DISCUSSIONS IN EGYPTOLOGY

29

1994

DISCUSSIONS IN EGYPTOLOGY ISSN 0268-3083

Editor: Alessandra Nibbi
Reviews Editor: Angela Tooley

Discussions in Egyptology 29, 1994 ISSN 0268-3083

TABLE OF CONTENTS

DISCUSSIONS IN EGYPTOLOGY: GUIDELINES

Annual Subscription consisting of three numbers from January of each year.

£23 for United Kingdom; £25 for surface mail abroad.
Students: £20 for United Kingdom; £21 for surface mail abroad.
Airmail abroad: £5.00 extra.
Single number: £10.00 **Back numbers:** £15.00

(Prices to change next year).

To be paid, in sterling only, please, to:

Discussions in Egyptology,
13 Lovelace Road
OXFORD OX2 8LP
United Kingdom

or

Discussions in Egyptology
A/c no 08268134
National Westminster Bank plc
Oxford Cornmarket Branch
542123
OXFORD OX1 3QH

Subscribers may find that the Post Office giro is the cheapest way to send this money.

Contributions should be sent to the above address.

a) They should be clearly typed in black ink, preferably on a new ribbon, on A4 paper, with margins of at least 3 cm at the top and 2.5 cm at sides and bottom. The lines should be well-spaced to allow for the effects of reduction because the sheets go to press just as we receive them. For reasons of cost, we prefer illustrations to be line drawings, but if the occasional photograph is necessary, please make sure that there is sufficient contrast so that it will reproduce satisfactorily.

b) Please type on one side of the sheet only.

c) It is to everyone's advantage to include a short summary with each contribution, to facilitate its inclusion in the *Annual Egyptological Bibliography*.

d) Each contributor will receive 25 offprints free.

e) When preparing for the post, please protect against accidental folding by enclosing some stiff cardboard inside the envelope.

f) Our numbers are now filling early so that articles are often held over until the next number.

Discussions in Egyptology 29, 1994 ISSN 0268-3083

The Stellar Geometry of the Great Pyramid

R. J. Cook

The recent discovery by Rudolf Gantenbrink of a 'door' or 'plug', terminating the southern shaft leading upwards from the Queen's Chamber inside the Great Pyramid, focusses attention upon a new 'star correlation theory', developed in the pages of this journal by Robert Bauval (1). Bauval has presented evidence to support the proposition that IVth dynasty funerary monuments were built as a counterpart to a heavenly landscape - the three Giza pyramids corresponding to the three stars of Orion's belt (2). He has further developed the discovery of Badawy and Trimble (3) to conclude that the four shafts leading upwards from the King's and Queen's chambers are 'starshafts', and aimed at the culminations of certain stars having particular cultic significance - in particular, the King's Chamber south shaft pointing towards the star Al Nitak which itself corresponds to the Great Pyramid in the heavenly scheme.

This starshaft correlation has recently been rejected by John Legon (4), who argues for the orthodox view that the shafts were designed to ventilate the chambers during building or ritual occupancy. Although one is offered an ingenious explanation to account for the fact that the Queen's Chamber shafts were sealed at both ends, no reason is given for the existence of two shafts for each chamber when one would have sufficed. A somewhat more cogent reason for the rejection is that the shaft angles given by Petrie (5) do not with precision align with the suggested stellar targets. However, Gantenbrink has now provided (6) the preliminary results of his resurvey and the revised shaft angles strongly point to an astronomical interpretation. More surprising still, these same angles indicate the geometry of the pyramid itself.

The proportions of Khufu

The dimensions of Khufu's pyramid are generally agreed as height 280 and base 440 cubits of value 0.5237 m. - so that the height to base proportion is 7/11. It is also well known that these proportions can be very closely approximated as $2/\pi$ or $\sqrt{\phi}/2$. In the first case the height of the pyramid represents the radius of a circle whose circumference equals the perimeter of its base. In the second the pyramid is constructed according to the golden section, where $\phi = 1.618...$, and pyramid apothegm and base are in proportion $\phi/2$.

Starshaft angles and geometric correlation

The table below sets out the shaft altitudes recently given by Gantenbrink (together with their star targets) for comparison with the angles defined by the proportions of Khufu -

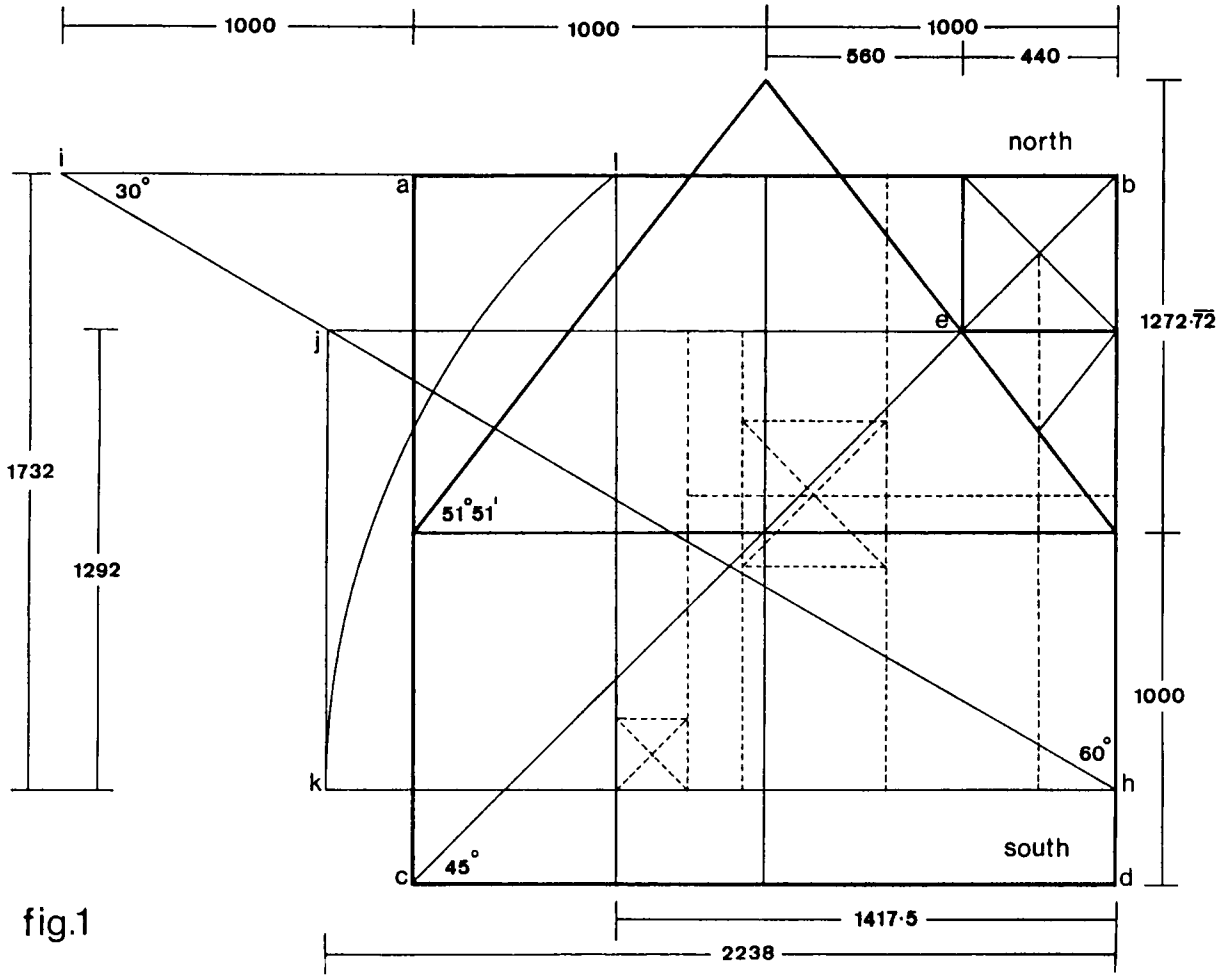
1000
1000
1000
560
440
north
i
30°
a
b
e
j
1272·72
1732
1292
51°51'
1000
60°
k
h
45°
c
south
d
1417·5
2238

fig.1

SHAFT	TARGET (Culmination)	ALTITUDE	GEOMETRIC IDEAL
KC North	Thuban (pole star)	$32^{\circ}28'$ (!)	Tan $32^{\circ}28'$ = 7/11
KC South	AlNitak (Osiris)	45°	Tan $45^{\circ}00'$ = 1
QC North	Kochab (adze)	39°	Tan $38^{\circ}58'$ = $\phi/2$
QC South	Sirius (Isis)	$39^{\circ}30'$	Sin $39^{\circ}29'$ = $\phi/2$

This close correlation prompts us to seek a geometrical solution to the positioning of the starshafts.

The Layout Pyramid

If we construct a model pyramid of side 2 units then its height will be in proportion 14/11 = 1.2727.. This model is effectively provided by the site layout.

Legon has described a Giza site plan (7) based upon simple geometrical proportion and developed from a square of 1000 cubits as unit. The writer's version of this plan is presented in Figure 1. The square ABCD of side 2000 cubits represents the base of our model pyramid. The 'height' of this pyramid will therefore be 1272.72. When the meridian section is superimposed upon the base as shown, then the 'side' of the pyramid intersects the diagonal of the square at point E to locate the southwest corner of Khufu and define its dimensions.

The rectangle defined by the northeast corner of Khufu and the southwest corner of Menkaura measures 1732 cubits north/south and 1417.5 cubits east/west. The former quantity is given by a simple root three construction on a base of 1000 cubits - as indicated by the line HI. The south side of Khufu is extended to intersect this line at J. JK is the base of an equilateral triangle of height 2238 cubits and an arc of this radius with centre H is drawn to point L to define the east/west dimension of the plan. (The dotted lines indicate the elaboration of this scheme to define the placing of Khafre (8)).

The geometry of the starshafts

In figure 2 the positions of the starshafts have been plotted onto four meridian sections of the pyramid using data from Petrie and Gantenbrink and it will be seen that they coincide with a geometrical model identical to that found in the layout (at one tenth scale).

Petrie calculates the intersection of shaft floorline and casing for the north shaft 151.2 cubits above pavement, and for the south shaft 152.5 cubits. Gantenbrink has announced that both shaftmouths are at the same level, giving a figure 153.9 cubits above base (9).

At a level 152.72 cubits above base the shaftmouths are seperated by a horizontal distance of 200 cubits. The alignment to Al Nitak becomes the diagonal of a square representing the base of the model pyramid. The alignment to Thuban is seen to be the diagonal of a rectangle enclosing the pyramid section.

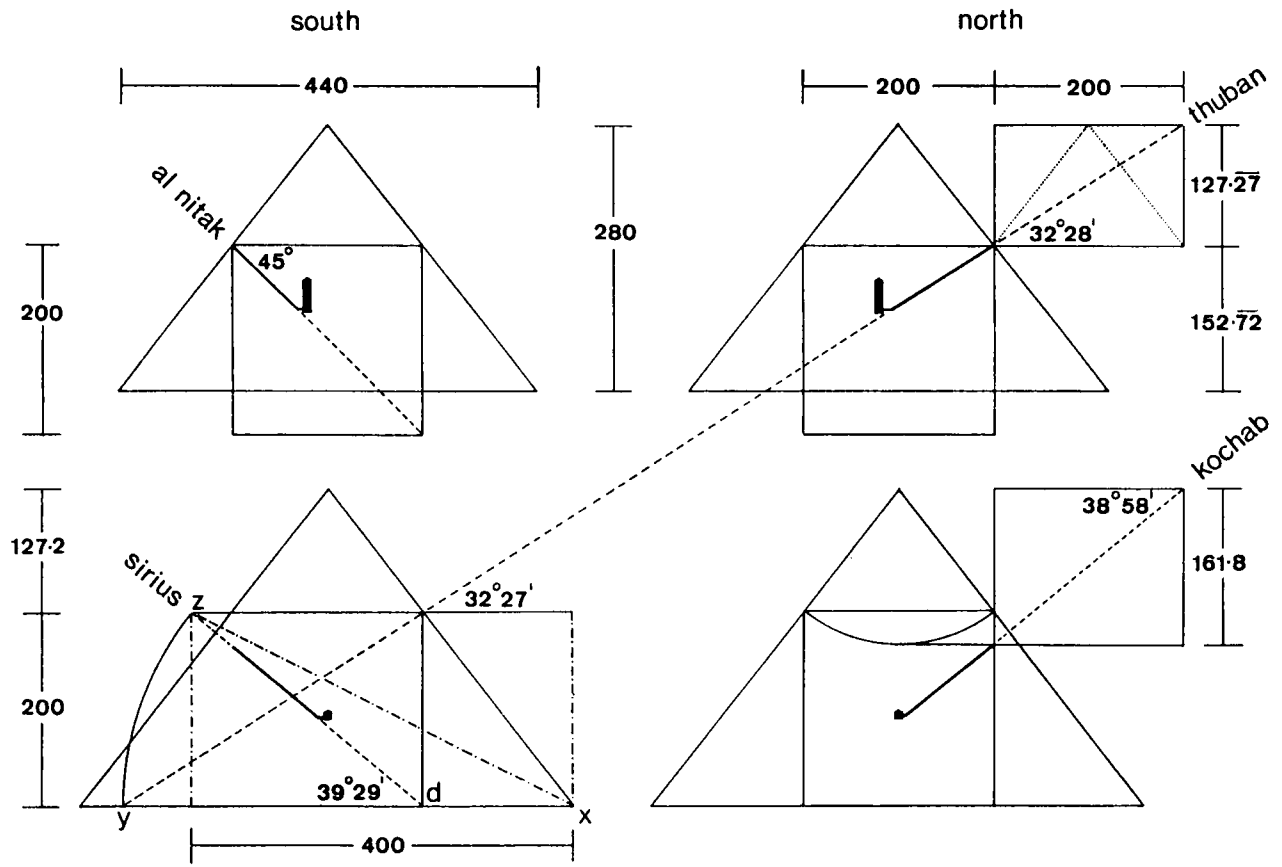
south
north
440
200
200
thuban
al nitak
45°
280
200
127·27
32°28'
152·72
kochab
38°58'
127·2
161·8
sirius
z
32°27'
200
39°29'
d
y
x
400

fig.2

The geometry of the Queen's Chamber shafts appears to be subtly different, with the proportions of the pyramid determined according to the Ø relation so that its base and height are in proportion 200 : 127.2.

The north shaft of the Queen's Chamber points to Kochab, whose culmination signals the 'Opening of the mouth'(10), and this in turn is given by the 'opening' of the pyramid profile to form a rectangle of proportions 200 X 161.8 (Ø X 100) cubits. The diagonal of this rectangle is the north shaft.

The south shaft of the Queen's Chamber points to Sirius. The Thuban alignment intersects the square base level at point Y. With centre D an arc is made from Y to point Z to give the south shaft. The line XZ is the diagonal of a double square of side 200 cubits and the general line of the upper passages.

The square of side 200 cubits is shown in figure 3 at larger scale in order to include other architectural elements. The axis of the King's Chamber lies 21 cubits south of the east/west plane of the pyramid, or 79 cubits north of the south side of the square, and this is mirrored on the north side of the square in the placing of the Grand Gallery. If the plan of the upper passages is superimposed upon this figure (with common reference axis MN and centre O) then a further suggestive correlation appears. The King's Chamber floorplan measures 10 X 20 cubits and its east side lies 15 cubits east of the reference axis (this dimension being derived from the diagonal of the end wall of the chamber). The diagonals of the floor intersect the central axis at points Q and P - 37 and 47 cubits respectively from centre. This latter dimension is very close to the 47.27 cubits required by the preceding analysis.

Naturally these results remain to be verified against the published figures of the new shaft survey. Yet the simplicity of the geometric scheme described here is very compelling. Moreover, because the proportions of this pyramid (and of the layout) are defined both geometrically from first principles and, with reasonable precision, 'astronomically' from the altitudes of cult stars at the time of building, we are provided with a possible means of interpreting the geometry in terms of the cult.

* * *

We have little idea of the conditions under which the pyramids were built (nor even how this was achieved) but it is certainly possible that the majority of the population were willing participants in the construction of the pyramids - an earthly counterpart to the dramatic landscape nightly on view to them all. Like the mediaeval mayors of small provincial towns, who yoked themselves to ox-carts for the honour of offering stones to the building of the first Gothic cathedrals, their motivation would essentially have been religious. Egypt was under the spell of a myth, promulgated by the priesthood and enacted in the heavens.

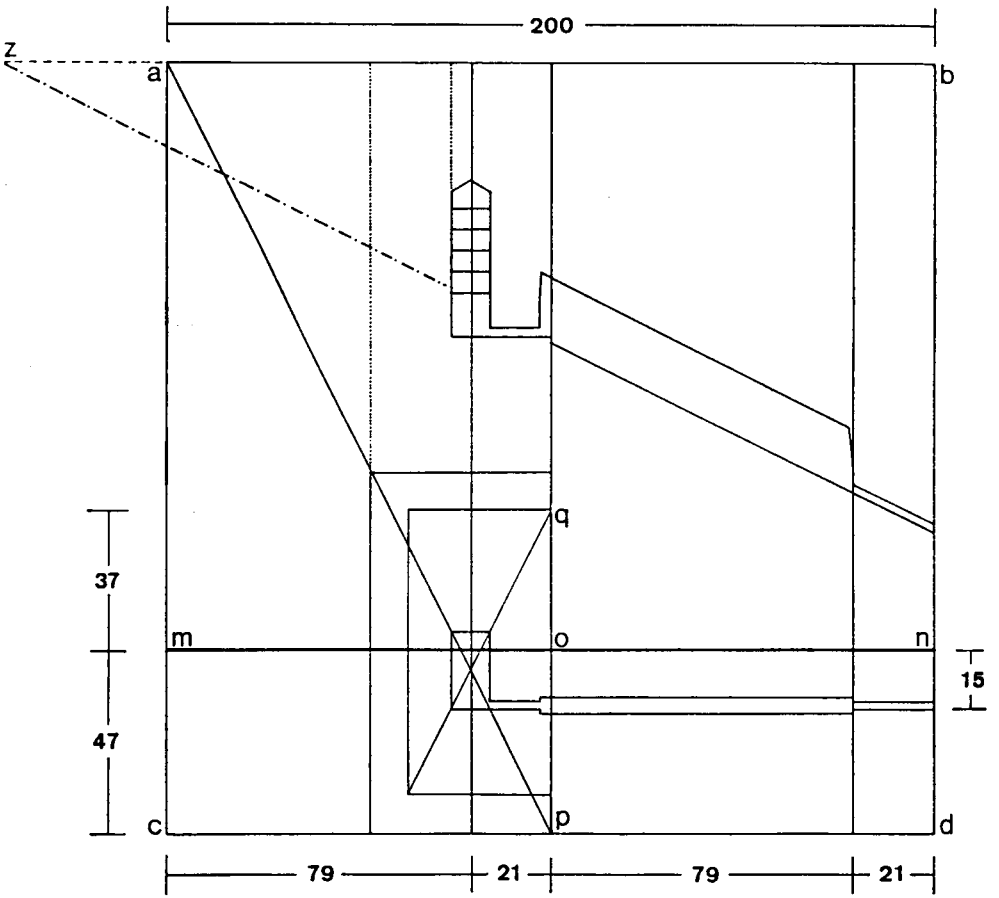

fig.3

These priests, at the estimated epoch 2450 B.C.(11), celebrated a remarkable coincidence existing between heaven and earth - between astronomical event (the culmination of important cult stars, the azimuth of the sunrise at the heliacal rising of Orion (12), and other features) and elementary geometry. A record of that event was built as the Great Pyramid, and its companion stars laid out within its geometric orbit.

Notes and references

1. See series of articles 1989 onwards.

2. Bauval, R.G. 1989. 'A Master Plan for the Three Pyramids of Giza based on the Configuration of the Three Stars of the Belt of Orion'. DE.13. and further papers.

3. Badawy, A. 1964. 'The Stellar Destiny of Pharaoh and the so-called Airshafts in Cheops' Pyramid'. MIOAWB. band 10.
Trimble, V. 1964. 'Astronomical Investigations concerning the so-called Air-shafts of Cheops' Pyramid'. MIOAWB. band 10.

4. Legon, J.A.R. 1993. 'The Air-Shafts in the Great Pyramid'. DE.27. and 1993. 'Airshaft alignments in the Great Pyramid'.DE.28. To my knowledge no other tombs are ventilated, and recent cleaning and survey work inside the Queen's Chamber has not revealed any special ventilation problems. If the Egyptians really had wanted to ventilate the pyramid chambers then it is difficult to understand why they embarked upon a scheme which, contrary to the impression given by Legon, would have required a great deal of work - the construction of angled shafts requiring many polygonal blocks to be fitted within the core-masonry. The effort required to construct these shafts, and their formal paired design emerging with symmetry on the pyramid faces, suggests that they had a purpose more important than that of ventilation. Yet Legon appears reluctant to accept the importance of the astral elements in the cult, so clearly associated with the pyramid's alignment and design,

5. Petrie, W.M.F. 1883. The Pyramids and Temples of Gizeh. London.

6. Personal communication to Robert Bauval. The preliminary estimate for the angle of the Queen's Chamber south shaft of 40° (given in by Bauval in DE.27) must be adjusted to 39.5° as shown in Bauval's diagram in DE.28.
Legon (in DE.28) provides a table of star declinations but does not allow for the variation one would expect in naked eye astronomy and construction work - accepted by astronomers and construction workers as plus or minus 20 arcminute variation. If this is applied to the angles provided by Gantenbrink one can see from the table that the best date one can allocate to the pyramid is c. 2450 BC. plus or minus 50 years.

Legon rightly observes that the shaft angles increase by about 1 degree from bottom to top. This may partly be explained in stellar terms - the altitudes of the stars in question would have changed during the construction period of the monument and the Egyptians may have 'built to follow a star'. However if, as argued by the present writer, Gantenbrink's angles correspond to geometric ideals symbolising key stellar alignments, (the striking example being the angle given for the north shaft of the King's Chamber 32° 28'), then they cannot be used for strict dating purposes.

7. Legon, J.A.R. 1988. 'A Ground Plan at Giza'. DE.10.

8. See Cook, R.J. 1992. The Pyramids of Giza. Glastonbury; and forthcoming.

9. The discrepancy with Petrie is considerable. Gantenbrink's figure seperates the shaft-floorline intersections with the casing by a distance of 198 cubits horizontally (equal to the vertical dimension from apex to King's Chamber floor level) rather than the 200 cubits of the present analysis. This may reflect a complementary geometric scheme. Pending Gantenbrink's published results I take here a mean figure.

10. Bauval, R.G. and Gilbert, A. 'The Adze of Upuat : The Opening of the Mouth Ceremony and the Northern Shafts in Cheops' Pyramid'. (Projected 1994).

11. Bauval, R.G. 1993. 'Cheop's Pyramid : A New Dating using the Latest Astronomical Data'. DE. 26.

12. Bauval, R. G. and Cook, R. J. 'The 'Sons of Ra' and the Osirian Rebirth of the Pyramid Kings.' Appendix to Bauval and Gilbert. 1994. The Orion Mystery. London.

R. J. Cook

December 1993.