Decoding the north and west walls of the upper chamber of the Great Pyramid

Abstract

The Great Pyramid of Giza's is a well known ancient building on the outskirts of Cairo and its internal architecture contains a series of passages, shaft and chambers. Its upper chamber, commonly known as the King's Chamber, is constructed from polished granite blocks which are assembled with a high degree of precision, and as a result contain horizontal and vertical wall joints with thicknesses in the sub-millimeter range.

In this paper I show that the vertical joints between the granite wall blocks of the upper chamber have been designed so that they can be read as binary ones when set into a regular grid pattern of rectangles covering the wall.

I then show that this binary data is formatted in an identical manner to our contemporary IEEE 754 floating point number storage system for 16 bit computers and subsequently decode the numerical data on the chamber's north and west walls. I show that the numerical data that is extracted from the top two levels of the walls specifies the binary format of the system required to decode the numbers and then show that the decimal numbers obtained from the lower three levels of the walls describe recognisable features within the pyramid.

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The upper chamber of the Great Pyramid is often referred to as the 'main chamber' or 'king's chamber' such is its obvious importance within the internal architecture of the building. Its walls are constructed throughout of polished granite blocks which are set within 5 equal height layers and these stones are joined together with the highest precision, the joints rarely showing a thickness of more than 1mm.

These joint locations have been measured in surveys of the pyramid so that the relative position of all the wall stones is now known, and diagram E1 shows a view of the north wall of the chamber through which the entrance passage to the room passes, shown as a dark 2 cubit wide rectangle in the bottom right corner. The numbers on the blocks on the walls are the measurements of the horizontal block lengths that were taken by Professor Smyth[1] and tabulated in his work, and have been converted over to cubits at a ratio of 20.60 inches to the cubit. They were measured to an accuracy of 0.1 inch, so the third decimal place in the numbers is a result of the conversion, not the measurement accuracy. A table of all of the stone lengths from Smyth's survey, converted into cubits, is contained in Table 1 in the appendix of this paper.

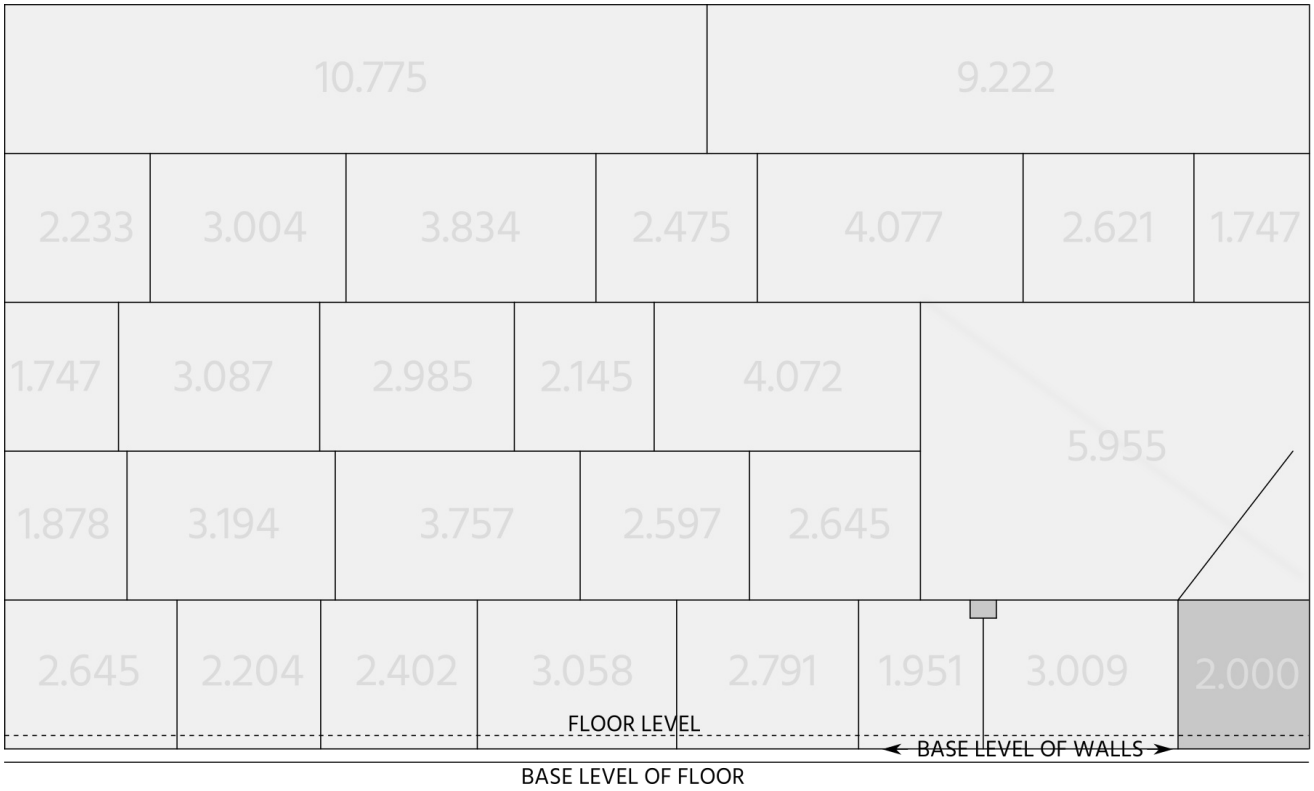


Diagram E1 - The northern wall of the upper chamber

The equidistant height of each of the 5 levels of wall stonework has also been measured, but referring to the vertical chamber stack that was documented in the earlier paper in this series[2], the full theoretical height of the chamber walls is known with considerable accuracy and is 11 + 2n cubits in height, where *n* is the stack constant used throughout the chambers and roof chambers, with a value of 153/748 cubits.

The height of each wall level can therefore be calculated rather than measured, and can be expressed as 2 +1054/3740 cubits using the architects method of expressing numbers in integer based fractions, or 2.28181 cubits as a decimal number (47.01 inches).

Of great interest when you first enter the chamber is the stone above the entrance which is the only stone in the chamber which does not conform to the regular wall level heights.

The north wall double stone

On the north wall, directly above the entrance to the upper chamber, is a massive granite block which spans two level of the wall's stonework and was measured by Smyth as being 5.94 cubits in length from the east wall to the end joint with the next stones. This stone block has two unusual lines running across it which are nearly but not quite perpendicular to each other at the point where they cross, as shown in detail on diagram E2. The line marked off as 'line 1' is a drafting line on the stone which is all but impossible to see on photographs of the wall and that was commented upon by William Petrie[3] as follows

"There is a remarkable diagonal drafted line across the immense block of granite over the doorway; it appears not to run quite to the lower corner on the E. side; but this is doubtless due to the amount by which the block is built into the E. wall, thus cutting off the end of the diagonal line."

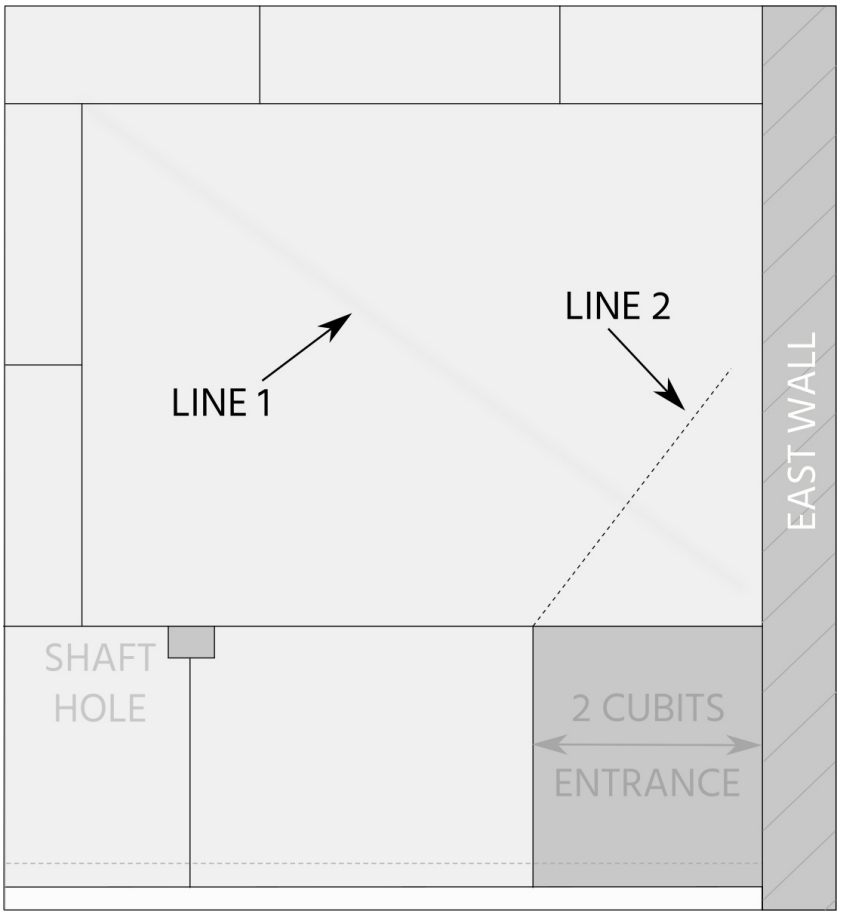


Diagram E2 - The double height block on the north wall

As Petrie correctly deduced, the reason that this drafting line does no run to the lower right corner of the double height wall stone is that the stone is inset into the east wall by a distance of one stack constant, *n*. The purpose of this line is to help in the analysis of the wall, because the classic view of the north wall as shown in diagram E2 is incorrect. The north wall does not terminate at the line where it meets the east wall but continues a further 0.2045 cubits (1 *n*) to the east and therefore the chamber's east wall needs to be removed from the drawing before any meaningful analysis of the north wall can be undertaken.

In fact the vertical chamber stack needs to be used when analysing the north wall of the upper chamber, so that the overlaps of the walls from the east and north elevations are correctly taken into account when trying to understand the architect's system in the upper chamber. Diagram E3 shows the same view of the north wall as diagram E2, but with the east wall removed.

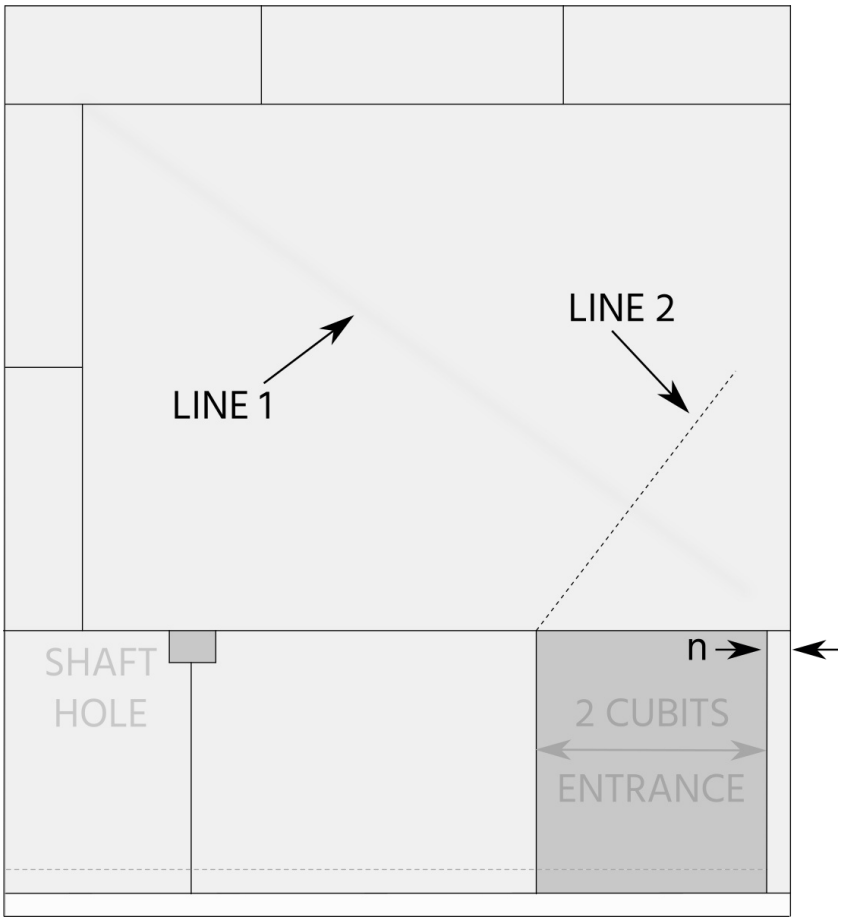


Diagram E3 - The double height block on the north wall, with the west wall removed

The diagonal drafting line now runs from corner to corner across the double height stone.

The line marked as 'line 2' on diagram E3 is even more curious than line 1 because it is only partially visible on most photographs of the chamber's north wall, but when lit from the center of the room it is well defined and distinct. The best imagery of this line that I have seen is in the BBC 360 degree video footage that was shot inside the pyramid and which is available publicly on the internet[4]. Illustration E4a shows a frame taken from the section of footage which runs from the time marker 1:00 to time marker 1:25 as the camera enters into the upper chamber of the pyramid. Line 2 is straight and runs from the left (west) side of the top of the door up to the level of the top of the second level of wall stones, where it abruptly ends.

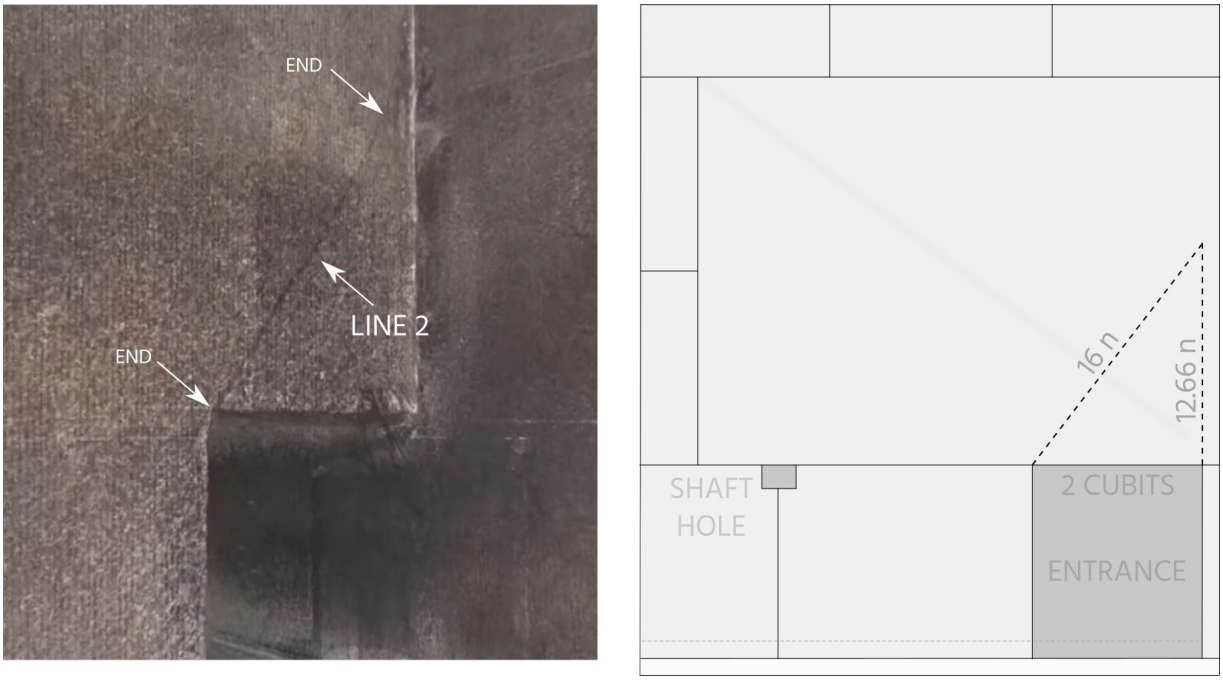


Illustration E4 - A photograph of the line across the double height wall block, and an illustration of the door triangle

To understand why this line was etched onto the stone by the architects, some 'rough' calculations need to be performed on the geometry that it forms with the east wall of the door. If the straight line is extended to a vertical line coming from the right (east) side of the door, the length of the extended line is 16 stack constants in length, 16 n. The triangle that is formed with the doorway by extending this line in this manner has a vertical side of 12.66 stack constants or very nearly 12 and 2/3 n as shown in diagram E4b, and because the width of the door is exactly 2 cubits wide this allows a relationship between the cubit and the stack constant to be re-evaluated using Pythagoras's theorem.

The resulting value is that one stack constant, 1 *n*, is 3/sqrt(215) cubits in length, and this value can be compared to the value of the stack constant that was determined from the lower sections of the vertical chamber stack in a previous paper in this series[5].

	As a fraction	Decimal	
Stack constant from vertical stack	153/748	0.204545454	(cubits)
Stack constant from chamber stone line	3/sqrt(215)	0.204598302	(cubits)

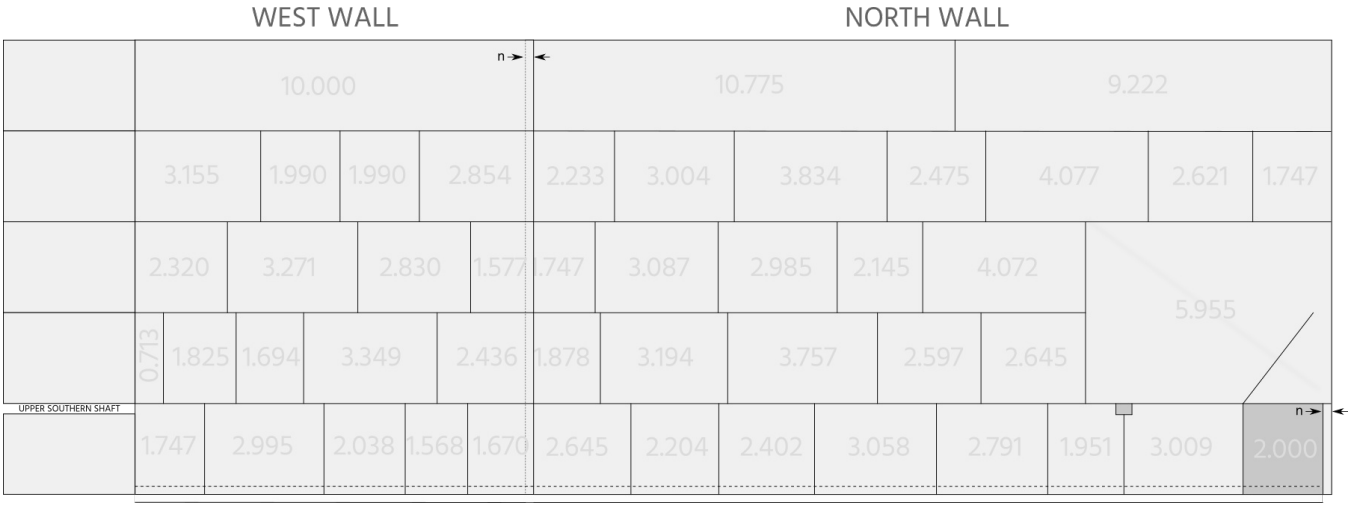
The difference between the two values is 3/100ths of a millimeter, or about half the width of a human hair.

The purpose of line 2 and its theoretical extension triangle is to bring attention to the fact that the value of 3/sqrt(215) is a very good candidate indeed for refining the calculations that were performed on the full chamber stack by making an adjustment to the value of the stack constant.

Line 2 and its triangle formation is purposefully intended by the architects to not be scientifically robust, it is intended as a deliberately imprecise clue, and it poses the question: can a precise and explicit version of the value 3 / sqrt(215) be found elsewhere within the upper chamber ?

The north wall entrance grid

The next step in the analysis of the upper chamber is to use the combined east and north elevation drawings of the building from a previous paper[6], rather than looking at the north wall in isolation. Diagram E5 shows the walls of the upper chamber locked together from the horizontal stack of the pyramid, and the length of the wall stones of the upper chamber's two walls are indicated on the diagram. Because this diagram is taken from the east elevation of the pyramid with the north wall then added on, the wall section to the south is also shown which contains the southern shaft hole, as seen on the left side of diagram E5.



IDiagram E5 - The west and north walls from the horizontal stack system

On this diagram of the combined west and north walls, the one stack constant gap to the right of the door is shown which matches the equal sized overlap on the other end of the north wall where the west and north walls overlap from the horizontal stacking.

Using the entrance as the primary feature on the wall, and the logical place to start any analysis, a grid of door sized rectangles can be placed on the north wall, a grid which has 10 rectangles running along the length and five rows of these rectangles up the wall's height. This starting grid is shown in diagram E6.

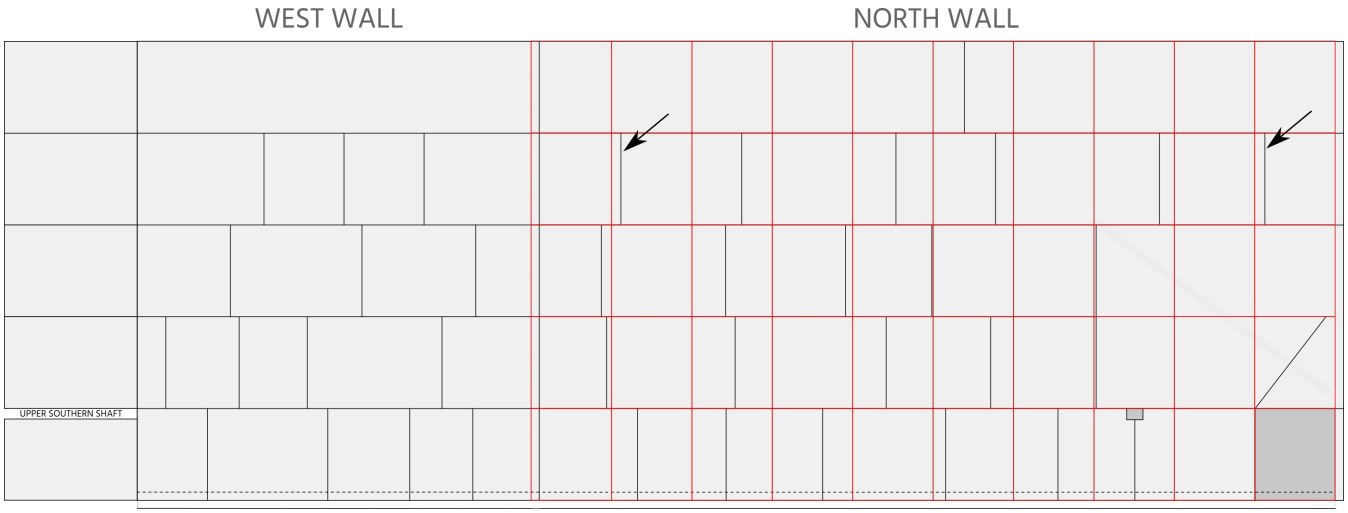


Diagram E6 - The grid of entrance door rectangles superimposed on the north wall of the upper chamber

When this grid is created there are two stone joints on the 4th level of masonry, marked with the black arrows, which are both spaced exactly one stack constant to the right of their nearest vertical grid line, and additionally the right side of the grid is one stack constant away from east end of the north wall by definition. Therefore the grid can be moved one stack constant to the right and it will snap into place with these three locations which are shown on diagram E7 with the black alignment arrows.

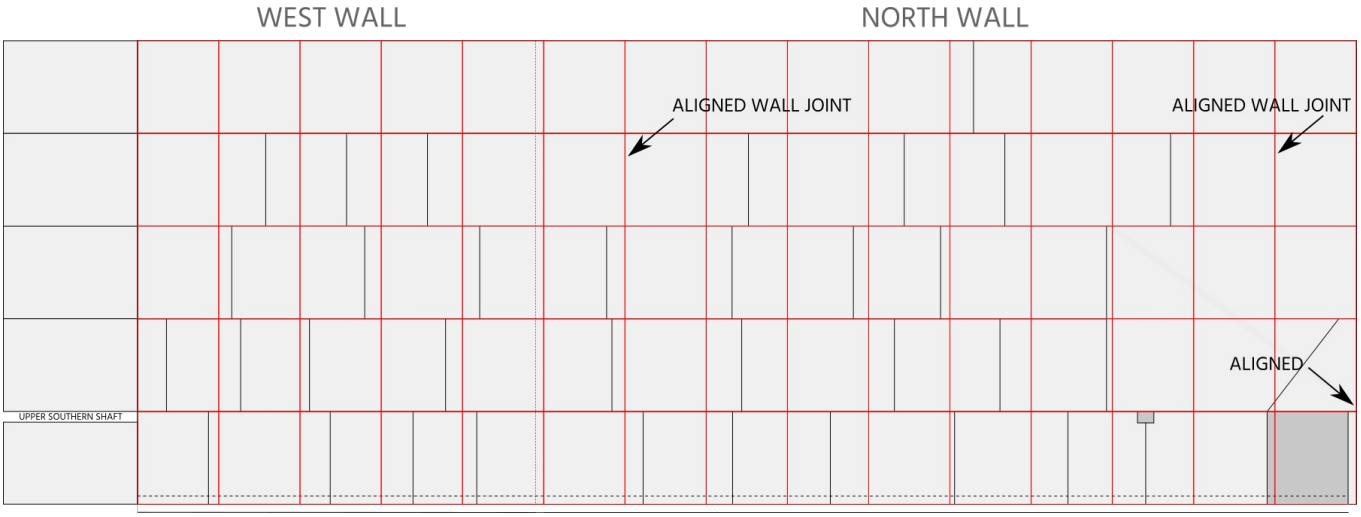


Diagram E7 - The grid of entrance door aligned with the north wall's eastern end

With the north wall grid correctly located at the east end of the north wall, there is now sufficient space on the left side of Diagram E7 to place further grid rectangles of the same size over the west wall, which has five rows and five columns of grid rectangles on it.

If you look carefully at diagram E7 you will notice that each of the grid rectangles on both the north and west walls contains either only 1 vertical wall joint or 0 vertical wall joints.

It is therefore entirely logical as a next step that each of the grid's rectangles can be said to contain either a one or a zero, and that the walls are a grid of binary numbers. The binary grid data is shown in diagram E8.

0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	1	1	1	0	0	0	1	0	1	1	0	1	0	0
0	1	1	0	1	1	0	1	1	1	0	1	0	0	0
1	1	1	1	0	1	0	1	0	1	1	1	0	1	1
1	0	1	1	1	0	1	1	1	0	1	1	1	1	1

Diagram E8 - The binary grid of wall joints in the north and west walls

On this diagram the vertical black line marks off where the west and north walls meet up, and there are a few points of note regarding the placement of the digits on the drawing. Because the grid is no longer aligned to the door, both the vertical sides of the doorway form 1s on the bottom row. The architect's line on the double height block, which was identified earlier as 'line 2', is also considered as a positive line feature on the wall and is represented by two 1s in the binary grid. The drafting line that Petrie mentioned is not considered to be representative of a feature because, by definition, it is a drafting line and not meant to be seen. The vertical joints on the 4th level of stones that were marked by the arrows on diagram E6 play no part in the binary digits as they fall directly beneath the vertical lines of the grid.

If the least significant bit in the binary is on the right side of the grid, then the top row of stones binary digits read as the decimal number 16. To be able to read the rest of the binary numbers from the walls, an understanding of the way in which computers store numbers is required.

16 bit floating point number storage

Because of the binary nature of computers they are able to store integers without problem or loss of precision, but trying to store numbers which contain a decimal point is an altogether more complex challenge. In the case of 16 bit computing and these 'floating point' numbers, some of the 16 bits need to be allocated to the integer portion of the number and the remaining bits allocated to the part of the number after the decimal point, but this is a far from trivial task to optimise.

The problem was studied at the advent of computer science and the most efficient manners in which to use the available 16 bits was discovered. If the same task were to be performed today by another group of computer scientists without knowledge of the previous solutions they would come up with exactly the same results because the solutions are the most efficient way of solving the problem. One of the commonly used protocols goes by the name of the IEEE Standard for Floating-Point Arithmetic[7] (IEEE 754) and has the following format for 16 bit computing, simplified for this explanation.

Of the 16 bits available, the bit on the left which is the 16th bit counting from right to left, is used to represent whether the number is negative, and a binary digit 1 in this location indicates that the number being represented is negative.

The ten bits on the right, numbered 1-10, are used to store the main number that is being used in the calculation and the remaining 5 bits, 11-15, are used to store the magnitude of the number. The value in these bits is used as a power of 2 to increase or decrease the main number stored in the previous 10 bits.

Most importantly is that there is an implicit 1 contained in the IEEE protocol which improves the efficiency of the storage, and which is shown in diagram E9 with a 1 enclosed in a descended square.

Diagram E9 shows a summary of the bit format of the IEEE 754 16 bit protocol and an example calculation of a stored number, arbitrarily chosen as 9.40625.

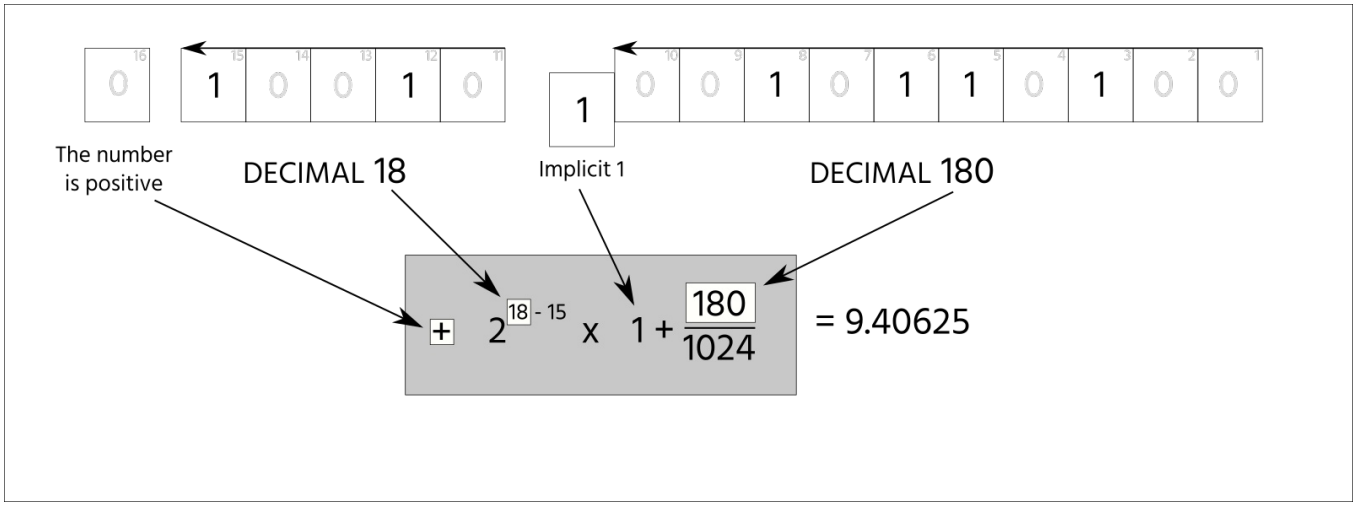


Diagram E9 - The IEEE 754 half-precision floating point number format

In this example the first 10 bits give the decimal number 180, which is inserted into the calculation box at the bottom of the diagram. The next 5 binary bits give the decimal number 18, and this is also inserted into the calculation box, as is the + sign from the 16th bit. The implicit 1 is always present.

As can be seen, this protocol has the same bit format as that taken from vertical wall joints in the main chamber, where the north wall contains 10 binary digits, the west wall contains 5 binary digits, and the negative number binary digit is the shaft hole in the south wall.

Decoding the north wall

5th level of wall stones

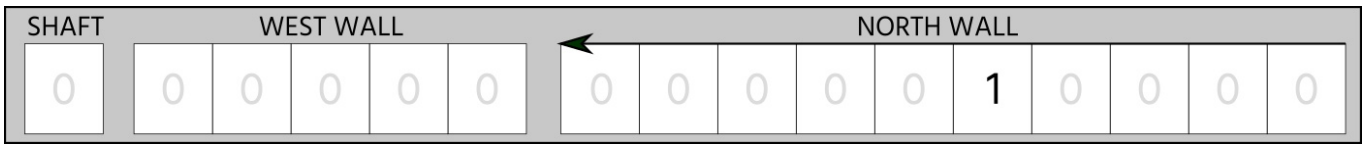


Diagram E10 - The wall joint binary digits from the 5th level of stonework on the north and west walls

The 5th level of stonework does not use the IEEE 754 protocol, but is just a straight set of binary numbers reading from right to left which declare the bit format of the system as being 16 bit and establishes where the least significant bit of the principal number can be found, on the right side of the north wall. On diagram E10 the arrow above the north wall's digits shows the direction in which the binary is encoded, with the most significant bit at the end where the arrow head is located.

The west wall is blank and therefore contains no information, and the location of the least significant bit on this wall cannot be assumed from that of the north wall, hence there is no direction arrow above the west wall.

4th level of wall stones

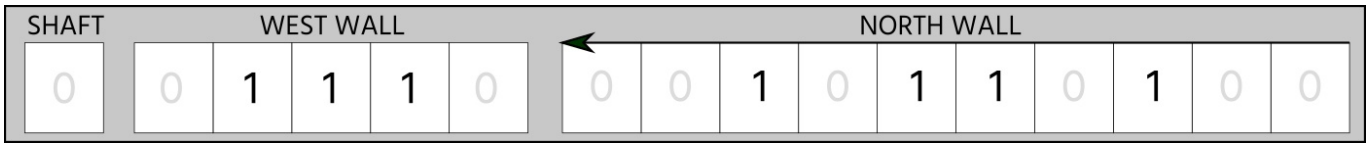


Diagram E11 - The wall joint binary digits from the 4th level of stonework on the north and west walls

The fourth level has the binary digits that make up the decimal number 14 on the west wall (the symmetry of the digits making the bit direction irrelevant) and 180 on the north wall, and plugging these numbers into the IEEE 754 protocol results in the floating point number 0.58789. Represented as a fraction this number is 10/17.0099 and is the nearest floating point number in the IEEE format to 10/17.

Level 4 is a declaration of the protocol being used, which is the 10 bits out of 17 bits of the IEEE 754 protocol. In the analysis of the upper roof chambers in a previous paper[8], on diagram D2 there are a series of integers contained in the gallery plan which start on a level with this 4th level of stonework of the main chamber walls, and that series begins 0,7,10,16 showing that the binary digits have been correctly extracted from the 4th level of the north and west walls and that the protocol being used is correct.

The binary digits on the 4th level are symmetrical on both the north and west walls and therefore the position of the least significant bit on the west wall cannot yet be established.

2nd level of wall stones

The second level of stones on the north and west walls of the main chamber needs to be understood before the 3rd level can be looked at because the format being used on the double height stone can only be recognised by doing the analysis in this manner.

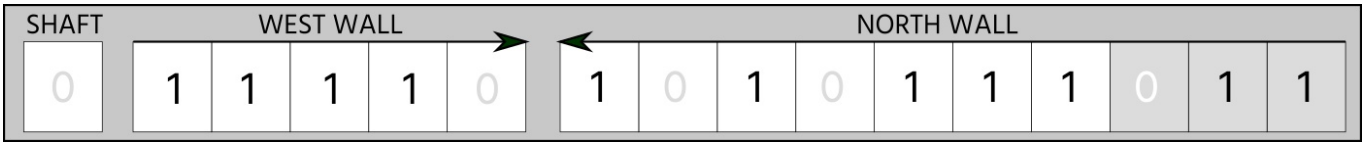


Diagram E12 - The wall joint binary digits from the 2nd level of stonework on the north and west walls

The three binary digits 011 on the right of diagram E12 with the darker background colour are formed from the line which was discovered running across the double height stone, and are therefore grouped together as one unit on the wall. The darker rectangles show the double height stone.

If the west wall's least significant bit is assumed to be on the left side of the diagram, then the west wall's binary digits make the decimal number 15, which has special significance in the IEEE format because it gives a value of one for the magnitude multiplier, and in the IEEE format this is used as a special case scenario to add extra functionality to the protocol. The same is done in the pyramid, and a value of 15 on the west wall signifies that the number contained on the north wall represents a fraction, with the first 3 bits on the double height stone being the numerator of the fraction and the other seven binary digits shown with a white background being the denominator. Each of these two sections of the north wall binary digits starts with two to the power zero (2^0) as the right most digit.

The numerical value on level 2 can now be decoded from the west and north walls. The double height stone binary digits on this level give the decimal number 3, and the remaining 7 digits on the north wall give the decimal number 215, and the fraction being shown is therefore 3/215. This fraction uses the same component integers as the value that was set out on page 5 of this paper when the stack constant was recalculated from the line across the double height stone as 3/sqrt(215).

The stack constant value has now been explicitly defined on the second level of wall stones, rather than

from the rough drawn triangle of the double height stones, and can now be used as an explicit definition.

Because the second level of stones decodes to a known number, the assumption that the least significant bit of the west wall is on the left side of the wall must be correct, and an arrow has been included on diagram E12 to show this fact.

3rd level of wall stones

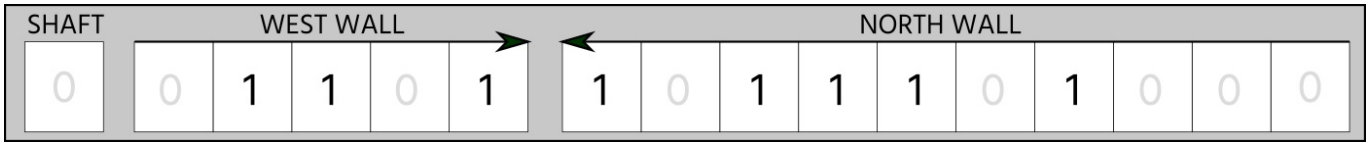


Diagram E13 - The wall joint binary digits from the 3rd level of stonework on the north and west walls

Now that the direction of the bits on the west wall has been established the 3rd level can be decoded.

The third level is a standard use of the IEEE 754 protocol. The binary digits of the west wall give the decimal number 22 and the binary digits of the north wall give a decimal value of 744. When these numbers are plugged in to the IEEE calculation method shown in diagram F9 they give the resulting floating point value of 221.

There is only one written number that has ever been discovered in the pyramid's internal architecture (excluding the glyphs of the roof chambers), and that was found during the robotics exploration of the Djedi Project[9] when the team drilled through the door at the end of the lower southern shaft of the Great Pyramid. Written in hieratic script was the number 221, as shown in illustration E14 which has had the glyphs enhanced for clarity.

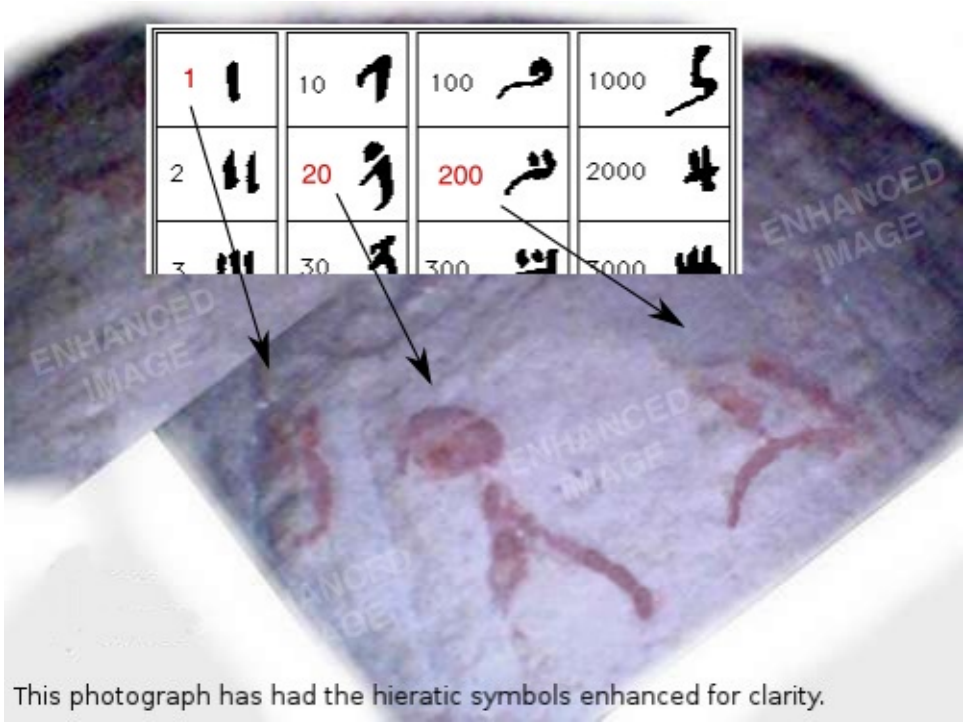


Illustration E14 - The number 221 in hieratic script in the lower southern shaft

The values extracted from the second and third levels of wall stones are both independent recognisable numbers, which appears to contradict the logic of the double height wall stone which would indicate that the numbers extracted from these two wall levels should be combined. The reason for this contradiction is that the opposite case occurs on the south wall, where the numerical data extracted from the second and third wall levels needs to be combined using the inverse of the north wall's logic.

1st level of wall stones, preview

The first level of wall stones adds an extra level of complexity to the decoding of the binary digits because the coffin in the upper chamber comes in to play and blocks off some of the wall joints on both the east and the north elevations. The coffin is a movable object, and there is no guarantee that it is currently placed in its intended location. The starting position of the coffin, in which it is currently located, is shown in diagram E15 in which the floor of the chamber has been included below the coffin.

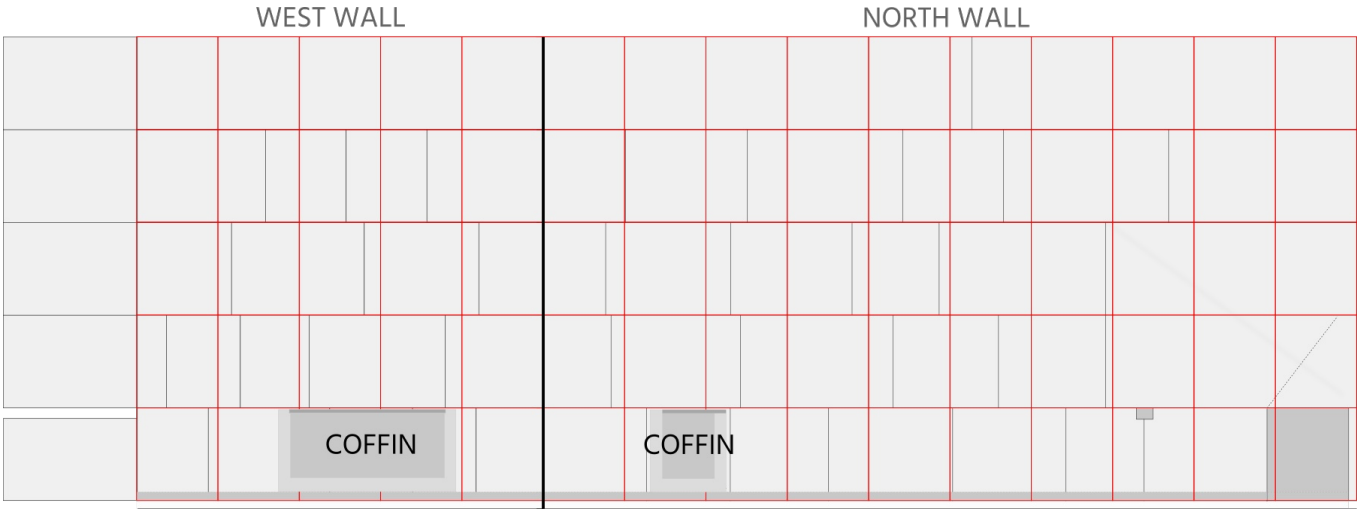


Diagram E15 - The current position of the coffin in the upper chamber

There are two vertical joints blocked off behind the coffin on the west wall, and on the north wall the coffin just fits in between two of the vertical wall joints. If the binary data of the walls is extracted with the coffin in this position, the west wall gives a decimal value of 17 and the north wall 479, leading to a floating point number from the IEEE 754 format of 5.871. This number is deliberately close to ten times the number that was decoded on the 4th level of 0.58789 and which signified the protocol that is in use as being 10 bits / 17 bits. Here on the 1st level the decoded number, as a fraction, is 100/17, indicating that the result is incorrect because the decoded number is a distortion of the protocol definition.

Aligning the coffin

The coffin can be aligned to its intended location by reference to the 1st wall level vertical joints on the north and south walls, and after that has been done, to the vertical joints on the west wall. Diagram E16 shows the architect's alignments of the coffin to the north and south walls.

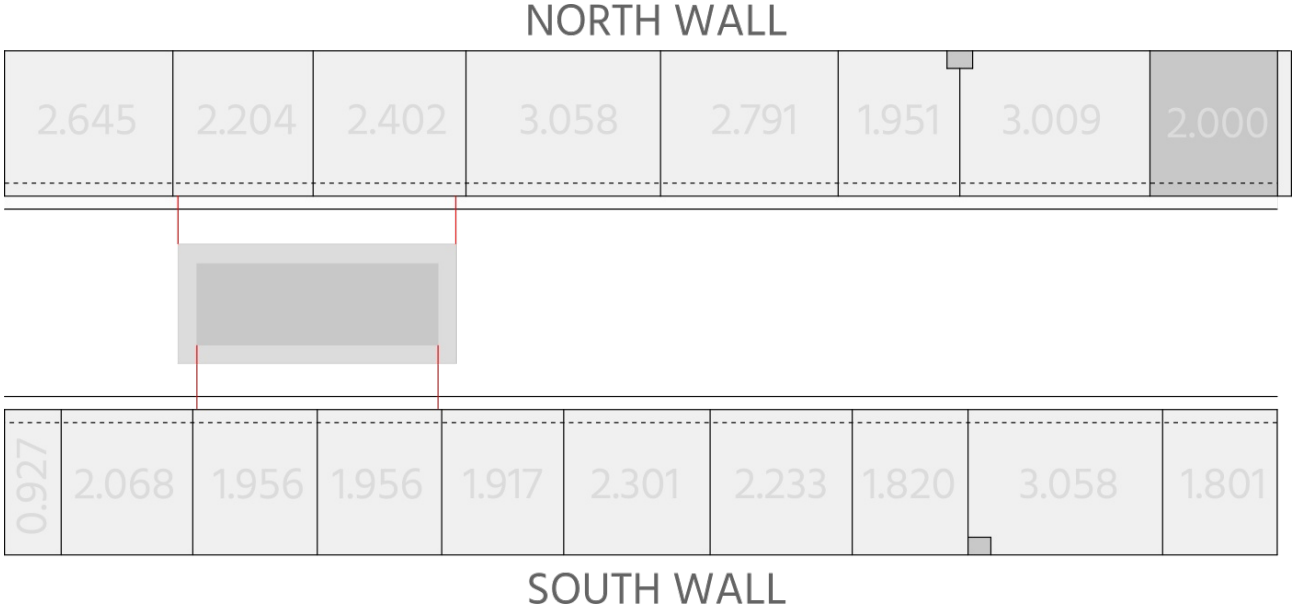


Diagram E16 - The architect's alignment of the coffin with the level 1 vertical wall joints

The widths of the 2nd and 3rd stones from the west on the north wall are designed so that the external length of the coffin will fit between the end joints of these two stones. Directly opposite on the south wall are two stones with equal widths of 1.956 cubits, and their length and position is designed so that internal length of the coffin just fits between them. In addition to aligning the coffin, this also shows that the north and south walls must be in line with each other and the floor plan of the chamber is rectangular.

The coffin can now be aligned onto the west wall of the upper chamber in a similar manner, as shown on diagram E17 which contains the alignments to all four walls (and the floor stones for reference).

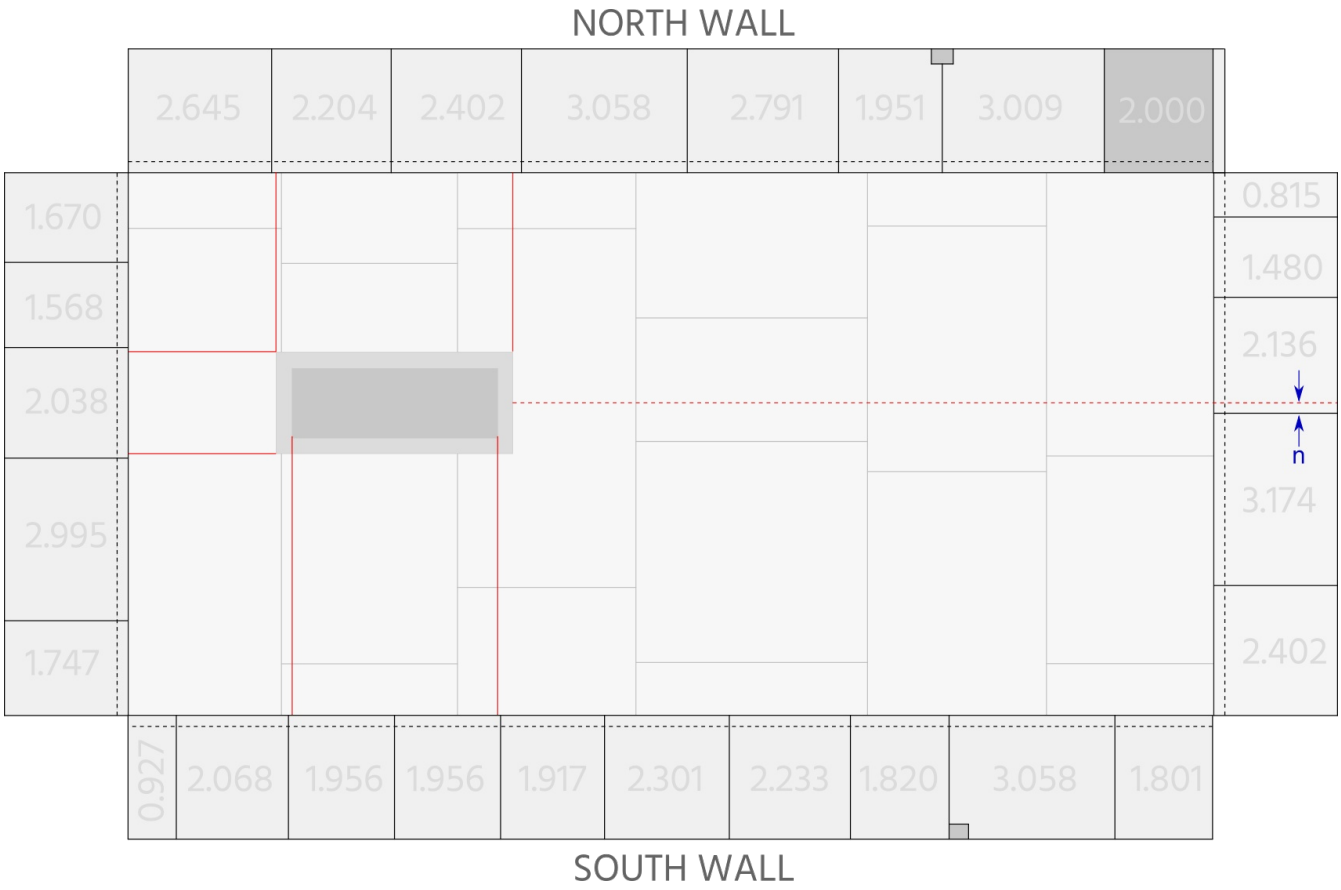


Diagram E17 - The alignment of the coffin in the upper chamber

The central stone of the first level on the west wall is positioned, and has a width, so that the end profile of the coffin will just fit between the wall stone's extremities. When this is done the central axis line of the coffin along its length projects onto the east wall and meets that wall one stack constant unit from a joint in the wall, an alignment that would be impossible to spot without a full knowledge of the chamber and vertical stack design.

1st level of wall stones

The binary encoding of the first level of the west and north walls can now be correctly viewed and is shown in diagram E18 which shows a drawing of the first wall level at the top and the binary encoded digits below. On the drawing of the walls, the vertical stone joints have been marked in blue as they are difficult to determine otherwise, especially in the proximity of the outer walls of the coffin.

The west wall's binary digits give the decimal number 29 and the north wall's binary digits give the number 351 which, when plugged into the IEEE 754 protocol, gives the floating point number 22000.

The length of the base of the pyramid from the central axis to the external face stones where they join the pavement of the building was surveyed[10] as 220 cubits, and the level one stonework of the west and north walls is giving this measurement in 1/100ths of a cubit - the units being as important as the length.

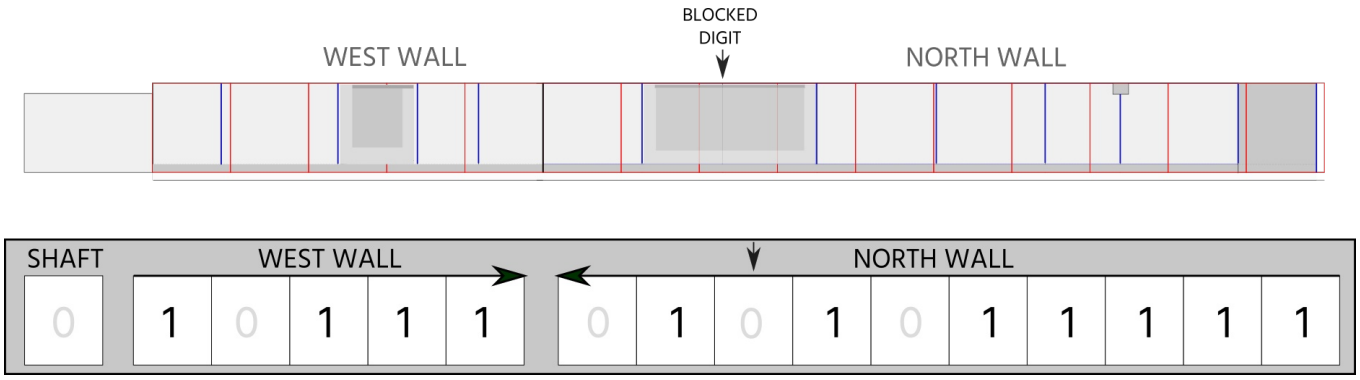


Diagram E18 - The binary encoding of the first wall level of the west and north walls

All five levels of stonework from the north and west walls are now complete, and each of the five lines gives a number which can be summarised as a set of instructions as follows

Level 5	16	The binary encoding you are looking at is 16 bit
Level 4	10/17	The system in use is a 10 bit from 17 bit format
Level 3	221	Here is a number you will recognise only of the format is correct
Level 2	3/sqrt(215)	This is the correct value of the stack constant
		This is a special case encoding format for fractions
level 1	22000	This is the half base length of the pyramid.
		The architect's unit of measurement is 1/100th cubit

The south wall

The east and south walls with the one stack constant overlap from the horizontal stack are shown in diagram E19.

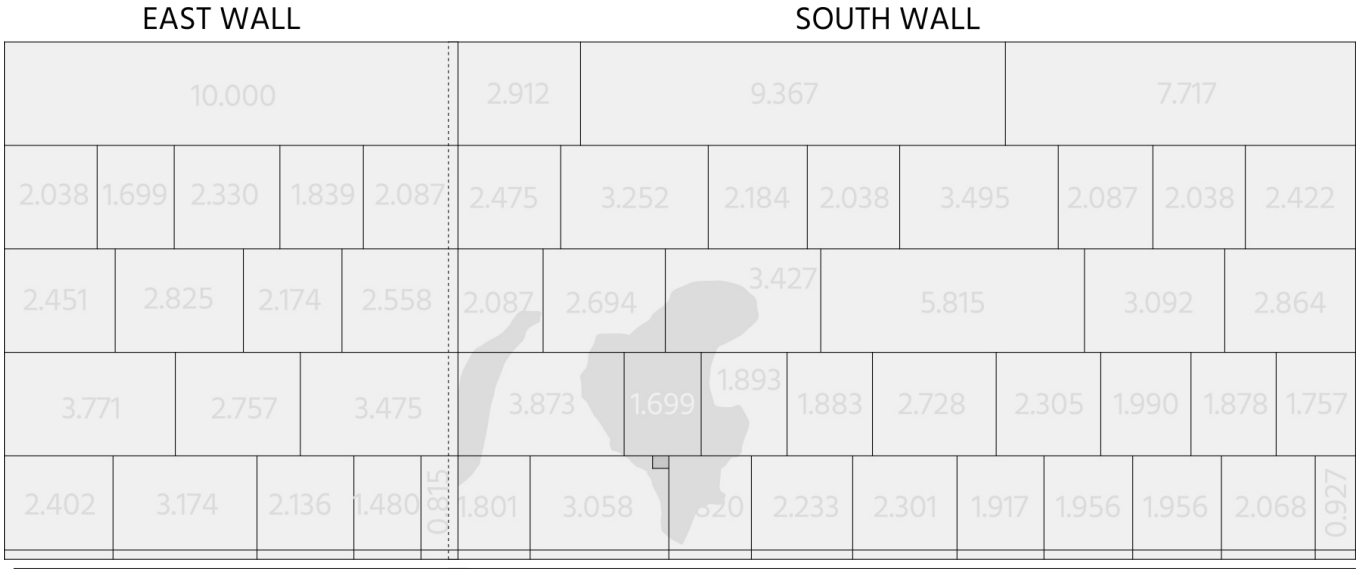


Diagram E19 - The stonework of the south and east walls of the upper chamber

On the north wall, the grid of rectangles that was used to decode the binary data used alignments on the 4th level of stonework to place the grid in the correct position, and the same is true of the south wall although the method is different.

Diagram E20 shows the grid of rectangles placed over the east and south walls, with the south wall length extended by one stack unit on its right (west) end so that the grid of 15 rectangles stretches from the left end of the east wall to the right end of the extended south wall.

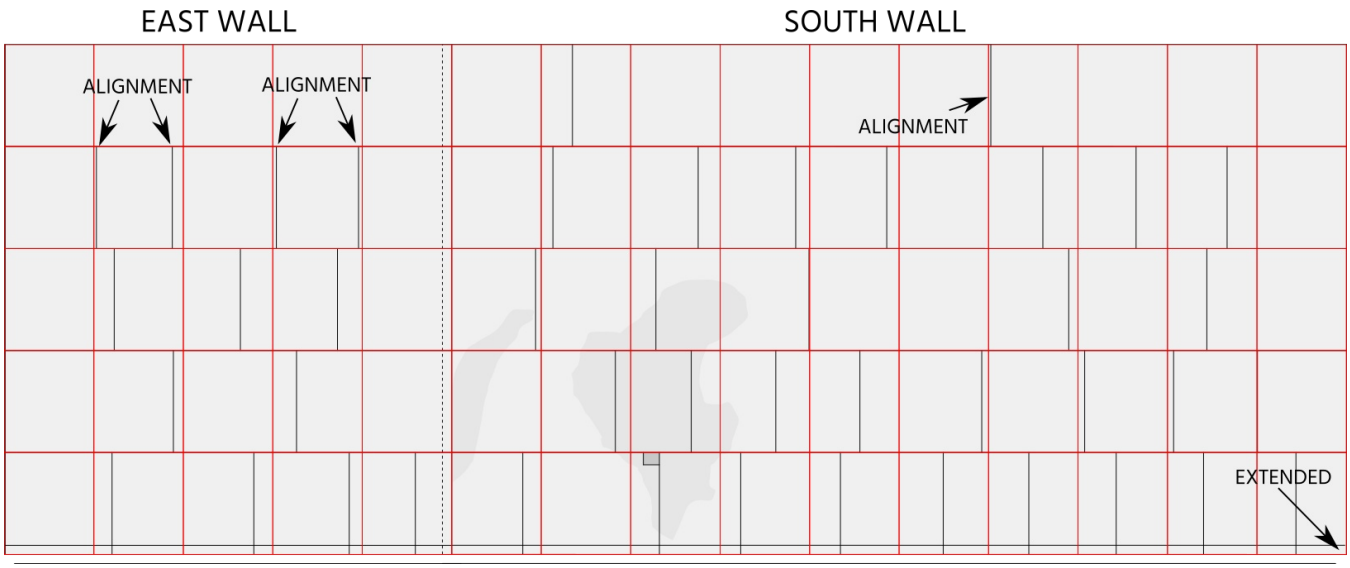


Diagram E20 - The grid alignment on the east and south walls

The alignment method is the same as was used to align the coffin to the lower level wall joints within the chamber, and the second and fourth grid rectangles from the left of the 4th level of stonework allow two vertical joints of stonework to just fit between them. There is also an additional alignment vertical joint on the top level of stonework on the fourth grid from the right.

The decoding of the east and south binary data is more complex than on the north and west walls because it involves an encryption system, and because none of the data that comes out of that wall is required to progress with the chamber stack system, the decoding of the south wall is covered in a later paper.

The upper chamber length

Having placed the grid of rectangles on both the north and south walls, the plan view of the chamber can now be correctly drawn with the internal length of the chamber between the west and east walls being 20 cubits in length, and the north and south walls length being 20 + 2n cubits, where *n* is the stack constant. Diagram E21 shows the upper chamber length and the corresponding wall lengths.

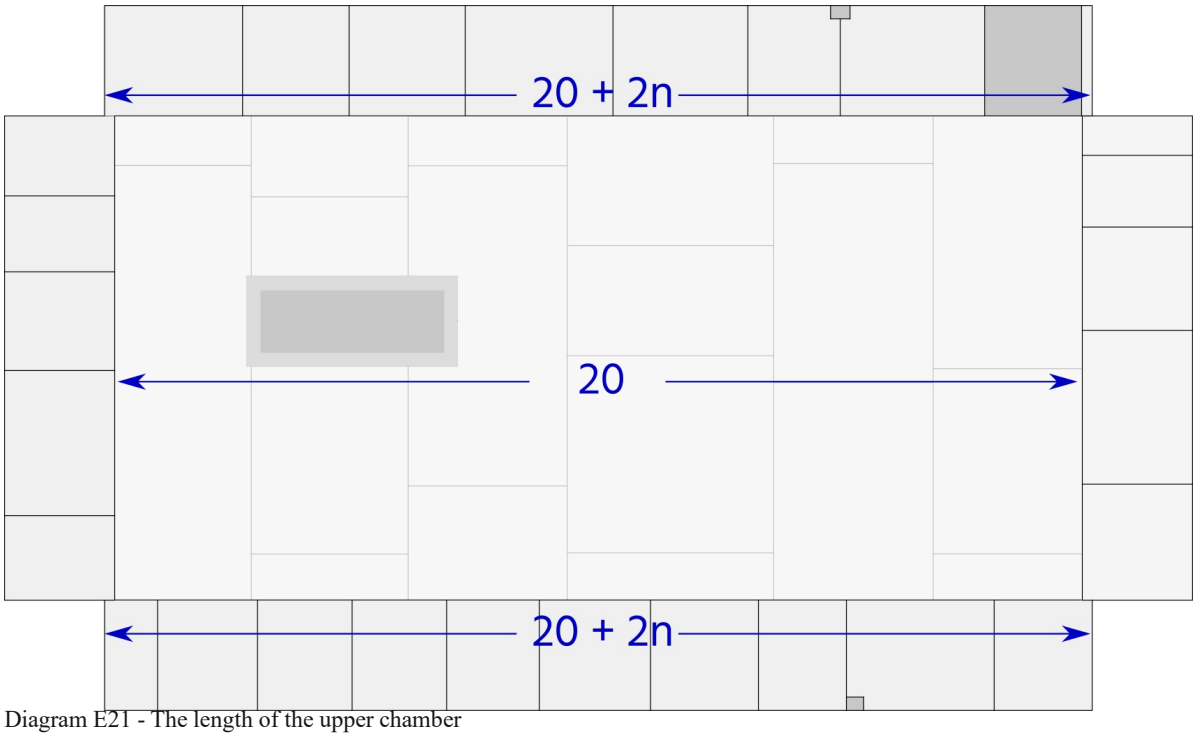


Diagram E21 - The length of the upper chamber

Appendix - Upper chamber wall stone lengths

	West wall	North wall	East wall	South wall
Level 5	9.993	10.775	9.993	2.912
		9.222		9.367
				7.717
	9.993	19.997	9.993	19.997
Level 4	3.155	2.233	2.087	2.475
	1.990	3.004	1.839	3.252
	1.990	3.834	2.330	2.184
	2.854	2.475	1.699	2.038
		4.077	2.038	3.495
		2.621		2.087
		1.747		2.038
				2.422
	9.989	19.992	9.993	19.992
Level 3	2.320	1.747	2.558	2.087
	3.271	3.087	2.174	2.694
	2.830	2.985	2.825	3.427
	1.577	2.145	2.451	5.815
		4.072		3.092
		5.955		2.864
	9.998	19.992	10.008	19.977
Level 2	0.713	1.878	3.475	3.873
	1.825	3.194	2.757	1.699
	1.694	3.757	3.771	1.893
	3.349	2.597		1.883
	2.436	2.645		2.728
		5.955		2.305
				1.990
				1.878
				1.757
	10.018	20.026	10.003	20.006
Level 1	1.747	2.645	0.815	1.801
	2.995	2.204	1.480	3.058
	2.038	2.402	2.136	1.820
	1.568	3.058	3.174	2.233
	1.670	2.791	2.402	2.301
		1.951		1.917
		3.009		1.956
		2.000		1.956
				2.068
				0.927
	10.018	20.060	10.008	20.035

Table E1 - The lengths of the wall stones in the upper chamber of the Great Pyramid, Smyth's measrements converted to cubits

The stone lengths are listed descending in the table representing from left to right when looking at the walls from inside the chamber.

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