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DIMENSIONS AND SLOPE IN THE NINETEENTH AND TWENTIETH DYNASTY ROYAL TOMBS

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After the work carried out by the Theban Mapping Project in the Valley of the Kings, it is finally possible to compare the ancient texts and drawings that refer to the quarrying of the Theban royal tombs with accurate and reliable surveys of these monuments. Two issues in particular are discussed here: the degree of correspondence between written records and actual tombs, and the way in which the slope of the descending corridors was established and measured. The available evidence suggests that the dimensions of the initial plan may have been significantly modified during the work, and that the ancient architects might have measured the length of the sloping passages in a way that does not correspond to our modern graphic conventions.

THE Theban area has provided a large amount of material related to work in the Nineteenth and Twentieth Dynasty royal tombs, including architectural plans and sketches, written records of supplies, daily activities and stages in the completion of the projects. In some cases, texts and drawings contain a description of completed or planned architectural elements of a tomb, together with their dimensions, expressed in cubits, palms and fingers. Lists of these documents (ostraca and papyri) have been published by Černý, who was the first to suggest an identification of the descriptions with existing tombs,[1] and Demarée, who added a number of other documents, and classified the material into three groups: plans, lists of measurements and journals.[2]

Černý founded his identifications on the basis of palaeography and comparison with the plans that were available at that time, but the lack, until recently, of accurate surveys of the Theban tombs hampered further developments of the research on this subject. The situation has now significantly improved thanks to the excellent work done by the Theban Mapping Project,[3] that finally makes it easier to compare the information provided by the ancient texts and drawings with the tombs as they were actually completed.

In June 1999 I had the opportunity to study the surveys carried out by the Theban Mapping Project before their publication and to compare them with the descriptions contained in some of the texts from Deir el-Medina and the Valley of the Kings.[4] The comparison between ancient documents and modern surveys provides a wealth of information on the relationship between project and practice, such as the degree of correspondence between planned and final dimensions, the importance attributed by the ancient architects to the dimensions themselves, the way sloping surfaces were measured and so on. Some of the results of this study are summarised below, with particular concentration on the way the slope of descending corridors was established and measured.[5]

[1] J. Černý, *The Valley of the Kings* (Cairo, 1973), 23–34.

[2] R. J. Demarée, ' "Royal Riddles" ', in R. J. Demarée and A. Egberts (eds), *Village Voices* (Leiden, 1992), 9–18.

[3] Theban Mapping Project, *Atlas of the Valley of the Kings* (Cairo, 2000).

[4] The research was generously funded by the Thomas Mulvey Fund and the Lady Wallis Budge Fund.

[5] This research would not have been possible without the help of Professor Kent R. Weeks, Dr Edwin C. Brock, Walton

The dimensions of corridors and chambers

One of the most important points is the correspondence between the dimensions given by the ancient documents and those in the actual tombs. Among the ancient texts, some record the work already carried out by the workmen,[6] while others refer to the initial plan laid out by the architects.[7] Whenever it is possible to check, the ancient surveys appear to be relatively precise, but the initial plan might have been significantly different from the final result. Our knowledge of the characteristics of the latter relies upon two sources, P. Turin 1923 and related fragments and O. Cairo 25184. The first contains the calculations carried out by the scribe to establish how many cubic cubits of rock should have been removed in one year in order to complete in three years the project of enlargement of KV 9, started for Ramses V and then taken over by Ramses VI.[8] This ambitious plan would have produced the largest tomb in the Valley of the Kings, but the tomb was never completed. The second is the plan of a tomb identified as the original plan of KV 6, quarried for Ramses IX.[9] That this was an initial plan, and not the survey of the completed tomb, may be inferred from the fact that the actual dimensions are significantly different from those given by the accompanying text. As in P. Turin 1923, the dimensions of the rooms and passages correspond to simple, round figures, such as 30 cubits for the length of corridors, 10 × 10 cubits for the 'hall of hindering', 20 × 20 cubits for the burial chamber, and so on.

The records of the work kept by the scribes from time to time during the quarrying of royal tombs, however, show that the initial dimensions were meant only as a rough guide. The final dimensions of rooms and corridors were either decided on the spot,[10] or might be influenced by various events, such as the sudden death of the king[11] or the collision with another tomb.[12] At the very end of the work a final survey took place in order to record every important detail, as may be inferred from the existence of P. Turin 1885 (recto), the detailed plan of KV 2, the tomb of Ramses IV, which is one of the most spectacular ancient Egyptian architectural drawings.[13]

Whenever scribes or architects recorded the work completed to a certain date—that is, took note of the results of a survey—the dimensions are expressed in cubits, palms and fingers (respectively about 52.5 cm, 7.5 cm and 1.8 cm).[14] In this way they were potentially able to express differences of a few centimetres. However, comparison with the most recent surveys shows that it is not easy to check the accuracy of these measurements, primarily because many rooms are significantly irregular. In these cases, only one length, one breadth

Chan, the entire staff of the Theban Mapping Project, Dr Salima Ikram and Nadine Möller. I wish to express my gratitude to Barry J. Kemp for his constant support and advice.

6 Group B (Lists of measurements) and group C (Journals) in Demarée's list.

7 Group A (Plans) in Demarée's list.

8 R. Ventura, 'The Largest Project for a Royal Tomb in the Valley of the Kings', *JEA* 74 (1988), 145.

9 G. Daressy, *Ostraca* (CG; Cairo, 1901), 35 and pl. 32, and 'Un plan égyptien d'une tombe royale', *Revue Archéologique* 32 (1898), 235–40.

10 As seems to be the case of O. Cairo 51936, discussed by R. Engelbach, 'An Architect's Project from Thebes', *ASAE* 27 (1927), 72–6. See also N. Reeves, 'Two Architectural Drawings from the Valley of the Kings', *CdE* 61 (1986), 43–9.

11 As might be the case, for instance, of KV 1, the tomb of Ramses VII.

12 As it was in the case of KV 11, abandoned by Sethnakhte after the collision with KV 10 (the tomb of Amenmesse). Later Ramses III took over and completed the tomb along a shifted axis, adopting a rising corridor as a solution to avoid the underlying chamber of KV 10.

13 H. Carter and A. H. Gardiner, 'The Tomb of Ramses IV and the Turin Plan of a Royal Tomb', *JEA* 4 (1917), 130–58.

14 For a parallel see N. de Garis Davies, 'An Architect's Plan from Thebes', *JEA* 4 (1917), 194-9.

and one height were taken and recorded, even if, for instance, in some corridors the height of the ceiling is not constant, and in other cases the side walls are not parallel.

Moreover, it is sometimes difficult to understand at which points exactly the measurements were taken, as in the case of pillared chambers with slides. These are rectangular, almost square rooms with two pillars on both sides of a steep slide starting from the upper entrance and leading down to a lower door. The texts, however, give a height which does not correspond either to the height of the chamber at the upper entrance (more or less corresponding to the height of the pillars on both sides of the slide) or to the height of the chamber as it corresponds to the lower door, when the depth of the slide is also taken into account. Another difficult case is represented by the external corridor, the 'god's passage which is upon the sun's path', where there seems to be no way to verify the length given by the texts. This length must have been measured from the entrance of the tomb to an outermost limit which was probably identified or established by marks which have long been obliterated by the passing of time or by the modern tourist paths.[15] Finally, it is unclear what was regarded as the upper limit of the corridor and therefore to what the height given by some texts should be compared.

In conclusion, it seems that these detailed surveys were meant to record not only that the work was progressing, but also that it was being carried out with accuracy. The round figures of cubits of the initial plan had been long forgotten, and there is no evidence to suggest that the irregularity of some chambers and corridors represented a problem for the architects or the scribes. This suggests that the initial dimensions were just a convenient starting point, and that the discrepancy between the original plan and the final result was an obvious consequence of the quarrying process.[16]

The slope of descending passages

In the Valley of the Kings, starting from the middle Nineteenth Dynasty the slope of the tombs diminished progressively, and almost disappeared in the late Twentieth Dynasty burials. Even though this must have been an extremely important element during the quarrying, the slope of the descending passages is never mentioned in the surviving texts. Moreover, our own assessment of the evidence may be influenced by the fact that modern plans of sloping tombs represent the projection of the sloping surface on a horizontal plane. The projection, therefore, happens to be shorter than the actual length of the sloping surface (figs. 1 and 3). But what do we really know of the way the ancient Egyptians measured and represented a sloping passage?

This is an ideal case to test the comparison between modern surveys and the group of ancient documents on the works. The surviving drawings do not help, since the two most complete original plans, that on papyrus of KV 2 (Ramses IV) and that on an ostracon identified as KV 6 (Ramses IX), correspond to rather 'flat' tombs. The steepest corridor among those of both tombs is the first in KV 2, which unfortunately is not included in the ancient plan and therefore cannot be compared with the modern survey. The verso of P. Turin 1885[17] contains the dimensions of some elements probably of KV 9 (Ramses V–VI),

[15] Could this landmark have been a foundation deposit? Cf. J. M. Weinstein, *Foundation Deposits in Ancient Egypt*, PhD Dissertation, University of Pennsylvania 1973, figs. 2, 3, 7 and 19.

[16] C. Rossi, 'The Plan of a Royal Tomb on O. Cairo 25184', *Göttinger Miszellen* 184 (2001), 45–53.

[17] Carter and Gardiner, *JEA* 4, 158, and K. R. Weeks, 'The Berkeley Map of the Theban Necropolis; Report of the Second Season, 1979', *Newsletter ARCE* 109 (Summer 1979), Appendix - Special Supplement, 14–15.

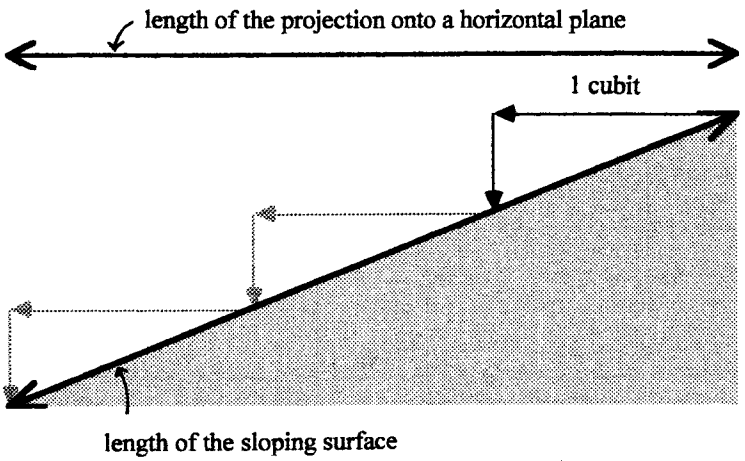

FIG. 1. Slope of a descending passage.

a long tomb consisting of four corridors, a well room, a pillared hall, two lower corridors, an antechamber and a burial chamber. In this case, too, the slightly sloping first and second corridors are not mentioned in the text and, therefore, cannot be compared with the survey. Among all the other documents, only O. Cairo 25537 (referring to KV 47, the tomb of Siptah) provides an interesting clue.

This ostracon was identified by Černý by means of the date and the name of the vizier, Hori.[18] The dimensions of the second corridor prove to be particularly important. As usual, the length of the first, external corridor as described by the ostracon is difficult to compare with the remains of the actual tomb. The height, however, given as 10 cubits in the text (about 5.25 m), may be measured as about 5.30 m at the entrance of the tomb, and the breadth given in the text and that of the actual external corridor correspond perfectly, 6 cubits for the ostracon (about 3.15 m) and about 3.14 m in the tomb. As for the second corridor, its final length appears to have been recorded as 30 cubits 3 palms, about 15.97 m (recto, line 4). The internal àength of the actual corridor (measured from the section) is about 15.83 m from doorjamb to doorjamb. This seems to suggest that the length was measured along the sloping surface of the oblique passage, since its projection on a horizontal plane would be much shorter, about 15.17 m only. This would also correspond to the general character of other ancient Egyptian architectural plans representing various types of buildings, which not only do not respect the exact proportions of the rooms, but do not show the use of any graphic device such as foreshortening or 'flattening' due to a projection either.[19] From these premises it would be extremely difficult to support the idea that, on their drawings and ostraca, the Egyptians wrote values resulting from graphic projections. It is more likely that, when the architect wrote that a corridor was 30 cubits long, this length was meant as measured along the sloping surface of the corridor.

[18] J. Černý, *Ostraca hiératiques* (CG; Cairo, 1930–5), 16, 33*, 34*, pls. 22 and 23.

[19] See, for example, the ambiguous sketch on O. BM 41228, discussed by S. R. K. Glanville, 'Working Plan for a Shrine', *JEA* 16 (1930), 237–9, and C. C. Van Siclen III, 'Ostracon BM41228: a Sketch Plan of a Shrine Reconsidered', *GM* 90 (1986), 71–7. See also the comparison between ancient drawings, written dimensions and modern surveys of the tombs of Ramses IV and Ramses IX in B. J. Kemp and P. Rose, 'Proportionality in Mind and Space in Ancient Egypt', *Cambridge Archaeological Journal* 1 (1991), figs. 10 and 11.

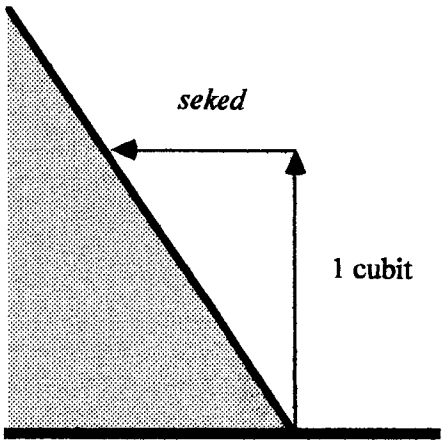

FIG. 2. Slope of a pyramid.

In theory, the system adopted by the ancient Egyptian architects to measure the slope of a descending corridor implied the possibility for them to calculate its projection on a horizontal plane as a consequence. As we know from the surviving mathematical sources, the Egyptians measured the slope as the horizontal displacement for a vertical drop of 1 cubit, that is, the number of cubits, palms and fingers by which the sloping side had 'moved' from the vertical at the height of one cubit (fig. 2). This distance was called a *seked*. Maragioglio and Rinaldi noted that in some of the sloping corridors of the Old Kingdom pyramids of Khufu, Khafra, the queen of Userkaf, Sahura, Neferirkara and the satellite pyramid of Djedkara, the architects adopted a slope of about 26°30', corresponding to the ratio 1:2 cubits, that is, a vertical drop of 1 cubit every 2 cubits measured along a horizontal line[20] (therefore corresponding to a *seked*-like ratio of $\frac{1}{2}$ cubit every 1 horizontal cubit). This is probably the same slope found in the descending corridors of the secondary pyramids GIc, GIIIa, GIIIb, Neferheteperes and Neith,[21] while the slope of corridors of other pyramids can be more or less easily expressed using similar *seked*-like ratios (for example, 3 palms every cubit for the 22° of Djedefra, the satellite of Neuserra and Khentkawes II,[22] 4 palms for the 30° of Meidum, the Bent Pyramid at Dahshur and GIIIc,[23] possibly 4 palms + 2 fingers for the 33° of GIa, GIb and Khendjer).[24]

Corridors of subterranean tombs were quarried into bedrock, and not built in the fashion of many corridors in pyramids, but the method of measuring the slope may have been the same. The slopes of the Amarna Royal Tomb corridors (fig. 3), for instance, can be easily interpreted by means of the clues provided by Old Kingdom pyramids. The first corridor has a slope of about 35°, very close to a *seked*-like ratio of 5 palms, the slope of the second corridor is about 15°30', corresponding to 2 palms and the third corridor has a slope of about 49°, equal to 8 palms (that is, 1 cubit + 1 palm). In the tombs of the Valley of the Kings, according to the survey of the Theban Mapping Project which I examined, the slope of descending corridors varies considerably, but the values that seem to recur more often

[20] V. Maragioglio and C. Rinaldi, *L'architettura delle piramidi memfite* (Turin–Rapallo, 1963–77) IV, 26; V, 52; VII, 24 and 50; VIII, 84.

[21] P. Jánosi, *Die Pyramidenanlagen der Königinnen* (Vienna, 1996), 184.

[22] Maragioglio and Rinaldi, *Piramidi* V, 14; VIII, 12; Jánosi, *Pyramidenanlagen*, 184.

[23] Maragioglio and Rinaldi, *Piramidi* III, 18 and 66; Jánosi, *Pyramidenanlagen*, 184.

[24] Jánosi, *Pyramidenanlagen*, 184.

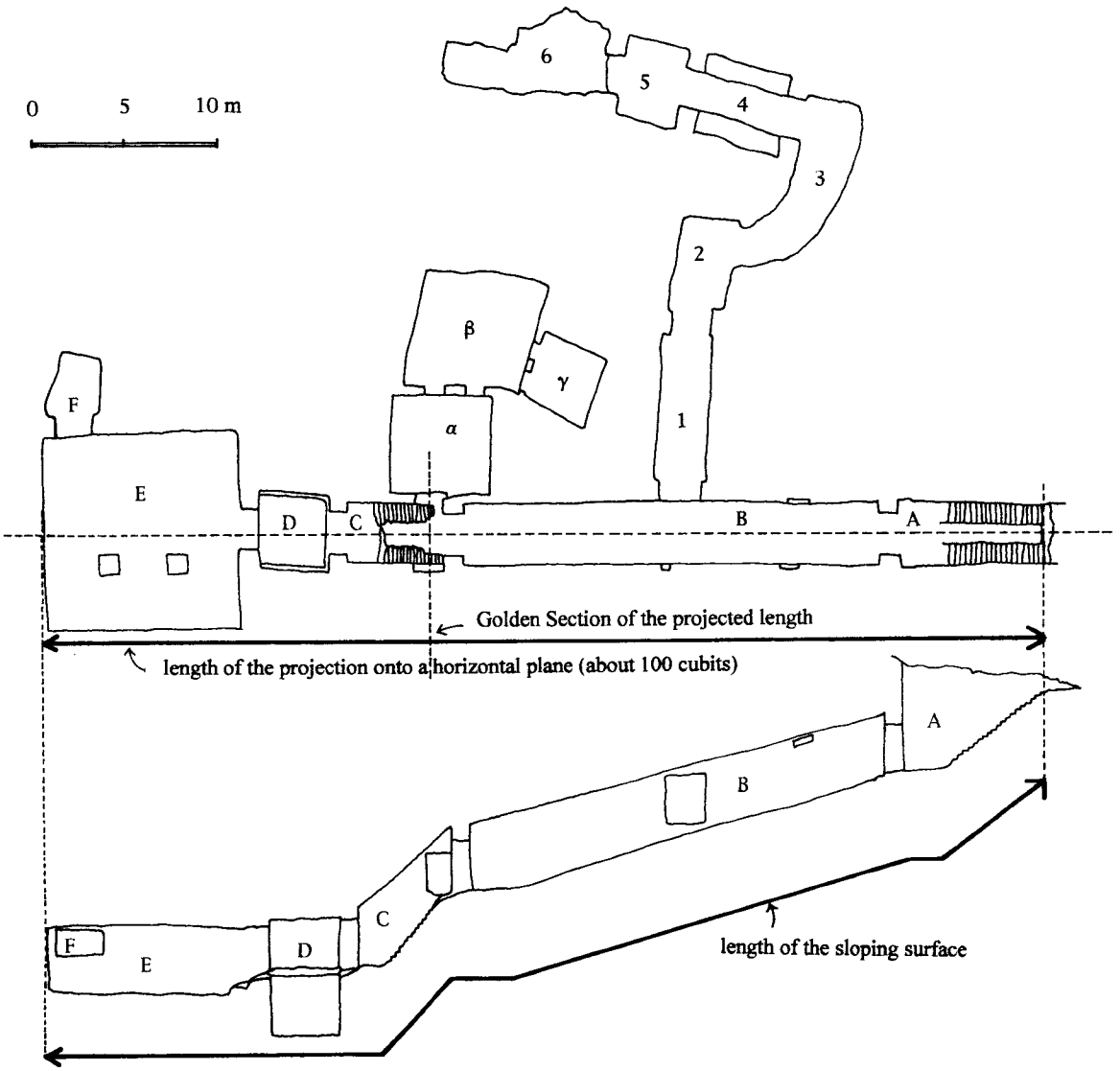

FIG. 3. Plan and section of the Amarna Royal Tomb, showing Lehner's suggestion that the plan was designed after the Golden Section, and the difference between sloping saurfaces and horizontal projection (re-drawn after Lehner, in Martin, *The Royal Tomb at el-ʿAmarna* II, pls. 1 and 12).

are about 8° (corresponding to a *seked*-like ratio of 1 palm) and about 16° (corresponding to 2 palms).

Of course, once a ratio between horizontal advancement and vertical drop (that means a right-angled triangle) has been chosen to fix the slope of a corridor, the final length, slope and depth of the corridor itself will reflect the proportions of that triangle (fig. 1). This means that, at least from a theoretical point of view, the use of a *seked*-like system implies that it would have been possible for the ancient architect to calculate the projection of the final length of the corridor simply by adding the horizontal 'treads' of the step-by-step process. However, from a practical point of view it was not necessary to check the slope

continuously: once it had been established, it could be just checked at more or less wide intervals, provided that it was considered necessary.

The absence of any mention of the slope in any of the drawings and the written sources might even be explained with the suggestion that this was one of the aspects that was not taken into account during the preliminary planning and was decided directly during the quarrying. If this is true, whenever new tombs were quarried in the vicinity of older burials in the increasingly crowded necropolis, certainly the lack of any record of the slope of the already sealed tombs did not help, and in fact, in a few cases collisions between tombs did take place. It is even possible that the risk of running into older tombs, of which only the position of the entrance was recorded, may be one of the reasons for the progressive reduction of the slope of the later tombs.

Evidence that the ancient architects were interested in the projection of the sloping surface on a horizontal plane is virtually non-existent. It is worth mentioning one case, however, where the ambiguous use of the word *mḏwt*, 'depth', might be interpreted as pointing in this direction. In P. Turin 1885 (recto) this word is employed in the description of two recesses in the walls of two corridors and refers to 'the distance to which these recesses are sunk beneath, or behind, the vertical side-walls of the chambers to which they belong'.[25] Therefore, here 'depth' appears to be a 'horizontal' dimension. In two ostraca from the tomb of Senmut, however, the word *mḏwt* is used to designate a 'horizontal' depth in one instance (as in P. Turin 1885), and a 'vertical' depth in another text.[26]

P. Cairo 86637[27] is another case where the word *mḏwt* seems to have been used to describe a 'vertical' dimension, possibly the height, since in the first corridor it follows the length (missing) and the breadth, while in the second and third it follows the length and, presumably, the missing breadth in the middle. According to Černý, the palaeography points to the reign of Ramses II as the period when this text was written.[28] The surviving dimensions (the text is damaged in the middle), however, have little in common with KV 7, the tomb of Ramses II, nor do they correspond to the tombs of his immediate predecessor (KV 17, the tomb of Seti I) or of his successor (KV 8, the tomb of Merenptah).[29] This is a pity, because it is impossible to check an interesting detail. Among the dimensions listed on this papyrus, the height of the external corridor, as usual, is difficult to check, but, if we assume that *mḏwt* refers to the height, the third and fourth corridors appear to be too high (respectively 9 cubits 4 palms and 8 cubits, about 5 m and about 4.18 m) not only in comparison with KV 7 (Ramses II), but with any other tomb. Therefore, it might be suggested that here the word *mḏwt*, in a more general meaning of a 'vertical' measure, referred to the total vertical drop of the corridor. Unfortunately, however, the dimensions of KV 7 (Ramses II) do not support this interpretation, and the problem of the precise identification of the *mḏwt* in this text must remain for the moment unsolved.[30]

25 Carter and Gardiner, *JEA* 4, 138.

26 W. C. Hayes, *Ostraka and Name Stones from the Tomb of Sen-mut (No. 71) at Thebes* (MMA Egyptian Expedition 15; New York, 1942), 21–2, nn. 88 and 115, ostraca nos. 62 and 75.

27 A. M. Bakir, *The Cairo Calendar No 86637* (Cairo, 1966), 56 and pl. 50.

28 Černý, *Valley of the Kings*, 25.

29 It may be worth mentioning that the description of the tomb given by P. Cairo 86637 excludes the possibility that the text referred to KV 5, the tomb of the sons of Ramses II.

30 If, despite the appearance, the 'depth' here referred to a 'horizontal' dimension such as in P. Turin 1885 (verso), in theory *mḏwt* might be interpreted as the projection on a horizontal plane of the total length of the corridor. Not even this interpretation, however, is supported by the actual dimensions of KV 7.

Therefore, it seems reasonable to suggest that the slope of corridors in New Kingdom royal tombs, just as any other sloping surface, was measured by means of a *seked*-like system. At the same time, there is no evidence to assume that the Egyptians gave any consideration to the projection on a horizontal plane of a sloping passage. The length was probably measured along the sloping surface, although it does not seem that the same starting points were always used. To measure the length of a corridor, the obvious distance would be from doorway to doorway, but in some cases the surveys which I have examined show that it might have been measured up to the edge of a step, thus including the thickness of a doorway, or it might have taken into account the presence of a double frame, and so on. Two cases of different methods are visible in the tombs described by O. Strassb. H.112 and O. BM 8505. In O. Strassb. H.112,[31] which describes QV 44, the tomb of Khaemweset, a son of Ramses III, the length of the treasuries and of the burial chamber includes the thickness of their entrances, and the length of the corridors includes the thickness of the upper doorway. In O. BM 8505,[32] which refers to QV 51, the tomb of Queen Isis, built under Ramses VI, the length of the second corridor is probably taken from step to step, thus excluding the upper doorway and including the thickness of the lower doorway.

If the suggestion is accepted that for the ancient architects the length of a corridor was the sloping surface and not the horizontal projection, then we must pay attention to the way we interpret modern plans. Mark Lehner, for instance, suggested that the Amarna Royal Tomb was intended to be 100 cubits long and that the entrance to the rooms α, β and γ lies at the point corresponding to the subdivision of the length according to the proportion generally called the 'Golden Section' (fig. 3).[33] This is true in plan, that is, on the projection on a horizontal plane, but not in section. If the Egyptians measured the length of sloping corridors along the sloping surface, the length of the tomb would be much more than 100 cubits, and the correspondence to the Golden Section of the entrance to the secondary funerary apartment in the Amarna Royal Tomb would disappear. In order to have a length in plan of 100 cubits, the ancient architects would have had to design the tomb both in plan and in section, but, as we have seen, no evidence of such a process, either drawn or written, seems to have survived.

In conclusion, this short article contains only a few observations on a vast corpus of material that deserves more attention. When revised or new translations of all these texts will be available, the study of the architecture of these tombs is likely to produce more interesting results.

[31] K. A. Kitchen, *Ramesside Inscriptions*, VII (Oxford, 1989), 288–9. See also Y. Koenig, *Les ostraca hiératiques inédits de la Bibliothèque nationale et universitaire de Strasbourg*, (DFIFAO 33; Cairo, 1997), pls. 44–7, and C. A. Keller, 'The Draughtsmen of Deir el-Medina: a Preliminary Report', *Newsletter ARCE* 115 (1981), 14. This ostracon is not included in Černý's and Demarée's lists.

[32] C. Rossi, 'The Identification of the Tomb Described on O. BM 8505', forthcoming in *Göttinger Miszellen* 187 (2002).

[33] M. Lehner, 'The Tomb Survey', in G. T. Martin, *The Royal Tomb at el-ʿAmarna*, II (ASE 35; London 1989), 5–9.