CHAPTER V

BUILDING MATERIALS AND CONSTRUCTION

It was my original intention to have the building materials and the construction of the Mycerinus temples described by Dr. C. S. Fisher, who made plans of the temples (except III-*c*) and took notes in view of writing this chapter. Unfortunately Dr. Fisher's work with the Eckley B. Coxe, Jr., Egyptian Expedition made it impossible for him to carry out the original intention, and I find myself compelled to give briefly the essential facts. A certain poverty in the use of architectural expressions will be evident as the material is necessarily described from the archaeological standpoint.

1. BUILDING MATERIALS

Stone was the building material used in the temples begun during the reign of Mycerinus — nummulitic limestone, red granite, and black granite. The building material in the temples erected by Shepseskaf was white limestone or crude brick with stone and wood accessories. The later additions, such as the screen wall and the blockings of the doorways, were also of crude brick, but the extensive restoration of the inner part of the pyramid temple in Dynasty VI, was of nummulitic limestone.

(*A*) Limestone

The basis of the Mycerinus temples and of the Third Pyramid was the local coarse nummulitic limestone. The core of the pyramid, the foundation platforms of the temples, and the massive core walls were all of this stone. It is in general the same as the strata in the quarry southeast of the Third Pyramid, which is of nearly sufficient size to have supplied the whole. Slight variations of color and texture make it possible, however, that some stones were taken from another quarry. But no stone occurs which may not be duplicated in the strata of the pyramid plateau.

The limestone used in the inner part of the pyramid temple (Dynasty VI) is also nummulitic limestone of the pyramid plateau, but that is certainly not from the Mycerinus quarry. Some of the stones have a softer texture and are yellowish in color.

Fine white limestone from Turah was used in the upper courses of the pyramid casing, above the granite, and in the kernel-structure of the inner temple, but elsewhere only as an accessory:—

(1) In the valley temple, the threshold slabs of the Shepseskaf temple of crude brick, the rectangular basin in the court, and the bases of the columns in the portico.
(2) In the pyramid temple, three threshold stones, of which one was in doorway (12) and the other two in the magazine corridor, a kerb socket in doorway (21), two door-lintels in the northern magazines, some of the packing stones used between the granite casing and the core walls and the unexplained niche-like stone at the western end of the entrance corridor.
(3) In the temple of III-*a*, the column bases, the threshold slabs, the kerb sockets for doors, and the offering tables.
(4) In the temple of III-*b*, the offering basin in room (3).
(5) In the temple of III-*c*, the column bases, the threshold slabs in the entrance doorway, the great circular basin in room (4), and the rectangular basin in room (6).

The limestone had been cut in quarries, the nummulitic usually in enormous blocks. By traces left on the terraces of the Mycerinus quarry and in the quarry of the Second Pyramid, the method of cutting is fully shown to have been that universally used for limestone in ancient Egypt. This was the method of isolating a block by trenches in the rock and breaking it loose by splitting along the cleavage line of the strata.

The trenches in the Chephren quarry average about 60 cm. in width and descend to 30–40 cm. below the cleavage surface along which the blocks had been split off. Before the removal of the blocks, the trenches must have exceeded a meter in depth, and their width is just about sufficient to have permitted a stone cutter to work standing in the trench. Unfinished trenches in the Mycerinus quarry show that the trench was excavated by cutting a very narrow trench or trough with a copper chisel along each side of the wide trench and smashing the ridge between with a heavy stone hammer. The method of

separating the blocks from the bed can only be surmised. It is usually taken for granted that wedges were used in one way or another. The long rectangular excisions in the large limestone blocks in the pyramid temple suggest that wooden beams were employed. The excisions extend the length of one edge only of the blocks, are 16 cm. × 16 cm. in section, and always occur at a thin stratum which is stained red.[1] This excision was manifestly made in the quarry, and I am inclined to think that when the block had been isolated by trenches, a groove 16 cm. × 16 cm. was cut near the bottom of the trench along one side of the block; a wooden beam of about the size of the groove was wedged fast in it; the trench filled with water (the ends could be easily dammed with mud); and the beam swelling in the water lifted the stone from its bed.

It is to be noted that by this method of quarrying, blocks of limestone of any desired dimensions and of approximately uniform size might be obtained. The trenches in the Chephren quarry prove that blocks about 270 cm. square were cut over a considerable area. On the other hand, the removal of stone from the Mycerinus quarry by terracing produced stones varying greatly in length, but of about the same width and height. In the second and third courses of the pyramid temple where the stones appear most uniform, the length ranges from 330 cm. to 630 cm. Of the larger stones, four measure 610±20 cm.; seven, 510±20 cm.; six, 470±20 cm.; and five, 400±20 cm. Four stones of the core walls were of remarkable size. The largest was in the great pier between the northwestern quarter of the court and magazines (15) to (20). This gigantic stone measured 8.5 × 5.3 × 3 meters which, after deducting two excisions made after the stone was in place, gives about 130 cubic meters (about 220 tons). Two other blocks in the southern pier between the court and room (10) measured 7.9 × 3.75 × 2.58 meters and 7.5 × 4 × 2.46 meters respectively, making 76 cubic meters and 73.8 cubic meters or about 125 tons each. The fourth stone was in the angle of the wall north of the doorway between the entrance corridor and the court and measured 8 × 4.20 × 1.8 meters, making about 60 cubic meters or 100 tons. These enormous stones were quarried by the trench method and without doubt in the adjacent quarry. One of the two stones in the southern pier shows the bottom of one of the trenches cut for the superimposed layer of stone, and the other has cracked across the middle after being set in place.

(*B*) Red Granite and Black Granite

The limestone core walls of the pyramid temple were already partly cased with granite when Mycerinus died, and no doubt it is admissible that Mycerinus had designed to case his pyramid, the pyramid III-*a*, the walls of the pyramid temple, the valley temple, and the temple of pyramid III-*a* in granite after the manner of the walls of the two temples of Chephren.

It was only on the pyramids, however, and in the pyramid temple that any part of the granite casing had been built. We found the unfinished black granite casing of the northern corridor, (13), still in place on both walls. On the northern wall four adjoining blocks and one isolated block, while on the southern wall, six stones of the first and three of the second course stood as set by the masons. Aside from this room, only one other block was found in place — in the southern end of the portico. In room (24) behind the broken southern casing wall of crude brick, another black granite block was uncovered, but it was found to be displaced and broken. And all along the core walls in the court and the entrance corridor, dressed emplacements in the floor and in the core walls proved that the casing had been begun in at least six places in these two apartments, that many blocks of the first course had been set in place by the builders, but were afterwards removed by those who plundered the temple for its stone. In both these apartments, many fragments of black granite were found in the débris of the breaks in the crude-brick casing, showing that the casing had been of black granite like the blocks still in place.

In the débris of the portico, we found four more or less complete casing blocks and a door lintel of red granite, and it was evident that the casing indicated by the cuts in the walls of the portico and the outer offering-room (8) had been of red granite. On the analogy of the Chephren valley temple, the pillars and antae should be reconstructed of the same material (Fig. 10). The marks on the walls show that the casing of these two rooms had been completed.

[1] See section 2a, (2), below.

The red granite of both temple and pyramid has the characteristic appearance of Assuan granite and was brought down in ships as described in the autobiographies of the Old Kingdom. The black granite has the same consistency as the red and was of course also from Assuan. It occurs not only in the temple casing but also here and there among the red granite casing blocks of the pyramid. Many of the blocks of granite in or from the pyramid casing were carefully examined when we removed the mass of them from above the pyramid temple, and aside from one hole bored with a cylinder borer, no trace was found of the use of metal tools, except on those blocks which had been split or partially split by Arab workmen of the 12th–13th century A.D. The stones split by the Arabs bore lines of wedge-shaped

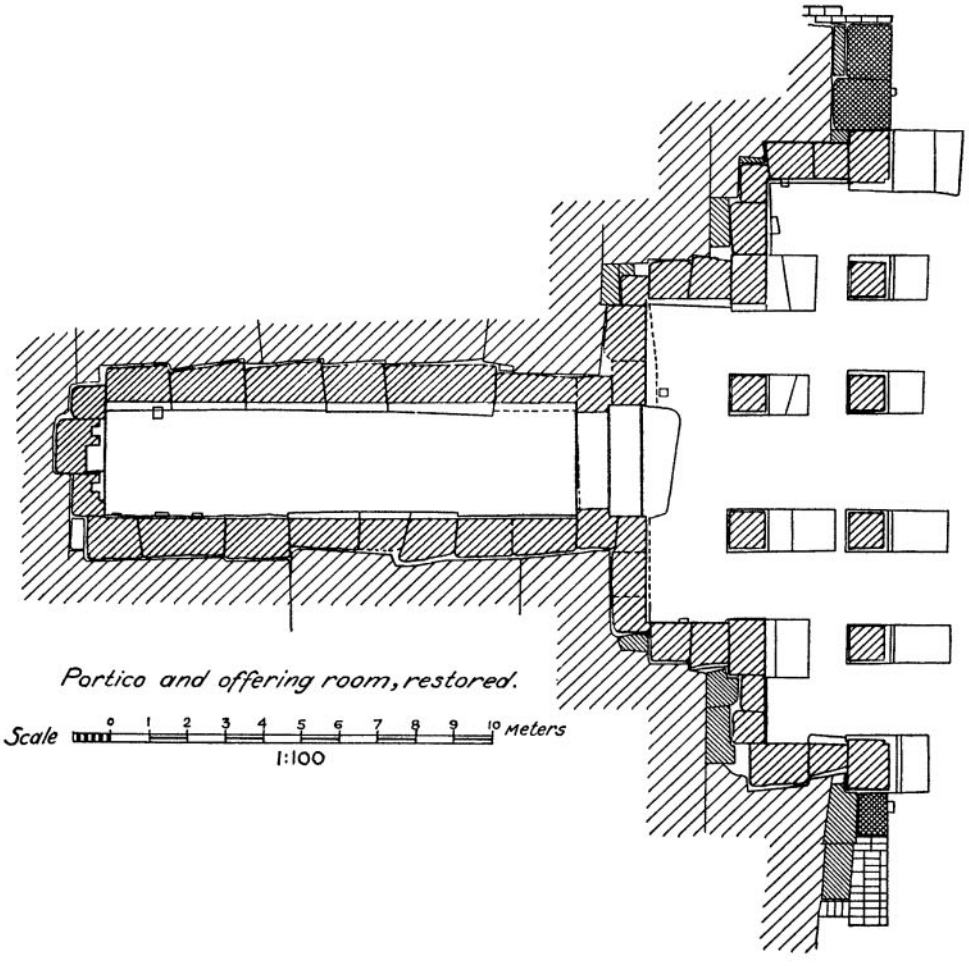

FIGURE 10

cuts, evidently made with the iron or steel chisels found among the stones, and presented the characteristic surfaces of split granite. The surfaces of the stones untouched by the Arabs, that is the great majority, showed only the marks of hammering and rubbing with stone implements. Moreover the undressed surfaces of some of these intact stones bore the characteristic weathering of the natural granite boulders as seen to-day in the granite deposits of the First Cataract. It seems to me probable that in Dynasty IV the greater part, if not all, of the granite blocks, were not quarried in the modern way, nor in the manner of the obelisks of the New Kingdom, but taken directly from the piled masses of boulders at Assuan in which the blocks lay already separated by internal splitting and weathering. To work these blocks loose one by one was no difficult matter, and the proximity of the water greatly facilitated transportation. The quality of those boulders was sometimes no doubt inferior to the living rock cut for obelisks of the New Kingdom, but was usually perfectly sound, as I personally observed during the breaking of many of the them for the great dam at Assuan. Granite weathers, hard as it is, and a number of the casing blocks in the Third Pyramid show a slight deterioration of the surface, but I have not noted one which had become unsound while in place. In the débris before the pyramid, however, we found four or five unsound blocks which crumbled at a blow or two of a heavy hammer, but these had lain for centuries in salty débris exposed to rain and heat.

The largest single block of granite was red, set in the fourth course of the pyramid casing opposite room (29). It measured 5.17 meters long by 0.98 meters high. The width could not be measured, but the stones which could be measured varied from 1.50 m. to 2.65 m. in average width, the longer the stone the greater its width. I estimated the width of the large block at a minimum of 1.9 m. but it may have been over 2.5 m. This estimate gives from 9.6 to 12.7 cubic meters or 26 to 34 tons. The pillars in the portico appear to have been slightly smaller, about 5 to 6 cubic meters or 11 to 16 tons.

(*C*) Crude Brick

Crude brick was the material used by Shepseskaf in finishing the pyramid temples of Mycerinus, and all five of the completed temples were of that material. Crude brick was also used in the screen walls, and in the other alterations in these crude-brick temples as well as in the restoration of the valley temple in Dynasty VI, but not in the restoration of the inner part of the pyramid temple. The manufacture of crude brick is known in detail from the observation of the methods of modern Egyptian brickmakers and is confirmed by the ancient models of brickmaking, and by bricks and brick moulds found in excavations.

(1) *Preparation of the Dough for Bricks*

Ancient bricks are for the most part of black Nile mud, but some of them have a lighter color and the mud in them was palpably mixed with other materials. Straw occurs in some bricks, but is by no means universal or even prevalent. Modern bricks show similar differences in color, and usually contain straw. At the present day, the variations in color are due almost entirely to the natural color of the deposit from which the mud is taken. In some places the old deposits of Nile mud are shot with sand, and at others, especially near the edge of the desert, with strata of fine rain-washed detritus from the desert above. The only material which is now deliberately added to the mud is dust and broken straw, by preference the sweepings of the threshing-floor; but even street-sweepings, which usually contain a certain amount of wind blown straw, are used by poor people. The ancient mixtures may have been less accidental in character, as they have a greater range towards yellow than the modern mixtures.

At present the mud is mixed in a nearly circular hole in the ground, if possible that from which the mud is being cut. The mortar, mixed carefully and kneaded by use of the short hoe and by treading with the feet, is prepared in the morning and lies all day and over night in the hole. The next morning, it is rapidly removed on circular mats, with two handles, which are sprinkled with dust to prevent the mud sticking. It is laid out in long bars on dust sprinkled ground alongside the place where the bricks are to lie. Meanwhile another lot of mud is mixed in the hole in the ground to lie until the following day. The amount of mud mixed in one batch is sufficient for 2000 to 3000 bricks, and if more are required two or more mixing places are prepared, each to turn out one batch.

(2) *Making the Bricks*

The bricks of the Mycerinus temples were made in the well-known Egyptian brick mould which is used also at the present day. This is a wooden box open on both top and bottom and with one side extended and dressed to form a handle level with the top of the mould. The process of manufacture was anciently much the same as to-day; as the marks on the bricks, the examples of ancient moulds, and the models of brickyards fully prove.

The process probably varies a little from locality to locality and from craftsman to craftsman, but, as I have observed it among the brickmakers of Coptos, it is mainly as follows:

(*a*) The brickmakers working in pairs squat on each side of the long bar of mud dough placed on the ground as described above; one takes from his right and one from his left and both shuffle back a pace after each brick is made.

(*b*) A lump of dough is torn off the bar and roughly formed as a brick, using dust to keep the mud from sticking to the fingers;

(*c*) The wooden mould is set on the ground lengthwise or parallel to the bar of dough having been dipped in water to remove the mud of the preceding brick;

(*d*) Some brickmakers dip the brick in water to prevent it sticking in the mould, while others trust simply to wetting the mould; the rough brick is then slammed sharply into the form and pressed down; the surplus mud on top is removed by scraping with the hand or with a stick; it is at this point that the long finger marks seen on ancient bricks were made; the bottom of the brick takes a print of the ground under the mould;

(*e*) The mould is then lifted, dipped in water as the brickmaker shuffles backwards to the place of the next brick, and the process is repeated.

(*f*) When the end of the dough is reached, two long lines of bricks lie end to end on each side and are left to dry. The drying process takes several days at least, and the bricks are turned over in the process.

(*g*) A pair of brickmakers and a mud mixer will produce from 4000 to 6000 bricks a day, but the usual production is less owing to the conditions under which they work. They work only on order. That is, when a man wishes to build he engages the usual gang of three, provides the place and the materials, and as his facilities and means are often only equal to one mixing place the gang is limited to 2000 to 3000 bricks a day on that job. Often, however, they may have two or even three such jobs going at one time and reach their maximum.[1]

(3) *Sizes of Bricks in the Mycerinus Temples*

Owing to the crushing of the heavier walls and the general destruction and decay, it was in many places impossible to distinguish the individual bricks in the walls of the Mycerinus temples. A certain amount of variation in size was no doubt caused by moisture and pressure after the bricks were laid.

In almost all Egyptian brickwork, the size of the individual bricks made in the same mould varies slightly, due to carelessness in lifting the mould, to settling while wet, to accidents during the drying process and the subsequent transport, and in part to trimming by the mason. The bricks used in the walls of Shepseskaf varied from 34 to 41 cm. in length, 16 to 20 cm. in width, and 9 to 12 cm. in thickness. The most common size was about 40 × 20 × 12 cm. Bricks of different consistency and from different moulds were observed side by side in the same wall. The essential feature of the proportions of these, as of all Egyptian bricks, is that the length of the brick was approximately twice the width, at any rate when laid with plastered joints.

The larger size, about 40 × 20 × 12 cm., was also used in the screen wall built probably in Dynasty V, and was found moreover in the mastabas of the Giza cemetery. But in the cemetery a smaller size was more usual.

A warning must be given that the size of the bricks is a very unreliable indication of date. It can only be used at one locality and under special circumstances. Conclusions drawn at one site should not be transferred to another.

2. MASONRY AND CONSTRUCTION

The types of masonry and the methods of construction used at the Mycerinus temples varied according to the purpose of the structure and the material of which it was built: —

(*a*) Stone structures —
- (1) Foundation platform;
- (2) Core walls — pyramids, walls of pyramid temple and valley temple.
- (3) Casings and pillars — pyramids and pyramid temple.
- (4) Simple free walls — the inner part of the pyramid temple.

(*b*) Crude-brick structures —
- (1) Foundations walls — all temples of Shepseskaf.
- (2) Casing walls — substitute for stone casing at pyramid and valley temples.
- (3) Simple free walls with wood and limestone accessories.

(*A*) Stone Structures

Except for the inner part of the pyramid temple, all stone structures were erected by Mycerinus.

(1) *The Foundation Platform*

The foundation platform of the pyramid temple, the causeway, and as much of the platform of the valley temple as had been built, were parts of one continuous construction. It consisted of enormous

[1] We have found it impossible when building camp-huts to buy ready-made bricks except as a favor from some one who was planning to build, and have been obliged to employ brickmakers to make our own bricks like everyone else in Egypt.

blocks of limestone, apparently as they came from the quarry but bruised by transport and loosely set together without any binding material. The interstices were filled with masons' limestone chips, débris, or quarry débris. The surface of the bed rock had been dressed but not leveled to take this platform.

The platform varied in depth to equalize the irregularity of the bed rock, and produce an approximately level surface. As already stated, the bed rock under the southwestern quarter of the pyramid temple rose in a knoll, the top of which was about 90 cm. above the floor level of the court. Over the area of this knoll, the core walls were usually laid on the surface of the rock which had then been cut away between the walls to admit the paving slabs which formed the floors of the rooms; but the southern wall of room (8) had been founded in a trench cut in this rock stratum. The southern side of the knoll sloped gently away to the south. The eastern and northern sides, however, descended abruptly along a line which crossed the court from the south, about eight meters east of the screen wall, to a point about four meters north of the central pathway where it turned sharply westward to the northern side of the pillar socket (E 4). From there, the line was traced northwestwards under the northern pier of the portico and under room (24) to the northern end of room (28); but the cliff became much lower in this direction. The abrupt side of the knoll was deepest north of the central pathway where its top was 110 cm. and its bottom 362 cm. below the court floor, giving a height of 252 cm. for the cliff. At the northeastern corner of the court, outside, the platform consisted of two courses of great blocks and the bottom of the lower course was 435 cm. below the court floor. As the top of the upper course was 86 cm. below the floor, the depth of the foundation platform was 349 cm. Wherever the Arab treasure-hunters had penetrated the platform, we found two courses of stone; but we observed that close to the abrupt side of the knoll, in rooms (24, 13, 26, and 28), the platform was only one course deep. Where there were two courses, the joints were broken but the stones of both courses were laid with large cracks occasionally 50 cm. wide, which had been packed with limestone rubbish.

As nearly as could be determined the transport of these immense blocks from the adjacent Mycerinus quarry took place, as usual, by dragging the stones on sledges out through the low southern side of the quarry and up the natural slope, either east or west of the quarry, to the place where each was to be set. No trace was found of any causeway other than the great one. The foundations of the valley temple were growing from the end of the causeway outwards and it is probable that the stones used there had been dragged down the causeway, especially as an opening had been left in the superstructure of the west wall at the end of the causeway.

The marks on the lower edges of these stones show that they were manoeuvred into place by means of large wooden (?) levers.

(2) *The Limestone Core Walls*

The walls of the two Mycerinus temples were also built of massive limestone blocks, even larger than the average used in the foundations. As already stated above (p. 70), four of these stones were of monstrous size, 60 to 130 cubic meters, with calculated weights of 100 to 220 tons.

The surface of the platform was dressed level on the lines of the core wall, not continuously but for each stone separately. In the southwestern quarter, rooms (7), (8), and (10), the rock was sufficiently high to take the preliminary dressing. The south wall of room (8), north wall of room (10), was in a trench about 80 cm. deep cut in the rock, and about 70 cm. wider on the south than the wall. On the north side of the wall the rock had been further cut away to a depth of 28 cm. to take the granite floor of room (8). The core walls were then laid in these prepared places directly on the rock or on the massive foundation platform. As the blocks rested in the walls, the tops, the bottoms, and the ends were seen to be dressed flat, and the stones to be closely fitted with fairly fine joints, badly weathered in places. The joints had all been closed with a pink plaster made of sulphate of lime and sand, and the stones appeared to have been adjusted in place by "floating" on plaster as was certainly done in the case of granite blocks.

The stones which were much longer than they were wide or high were laid generally as stretchers in all three courses; but in the core walls of the entrance corridor the stones were shorter, between 3.5

and 4 meters long, and were laid as headers in the bottom course. The stones of the second course in all the walls were generally slightly longer than those of the first course, and those of the third course were more narrow than those of the first two courses. The four enormous blocks mentioned above were in the bottom course (first course). The joints were well broken from course to course and the corners were properly bonded.

The blocks of stone in the core walls, like those in the foundations, had been brought up on sledges from the adjacent quarry, still with the rough surfaces left by quarrying. Each stone had probably been turned over in loading on the sledge so that its strata ran vertically. Brought to its intended place in the wall, the exposed side which was to be the bottom and the end which was to fit the end of the stone already set were dressed flat. The block appears to have been then turned over on its long axis to fall into the place prepared and was adjusted with wooden levers, probably having been "floated" on plaster. The place for the next block was then prepared by dressing the exposed end of the stone just set and the floor or the top of the course below. The process of dressing the floor for the stones singly has produced a very uneven base, but as applied to the tops of the courses has resulted in fairly even but not level lines. There is a slight slope downwards from west to east in the great outside walls; and at various places there are small steps in the course lines, in particular in the northern core wall of the court. The great piers which form the western side of the portico (8) and those which bound the western side of the court north and south of the portico, were manifestly set before the rest of the core walls. These contain three of the four enormous stones so often mentioned and their course levels do not correspond with those of the other core walls. These irregularities may be illustrated by the following series of course levels:

	Court S. wall	South pier	Room 7 S	7–8 door S.	8, S, E. end	8 W. wall
Rock basis	61.04 m.	61.64 m.	61.27 m.	61.58 m.	61.58 m.	61.37 m.
Top of c. 1	62.08 m.	64.20 m.	62.49 m.	62.42 m.	63.21 m.	63.35 m.
Top of c. 2	64.46 m.	65.17 m.	64.14 m.	64.26 m.	65.06 m.	65.15 m.
Top of c. 3	66.16 m.	(none)	65.89 m.	65.89 m.	(none)	66.82 m.

Similar differences were found in the levels of the corresponding walls on the north. The step in the northern wall of the court is 5 cm. high in the top of the first course and 10 cm. high in the top of the second. All these walls are shown by the carefully drawn outlines in the plan to have been very irregular, indeed crooked in their lateral lines, a fact which is explained by the nature of the walls which were merely to act as supports for the granite casing. The granite blocks already set prove that in places the limestones wall cut away on both sides would have been only 30–50 cm. thick.

These huge stones exhibit three different kinds of excisions —

(1) A rectangular excision, about 16 × 16 cm. running the length of one edge only; this edge was sometimes the bottom edge and sometimes the top edge, but always at a reddish stratum in the stone.
(2) One to five rectangular excisions, from 20–30 cm. long, 10–15 cm. wide, and 10–15 cm. deep, always in one lower edge.
(3) A sloping excision about 30 cm. long in one top edge of a few stones of the second course.

The long excision No. 1, above, was manifestly a quarry cut as it was sometimes above and sometimes below in the wall, and in at least one case the stone above had five rectangular excisions of type No. 2, adjoining the long excision. I reconstruct the long excision as one used in separating the block from the bed in the quarry by cleavage. Probably a wooden beam was wedged in the cut and swollen with water. The rectangular cuts No. 2, I interpret as lever holds for adjusting the stone in place in the wall by means of large wooden beams operated on the same simple principles as those which we apply to the use of such levers in our own excavations. The sloping excisions No. 3 in the top of the second course I think were also to facilitate the use of levers in adjusting the stones of the third course.

It is to be noted that the stones rest in the walls with the natural strata horizontal and usually with that side up which was upwards in the quarry. Those stones which have the quarry ledge on the upper edge have probably been turned over the wrong way in setting, but still have the strata horizontal. One exception to the horizontal position of the strata was presented by the first stone on the west in the

wall between corridors (13) and (15). In this block the strata run vertically and it is to be noted that the levelling line in red and the inscription attached to it also run vertically. The only explanation is that this stone once stood in a core wall on which the levelling lines had been already drawn and had then as an afterthought been shifted to its present place. The gap in the limestone wall in which the doorway (25) was built appears to me to be the place from which this stone was removed. In that case, the gap left for the doorway was originally much smaller and was enlarged by removing this stone. Another gap, perhaps originally left for the stairway to the roof, is seen in this same core wall opposite stairway (23). It was afterwards closed with light masonry when the crude-brick temple was built.

From the quarry to the wall, the stones were dragged on sledges. The great blocks weighing from 100 to 200 tons, although not so heavy as the greatest of the granite obelisks of the New Kingdom,[1] give evidence of the ability of the Egyptians to deal with great weights as early as Dynasty IV. In comparison with these colossal blocks, the handling of the smaller stones of 10–30 tons was a simple matter. It is, I think, almost impossible to escape the conclusion that these huge stones were turned over twice, once in the quarry in loading on the sledge and once in unloading the stone into its place in the wall. For all the stones of the first course, the sledge was dragged on the surface of the rock or the foundation platform. For the second and third courses, construction planes of rubble packed with limestone rubbish were used, on which the sledges were dragged up to the higher levels. The condition in which the use of these construction planes left the spaces between the walls was clearly proved by the unfinished room (10). This was completely filled to the top of the second course with worn boulders and rubbish which formed the construction platform on which the stones of course three had been dragged to their places, but this platform covered another platform at a lower level. The approach to these platforms was through a gap left in the western wall of room (10), and I conclude that this gap was reached on the outside by an inclined plane. Apparently the wall served by these platforms was the southern wall of room (8), but perhaps also the back part of the southern pier of the portico. The stones of the first course of the wall of room (8) had been dragged along the rock to the edge of the trench in which that course was set. After this course was laid, the space was filled in to the top of course one with limestone rubbish, and the stones of course two dragged across the hard packed surface of this plane. After course two was in place, the space was filled with worn limestone boulders to the top of that course and the stones of course three were dragged over the hard packed surface of this plane. It is to be noted that in the foundation platform of the causeway, which had been used also as a construction plane, the irregularities of the top of this platform had been filled with limestone rubbish, the surface of which was worn and darkened by usage.

The effect of this method of construction was to leave the rooms of the temple completely filled with the material of the construction platforms when the core walls had been finished. It is obvious that this material had to be removed before the granite casing could be begun. Similar construction planes and platforms had to be built, at any rate for the granite courses, above the second course and for the roof, filling the rooms a second time up to the roof. This second set of platforms was removed gradually in dressing the surfaces of the granite casing from the top down. The same process was observed in the unfinished limestone rooms of the inner temple (see p. 21). In the case of the great open court, the planes were probably confined to a sufficient width along the walls. The repeated handling of light masses of construction material of this sort is no great matter. The large room (10) could have been emptied by 100 men in five or six days. The material when removed was not carried far away, but left close by to be used again or it was simply transferred from one part of the temple to another. The limestone boulders were all rounded and worn by repeated use. The worn boulders in the later construction plane south of the inner temple were probably boulders previously used in the Mycerinus work; and the rubble used in the walls of room (36), and in the retaining wall north of the entrance corridor, probably also came from the material of the construction planes.

The interior and the exterior faces of the core walls had been marked with horizontal parallel red lines, one Egyptian ell apart. At irregular intervals, pendent isosceles triangles were drawn on the un-

[1] Engelbach, *The Aswan Obelisk*, p. 9, calculates the weights of nine obelisks at the following figures — 1168 tons, 507 tons, 455 tons, 823 tons, 331 tons, 227 tons, 193 tons, 121 tons, and 143 tons.

dersides of these lines, forming vertical rows, but not exactly in a vertical line. These vertical rows were usually one to two meters from the ends of the walls and sometimes on long walls at intermediate points as well. One of the triangles, as observed in three places—that of the 3-ell mark—was filled in solid with red paint. These red lines, which are known to be levelling lines, have suffered greatly where exposed to the weather and had been partially cut away wherever the granite casing had been set. The vertical distance between the ell lines varied from 50 to 54 cm., tested both by telescopic level and by dead measurement, and the levels above our arbitrary datum line also varied as much as seven centimeters. For example, the 5-ell line was at level 63.76 meters in room (10) and at 63.83 meters in room (13). The zero mark as calculated from the ell lines in rooms (10 inside and out), (13), (14), (15), (19), (20 inside and out), (24), (27), and the great court, was between 61.17 and 61.19 meters; and the 1-ell mark on the southern face of the entrance corridor at the east end gave a zero of 61.165 meters (plus or minus 5 millimeters). The zero mark would have been just about level with the top of the foundation platform where the causeway joined the entrance doorway. It was not found marked, however, at any point. In the court, the zero line was slightly below the top of the foundation platform, and the floor of the court in front of the portico was about at the 1-ell level. Further west the floor rose to 63.14 m. (just under the 4-ell level) in the granite pavement in room (29); and the base of the pyramid casing at this point was 62.04 m. (just under the 2-ell level). Under the southern side of the portico, the rock surface rose above the 1-ell mark.

The irregularities of the levelling lines is illustrated by the following list of levels:

	Room (13) S. wall		Room (13) N. wall		Room (10)	Court
	west	east	west	east	south	N.W. corner
7-ell mark	64.69 m.	....	....	....	64.79 m.	....
6-ell mark.	64.36 m.	64.385 m.	64.37 m.	64.36 m.	64.27 m.	....
5-ell mark	63.823 m.	63.835 m.	63.83 m.	63.83 m.	63.76 m.	....
4-ell mark	63.29 m.	63.28 m.	63.33 m.	63.32 m.	....	....
3-ell mark	62.765 m.	62.76 m.	....	62.80 m.	....	62.75 m.

In room (10), where the levelling lines were especially well preserved on the north and the south walls, the lines from 3-ells to 7-ells were marked on the north wall and the triangle of the lowest mark, 3-ells, was in solid red. On the south wall, the lines and marks for 5-ells to 7-ells were plain, but no line could be found below the 5-ell marks. The 4-ell marks would have fallen about in the top of course one of the core wall. It was clear that the 3-ell line on the north wall had been marked before the making of the "first construction plane" in this room and that the lines on the second course both north and south had been made after the "first plane" and before the "second plane." Probably the ell lines on the second course were fixed by dead measurement from the 3-ell line, which could easily have been exposed at the two ends. The lines on the south wall on the second course could have been fixed by a secondary levelling operation from the north wall.

Professor Borchardt [1] reports two zero lines from the pyramid of King Ne-weser-re of Dynasty V, one at the level of the foundation platform and the other at the level of the top of the pavement. At the Mycerinus temple, the building had not advanced so far as to require the drawing of the second set of levelling lines which would naturally have been placed on the granite casing. In our temple therefore we have found only one zero level indicated by the marks preserved.

I would reconstruct the process of levelling at the Mycerinus pyramid temple as follows:

(*a*) The zero mark was fixed on the top of the foundation platform at the entrance, probably on one side, and after the construction of course 1 of the core walls.

(*b*) The marks for ells 1 to 3 were set on the core wall by dead measurement from zero.

[1] See *Das Grabdenkmal des Königs Ne-weser-re'*, p. 154. Professor Borchardt has recovered from the Abu Sîr temples four very interesting technical terms used by the Egyptian architects in levelling, and a fifth is recorded by Professor Petrie (*Medum*, p. 12 b):

"zero" ..... *nfrw* .....

"zero line" ..... *m tp n nfrw* .....

"above zero" ..... *ḫr nfrw* .....

"below zero" ..... *mḏ ḫr nfrw* .....

ḫr n nfrw (Medum)..