (right). At this point, there is a 23 cm step in the ceiling of the passage, with the outer masonry lower than the core (Fig. 9). In addition to the drop in the ceiling, the blocks lining the walls in this section of the passage are cracked and broken and cavities either side of the passage suggest some shattered blocks may have been removed by early explorers.

The fallen ceiling block at the major dislocation was initially re-trimmed by about 3 cm, indicating that movement began during the building of the pyramid. I believe, however, that the entire 12-metre-long outer section of the Northern Passage from the major dislocation to the outer casing, had moved by the time the casing was added. Evidence for this comes from the casing around the northern entrance. Generally across the northern face of the Bent Pyramid, the blocks within each course of Tura-quality casing are of the same height, resulting in a series of horizontal courses of casing stones. The casing block over the entrance however, is conspicuous because in order to align the underside of this block with the ceiling of the Northern Passage, the casing is some 20 cm thicker than the adjacent blocks (Fig. 10).

The way in which not only the block over the entrance but also the adjacent casing blocks have been cut suggests that this section of casing was placed once movement had already occurred. Furthermore, the generally tight joints between these blocks suggest that although some movement has occurred since the casing was completed, this has been relatively minor.

Further evidence for movement in the Northern Passage occurs a short distance downslope of the major dislocation, where there is an 8 cm step in the ceiling. A lack of movement of the joints in the adjacent passage walls indicates that this smaller step is unlikely to be the result of settlement however, the joints between the ceiling blocks at this position have widened by approximately 2 cm, allowing glimpses of the masonry above. These widened joints suggest that there has been a significant element of extension along the main axis of the ceiling. Further confirmation of extension of the Northern Passage can be seen at about 21 m from the entrance,

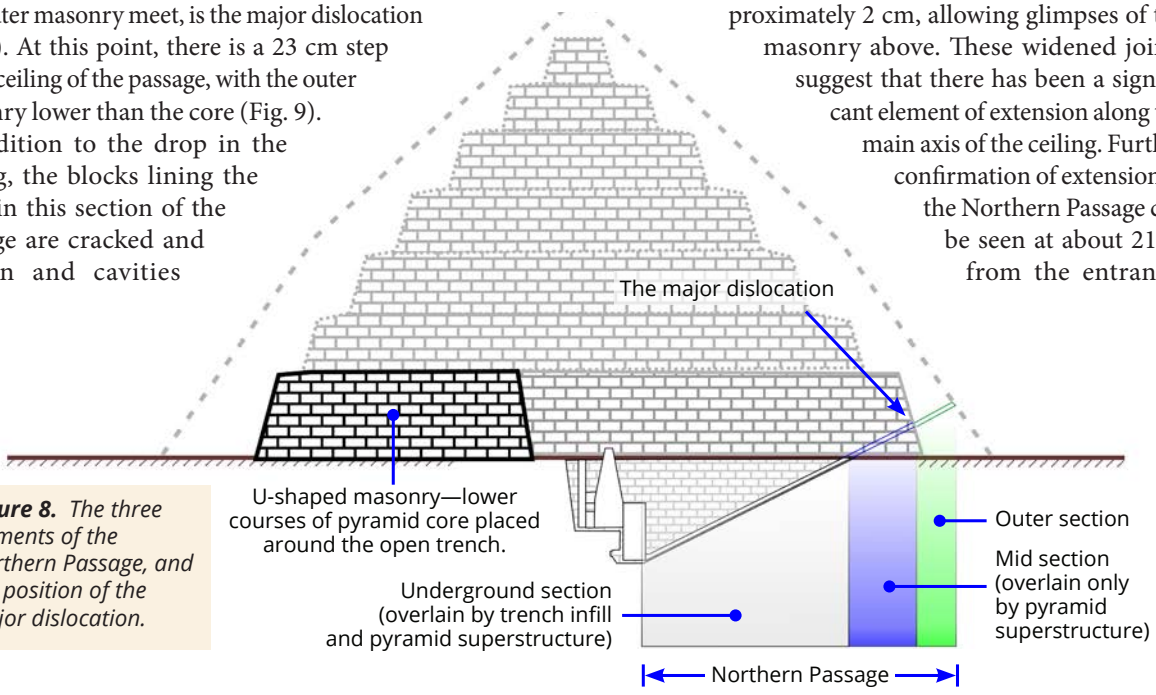


Figure 8. *The three elements of the Northern Passage, and the position of the major dislocation.*

Figure 9. *The major dislocation in the Northern Passage, showing the 23 cm step in the ceiling, and (to the right) the initial 3 cm cutting that was made in an attempt to correct movement in the ceiling by the ancient builders.*

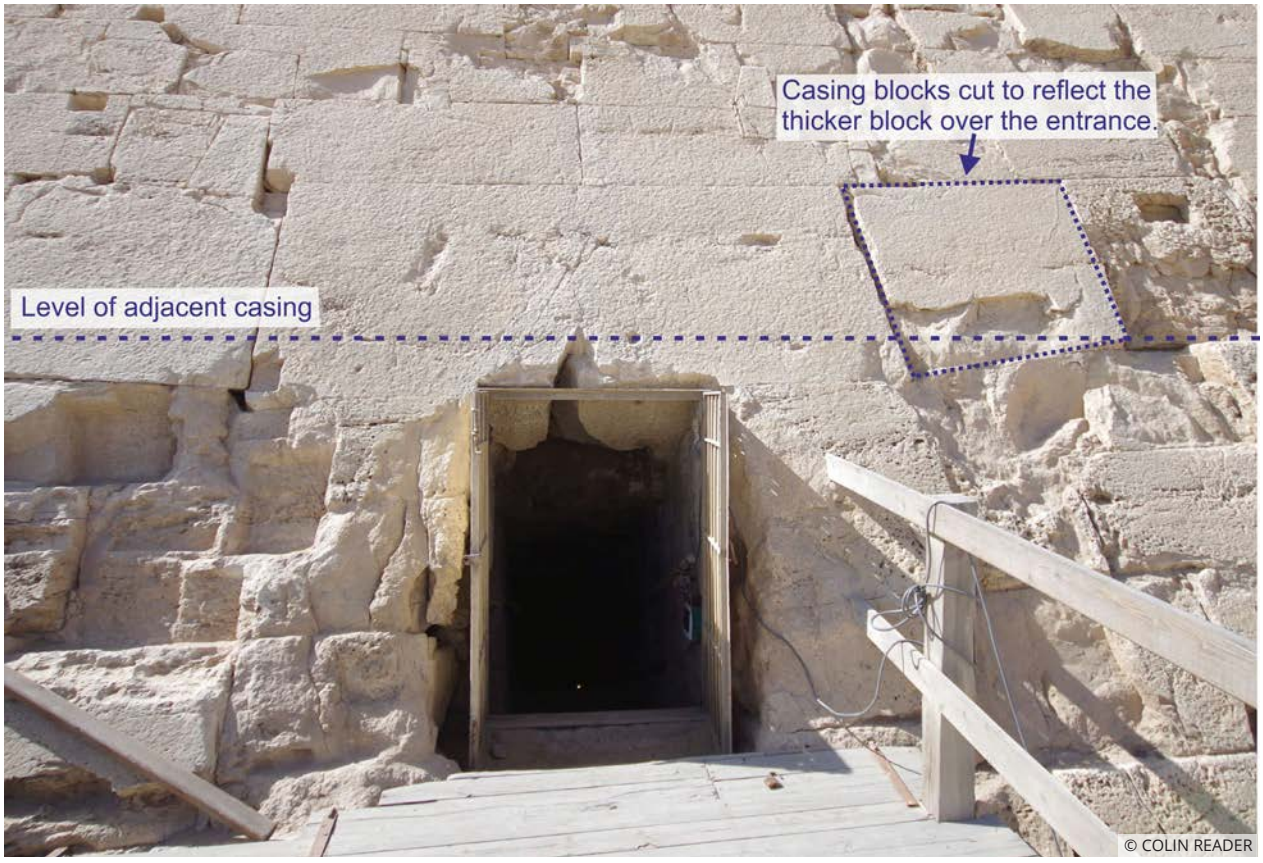


Figure 10. *The thicker casing block over the northern entrance (and the adjacent blocks), all appear to have been cut to accommodate the dropped outer ceiling of the northern entrance (see also Figure 9).*

Figure 11. *Now open to the sky, the Bent Pyramid's Western Passage shows significant movement of the blocks forming the ceiling and walls. The Sneferu's Bent Pyramid at Dahshur was the largest pyramid the Egyptians had yet attempted. At 105 m high, it was 45 m taller than the very first pyramid—Djoser's Step Pyramid at Saqqara— built only around 50 years earlier. The ancient architects were learning quickly, but mistakes were bound to be made.*

close to where the mid-section and underground section of the Northern Passage meet (Fig. 9). At this point, movement between three adjacent ceiling blocks has resulted in a pair of approximately 10 cm-high-steps. Joints in the passage walls have opened up to such an extent that rough fragments of limestone have been inserted as filler into the resulting gaps.

How can we explain the movement in the Northern Passage, particularly the evidence for extension along the main axis? To answer this, we need to consider the three elements of the Northern Passage that we discussed earlier. As shown in Figure 8, the underground section of the Northern Passage would have been subject to loading from the overlying trench infill, as well as considerable loading from the core masonry as the superstructure of the pyramid grew. The loads imposed on this underground section were larger than those acting on the mid- and outer section of the passage, where the height of the overlying pyramid superstructure was much reduced.

Combine the much greater loading with the greater potential for settlement within the backfill to the deep trench, and it is evident that the apparent extension along the main axis of the Northern Passage is likely to be the result of greater settlement in the underground section, compared to the mid- and outer-sections of the passage.

The movement at the major dislocation may have been due in part to the relatively poor foundations provided for the outer casing, however, I suspect that the cause of the major dislocation was not so straightforward, involving a complex interplay of forces and stresses associated with relative movement between the three sections of the Northern Passage and the surrounding elements of the pyramid core and outer masonry.

It is clear that by attempting to construct a northern entrance passage that runs through three discrete sections of masonry and reaches significant depths below ground, the Construction Manager was faced with a number of major technical challenges. With hindsight, it is clear that differential movement between each of the sections of the Northern Passage was inevitable. However, given that the ancient Egyptians had not previously attempted such a technically challenging construction and therefore had no experience of the complications that were likely to arise, all the Construction Manager could do was to try to respond to each issue as it presented itself. Ad-hoc decisions and untested solutions are likely to have contributed to an evolving construction project that became increasingly at variance with what had originally been intended.

The Western Passage

When the interior of the Bent Pyramid was first documented in the 1830s, it was found that the sloping section of the Western Passage, beyond the lowered outer portcullis (Fig. 1), had been filled with masonry. As discussed earlier, if the intention had been to abandon the chimney in favour of the western entrance, why had the Western Passage been completely filled with masonry, leaving no direct access to the Burial Chamber?

From my inspection in early 2018, I was able to

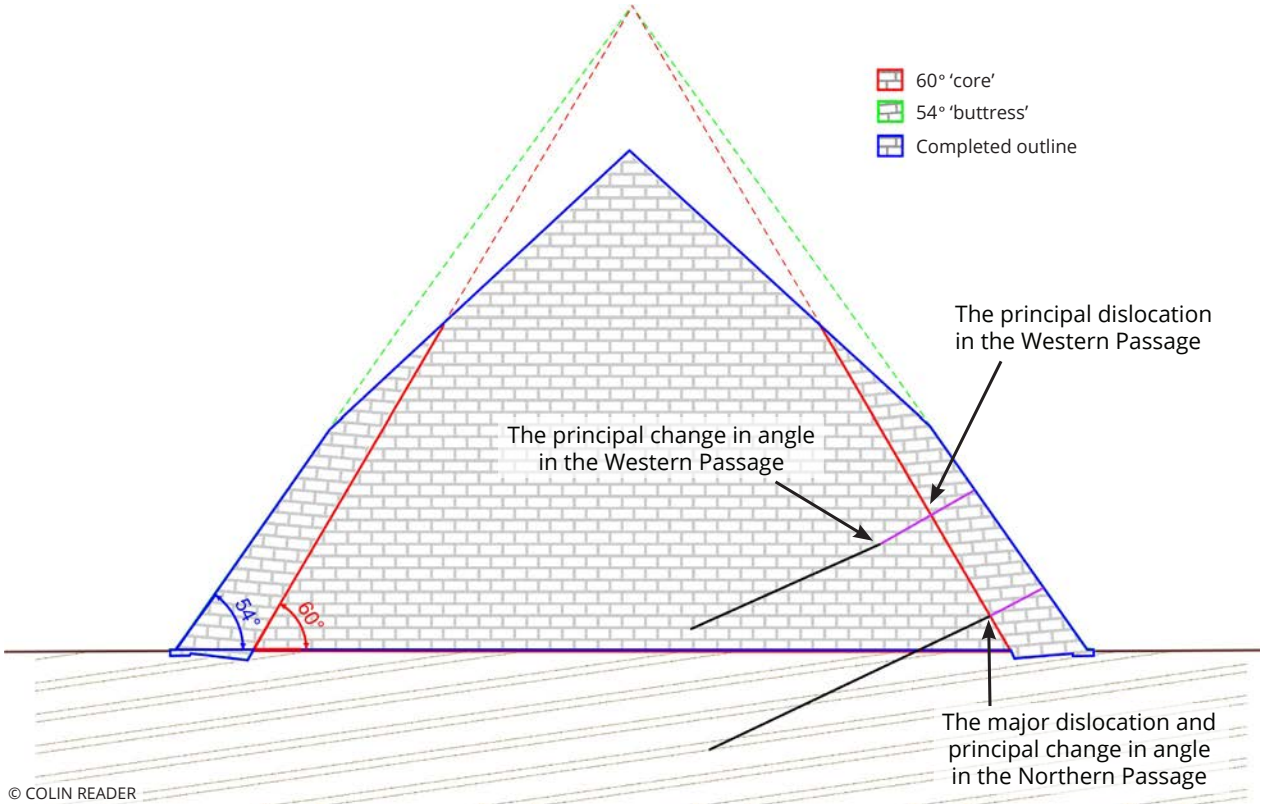


Figure 12. *The "60° Pyramid" theory suggests that the Bent Pyramid began as a small, steeper structure. Shown here are the different forms of the Bent Pyramid that have been proposed by various researchers.*

identify abundant evidence for movement along the full length of the Western Passage, with numerous areas in which the walls are badly damaged and the ceiling blocks have dropped (refer to Fig. 11). In addition to its generally poor condition, the Western Passage also has a dislocation some 11 m from the western entrance of the pyramid, which, like the major dislocation in the Northern Passage, suggests movement between the core and outer masonry.

Some researchers have noted that when the relative positions of the principal dislocations in both the Northern and Western Passages are overlaid, they lie along a line which measures approximately 60° to the horizontal, concluding that the original intention had been to build the Bent Pyramid with a steep outer slope of 60° (refer to Fig. 12, above). According to these theories, movement in this steep structure occurred during construction, leading to the addition of an outer reinforcing masonry buttress around the base of the pyramid, which was built at a reduced angle of 54°. These theories conclude that subsequent settlement of the reinforcing buttress relative to the 60° core led to the formation of the principal dislocations in the Northern and Western Passages.

As we have already seen, it is possible to explain much of the movement evident in the Northern Passage without recourse to the "60° pyramid" theory and there are a number of other issues which in my opinion, make this theory untenable. Firstly, unlike the principle of a stepped core, the construction of a 60° pyramid in the Old Kingdom is entirely without precedent.

Secondly, whereas in the Northern Passage it is the outer masonry that has dropped (23 cm) relative to the core of the pyramid, movement is reversed in the Western Passage, where the outer masonry sits 5 cm higher than the core. It is difficult to reconcile the predictions of the "60° pyramid" theory with the evidence for movement in different directions at these two locations.

Thirdly, both the Northern and Western Passages exhibit distinct changes in angle. Although the change of angle in the Northern Passage occurs at the major dislocation and is therefore not at odds with the "60° pyramid" theory, the principal change in angle in the Western Passage occurs some 22 m from the western entrance—far beyond the principal dislocation (Fig. 12). I also suspect that if a modern survey was undertaken, several other distinct changes in angle would be identified along the Western Passage.

Although the evidence for the movement of the outer section of the Northern Passage does appear to be consistent with the "60° pyramid" theory, it is my view that the theory cannot account for the significant movement that can be seen elsewhere in the Northern and Western Passages. Particularly troubling for the "60° pyramid" theory are the changes in angle of the Western Passage, which generally bear no relation to the position of the interface between the 60° core and the outer reinforcing buttress that the theory proposes. The evidence from both the Northern and Western Passages suggests therefore, that widespread movement occurred during construction of the Bent Pyramid. I believe that it was in an attempt to counter this movement that the Construction Manager abandoned the Western Passage and filled it with masonry.

Settlement

All buildings settle. In modern construction, engineers will

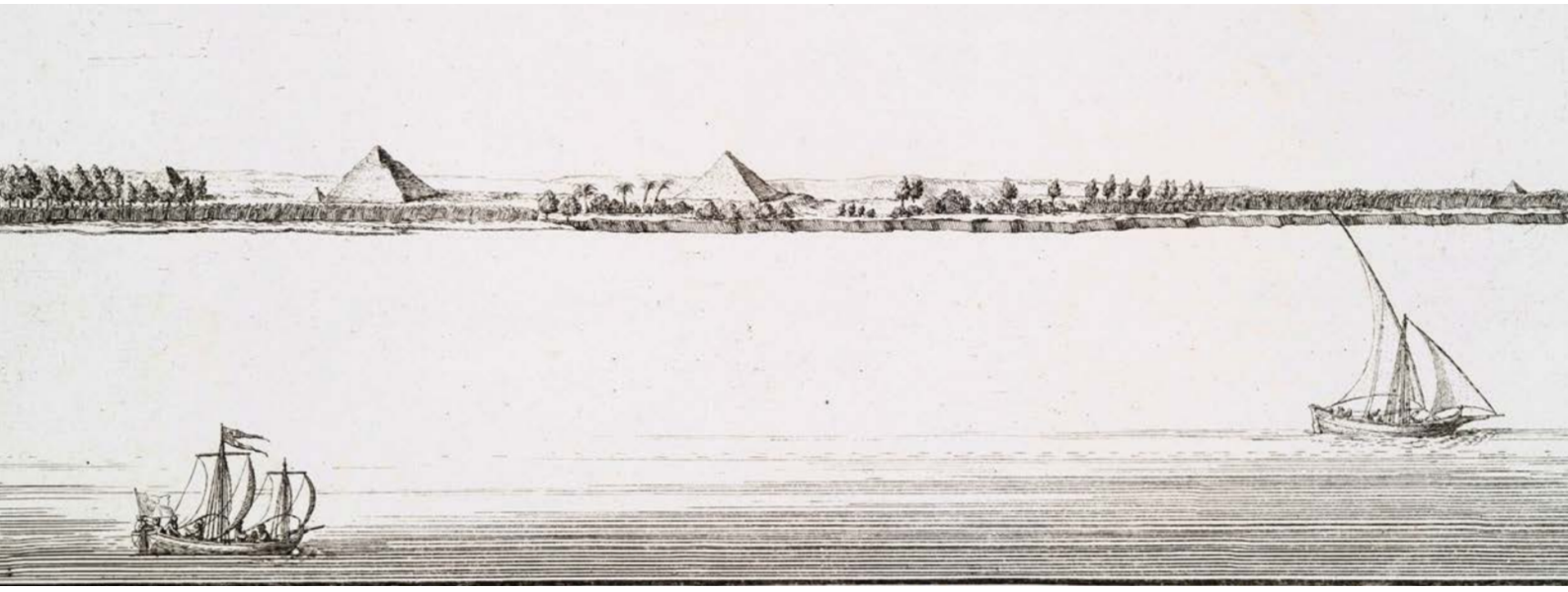
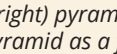
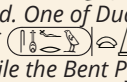


Figure 13. *In 1737, Danish naval architect Frederic Norden sailed up the Nile on a voyage of exploration on behalf of King Christian VI. As he passed Dahshur, he sketched this scene of the Bent (left) and Red (right) pyramids.*

Rather than reject the Bent Pyramid as a failure, it was completed with smooth casing stones, a subsidiary pyramid, an enclosure wall, a valley temple, and pyramid temples for both the Bent Pyramid and subsidiary pyramid.

It appears that later Egyptians considered Sneferu's two Dahshur pyramids as parts of a massive kingly estate. Around 100 years after Sneferu's death, a 5th-Dynasty priest named Duare  *was buried east of the Bent Pyramid. One of Duare's responsibilities in life was as "Overseer of*  *"—the Two Pyramids of Sneferu. While the Bent Pyramid had problems during construction, it certainly wasn't being snubbed.*

only be concerned if settlements are predicted to be greater than 25 mm or significant differential settlement occurs. If the Bent Pyramid had been built throughout with carefully squared and coursed blocks of masonry, it's likely that the inevitable settlement in the underlying geologically young Pliocene bedrock will have been accommodated by a relatively even distribution of settlement-induced stresses as the closely spaced blocks of the superstructure came into contact with one another.

The abundant evidence for movement observable within the Northern and Western Passages, however, suggest that the core of the Bent Pyramid was built with a high proportion of roughly shaped and poorly-coursed stones. Irregular core masonry such as this will behave far less predictably as the foundations settle, with the relatively wide and unevenly-spaced joints between the blocks allowing greater localised movement. Small points of contact between such roughly-shaped blocks lead to much greater localised stresses and the potential for failures of individual blocks.

It is my conclusion that the evidence for widespread movement that can be seen in the passages of the Bent Pyramid, reflects the adjustment of a mass of relatively rough core masonry in response to the settlement of the underlying Pliocene bedrock.

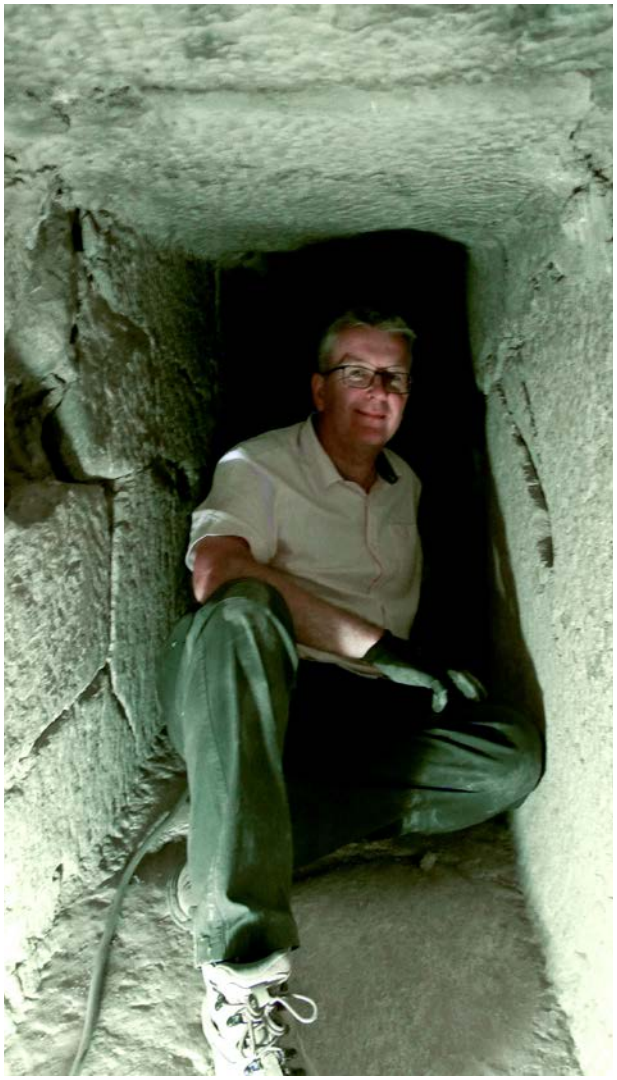
In the case of the Northern Passage, settlement within the bedrock was complicated by the fact that the passage was built within three very different elements of the pyramid—the substructure, the stepped core masonry and the outer masonry (Fig. 8). Add to this the difficulties associated with the construction of a deep substructure in a rock-cut trench and it's perhaps not surprising that the Bent Pyramid was prone to damage brought about by settlement.

Given the many challenges faced by the Construction Manager and the design changes that were made to address these challenges, I believe the unprecedented step was taken to abandon the Bent Pyramid and begin work on a second pyramid at Dahshur—the structure we know as the Red Pyramid. Having learned a number of hard lessons during the construction of the Bent Pyramid, it is probably no coincidence that the entrance passage and all three internal chambers of the Red Pyramid were placed in the superstructure and that for Sneferu's second pyramid at Dahshur, excavation below ground was avoided completely.

In closing, what should we make of the fact that the 44° angle which was adopted from the outset for the Red Pyramid, matches the angle of the upper section of the Bent Pyramid? The change of angle occurred a little under half way up the Bent Pyramid, when all the internal elements of the pyramid had been completed. By the time the change in angle was implemented, it is likely that most of the drivers that led to foundation settlement and to movement within the masonry of the Bent Pyramid were already in play and that changing the angle made little difference to the outcome. Nevertheless, it is likely that the ancient builders would have drawn confidence from their observation that once the angle had been changed, few new significant issues arose. It is fully understandable that the builders of the Red Pyramid took heed of this apparent success, and together with the many other lessons learned during the building of the Bent Pyramid, adopted the reduced angle of 44° from the outset.

Before the decision was taken to abandon the Bent Pyramid however, the Construction Manager was still making design changes in a valiant attempt to complete a functioning pyramid. One of the final changes taken in

Figure 14. *The Bent Pyramid, as viewed from the Red Pyramid at Dahshur. Built for King Sneferu, around 2600 B.C., the king had his workers finish it off with a gentler slope. Seemingly having learned a lesson, Sneferu commissioned another massive pyramid nearby—the Red Pyramid: the world's first colossal true, smooth-sided pyramid.*



response to the decision to infill the Western Passage with masonry, was to provide a new route into the Burial Chamber. I believe that the tiny Construction Passage between the Second Antechamber and the horizontal section of the Western Passage (Fig. 15, left) represents the first phase of this new access. Having used this small passage to identify a route through the core of the pyramid, the intention would have been to widen this Construction Passage into a more formal internal space. The heartbreaking decision to abandon the Bent Pyramid however, was taken before this work could be completed.

The Bent Pyramid is still closely guarding its secrets and until a modern survey can be undertaken, is likely to continue to do so for many years to come.

Further Reading:

Howard Vyse: *Operations Carried on at the Pyramids of Gizeh in 1837*, Volume 3: Appendix.
Colin Reader: *The Meidum Pyramid*, Journal of the American Research Center in Egypt, Vol. 51.
Maraglioglio and Rinaldi: *L'architettura delle Piramidi Menfite*, Part 3.
Keith Hamilton: *The Bent Pyramid, the curious case of the 60 degree pyramid.* Https://www.academia.edu/33288308/The_Bent_Pyramid_the_curious_case_of_the_60_degree_pyramid.

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Figure 15. *The author, Colin Reader, in the Construction Passage of the Bent Pyramid, showing the "cosy" size of this unfinished feature.*