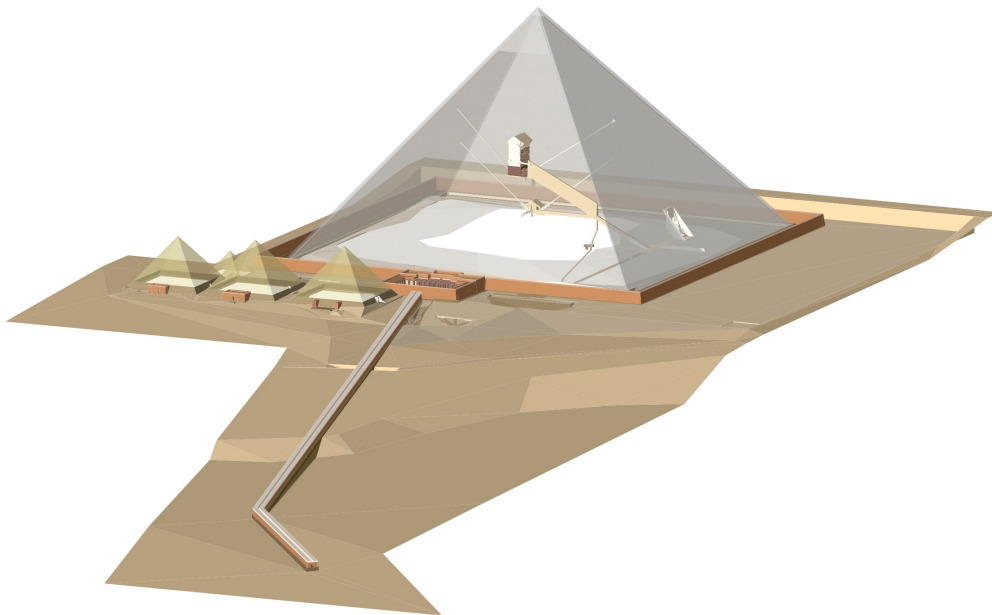


Architectural Visualization of the Great Pyramid of Khufu and Its Complex

Abstract

This paper presents detailed architectural drawings of the most famous stone structure of the ancient world, the Great Pyramid of Khufu and its complex. The drawings were created from data accumulated by archaeologists, architects and Pyramid explorers over the past two centuries, and are part of a massive project called 'All Pyramids'. The study of the Great Pyramid from an architectural and engineering point of view is the key to understanding how it could have been built, so the drawings with the attached architectural model can not only serve as a good start for studying, but also will facilitate the work of all researchers of this mysterious structure¹.



Architectural model of the Great Pyramid Complex made by Serafima Polikarpova

Keywords: Great Pyramid, Cheops, Khufu, Egypt, Pyramids, architecture, technical drawings, engineering, Flinders Petrie, Vito Maragioglio, Celeste Rinaldi, Rudolf Gantenbrink, Gilles Dormion, Mark Lehner, David Goodman, All Pyramids.

¹ I would like to express my sincere gratitude to Igor Yatskovich for proof-reading the English text of this paper. Any remaining mistakes are the responsibility of the author.

Introduction

The Great Pyramid of Khufu is probably the most popular object of study not only among Egyptologists, but also among specialists from various fields, but despite this, the Pyramid still continues to hide its secrets for several millennia. This circumstance is confirmed by the amazing discovery in 1993 of the so-called 'Gantenbrink's door' with copper pins in the southern 'air shaft' of the Queen's Chamber. Furthermore, in 2017 the ScanPyramids Project using muonic particles revealed a large unknown cavity above the Grand Gallery. However, the most recent sensational statement by the researchers of the mentioned project was the discovery of a previously unknown 9.5 m long chamber above the original entrance to the Pyramid in March 2023. Apparently, the last 30 years of studying this monument brought only surprises for researchers, often not even directly related to archeology, and this means that the unification of the efforts of specialists from different branches of science is bearing fruit.

Over the past two centuries of the existence of Egyptology as a science, the Great Pyramid has been studied by a large number of archaeologists and like-minded enthusiasts, however, from an architectural and engineering point of view, the most significant are the works of the following researchers:

- William Matthew Flinders Petrie, a British Egyptologist, carried out archaeological research and accurate measurements of the Great Pyramid between 1880 and 1882. His meticulous measurements and research report *The Pyramids and Temples of Gizeh* still remain in the golden fund of fundamental pyramid research.
- Kamal el-Mallakh, an Egyptian archaeologist, inspector of the Department of Antiquities, discovered in 1954 two sealed boat pits containing intact cedar solar boats on the south side of the Great Pyramid.
- Vito Maragioglio and Celeste Ambrogio Rinaldi, Italian architects, published detailed descriptions and scale drawings of the interior and exterior of the Great Pyramid in 1965 under the title *L'Architettura delle Piramidi Menfite. Le Grande Piramide di Cheope* as the 4th volume of a multi-volume study of the pyramids of Memphis.
- Mark Lehner, an American Egyptologist, and David Goodman, a surveyor, under 'The Giza Plateau Mapping Project' in 1984, conducted a comprehensive geodetic survey of the base of the Pyramid to accurately determine its length and orientation to the cardinal points.
- Zahi Hawass, Egyptian archaeologist, head of the Supreme Council of Antiquities, has been excavating and restoring the Giza Plateau on the east side of the Great Pyramid. In 1991, his team discovered the base of a previously unknown cult pyramid (G1-d) on the southeast side of the Pyramid.
- Rudolf Gantenbrink, a German engineer, and Rainer Stadelmann, an Egyptologist from the German Archaeological Institute (DAI), using specially designed robots with a camera (Upuaut I, Upuaut II) cleared and studied the 'air shafts' of the King's Chamber, and partially of the Queen's Chamber in 1992-1993. Detailed drawings of the shafts they explored were published on Rudolf Gantenbrink's website.
- Gilles Dormion, a French architect and independent researcher, published a book of drawings in 2004 called *La chambre de Chéops. Analyse architecturale*, where he described his research and measurements of the interior of the Great Pyramid. In terms of accuracy, quality and description of the details of the Pyramid, the book is one of the best of its kind.

Thus, the above-listed studies, complementing each other, together provide a unique 'picture' of the Great Pyramid and its complex, precisely as a separate architectural structure, with numerous engineering solutions and details.

Architectural visualization

As part of a large-scale non-commercial project and unified digital archive called 'All Pyramids', drawings and other data from all these scientific publications were studied in order to recreate the most accurate and detailed architectural 3D model of the entire Great Pyramid complex.

The model of the complex was created by the architect Serafima Polikarpova in 1:1 scale in ArchiCAD, an architectural BIM CAD program developed by Graphisoft for the design of architectural structures and solutions, as well as landscape elements.

For the creation of the model of the Great Pyramid, the key data, such as the location and dimensions of the interior chambers and corridors, the design and location of the entrance, and other details were taken from the drawings of Gilles Dormion. His data was largely supplemented by details from the descriptions and drawings of Vito Maragioglio and Celeste Ambrogio Rinaldi. These clarifications mainly concerned the landscape and the complex around the Pyramid, the boat pits, satellite pyramids, Trial Passages, the mortuary (upper) temple, as well as the relieving chambers and other small details of the Pyramid itself. The use of geodetic data from 'The Giza Plateau Mapping Project' helped to more accurately determine the lengths of the sides of the base of the Pyramid and the platform on which it was erected. Carefully carried out by Flinders Petrie, measurements of the height of each course of the Pyramid masonry made it possible to not only define its external structure, but also compare the core masonry and the location of internal chambers and corridors in order to search for structural connections. And finally, thanks to Rudolf Gantenbrink's published 2D and 3D drawings created in the AutoCAD software application (by Autodesk), despite their obsolescence in terms of software and some formatting difficulties, it became possible to recreate in detail the so-called 'air shafts' of the King's and Queen's Chambers in the Great Pyramid.

I would like to express my sincere gratitude to the architect Serafima Polikarpova, who, using the above-mentioned works, professionally, diligently and patiently worked on a 3D model of the Great Pyramid and its complex for many months, eventually creating a digital package of drawings.

The final architectural model in PLN format for the ArchiCAD software, along with the drawings are available for free download on the All Pyramids project website here: [model and drawings](#).

The 12 pages of detailed technical drawings provided in this work were created from an architectural 3D model of the Great Pyramid and its complex, and made public in the hope of helping everyone to delve into the details of the architectural and engineering solutions of this monumental structure.

Conclusions

The Great Pyramid of Khufu is the last surviving monument of the Seven Wonders of the World, a structure unparalleled in the ancient world. The length of the original base line of the Great Pyramid was 921 m with an average side length of 230.329 m, with an average azimuth of 3° 38" (0.061°), but the difference between the lengths of the sides is less than 10 cm. The base of the entire first course of the Pyramid masonry differs in height by less

than 2.1 cm from a perfectly horizontal level. These specifications are just a few of those often mentioned by researchers, but they highlight that the builders of this monument accomplished an engineering feat in their time.

To find out exactly what solutions were used in the construction of this structure and what skills its builders had, it is necessary to have the maximum amount of data collected in one place. The created architectural 3D model of the Great Pyramid and its complex and the technical drawings made on its basis are intended for this purpose, as well as for researchers of all directions, both professionals and amateurs.

The work does not claim to be perfect or exhaustive, but strives to be so. Therefore, if the reader has any comments or a desire to add details to the model itself or the drawings, the author will gladly accept it.

Viewing a simplified 3D model of the Great Pyramid and its complex for those with an account in the 3D Warehouse online platform is available [here](#).

Simplified 3D models of the Great Pyramid and its complex in pln, skp, 3ds, bmx, dwg, mtl, and obj formats² are available [here](#).

The mentioned model and drawings of the Great Pyramid complex are only a small part of a large project called All Pyramids (allpyramids.com).

The All Pyramids project is dedicated to the collection, arrangement and digitization of scientific information about all the pyramids and tombs in Egypt, and its conversion into a unified searchable digital archive. We are facing an impressive body of knowledge scattered across various, often hard to access sources in various languages.

In this archive the following is available to everyone:

- Detailed characteristics of the pyramids with links to sources and authors of studies,
- Exact geographic location,
- History of archaeological research,
- Laboratory and field studies,
- Architectural 3D models,
- Detailed technical drawings,
- Image bank with archival and contemporary photographs,
- The most complete bibliography.

Work on the archive is still in progress, since the volume of material is colossal, but even now any researcher of the famous pyramids of Egypt can find a lot of information for themselves.

² I would like to express my sincere gratitude to the architect Roman Drozhzhin for kindly helping in formatting the finished model for use in other 3D programs.

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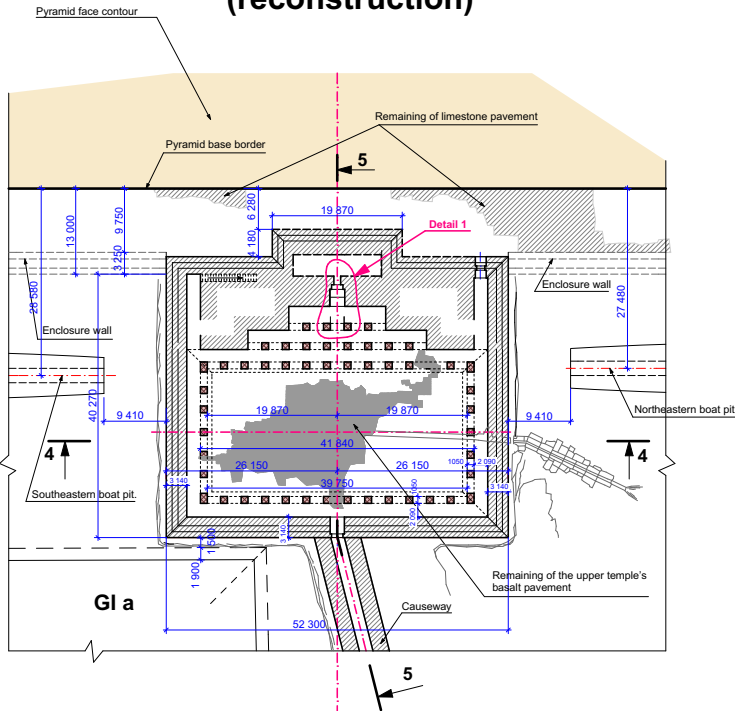
Nour, Mohammad Zaki, Mohammad Salah Osman, Zaky Iskander & Ahmad Youssef Moustafa. *The Cheops Boats*. Cairo: General Organization for Government Printing Offices, 1960.

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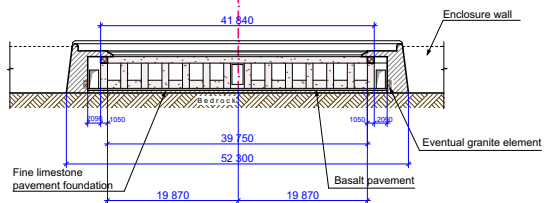
Petrie, William Matthew Flinders. *The Pyramids and Temples of Gizeh. New and Revised Edition*. London: Histories & Mysteries of Man Ltd., 1990 (1st ed. London: Field and Tuer, 1883).

The Great Pyramid of Khufu (Cheops)

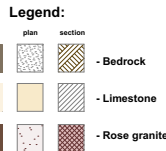
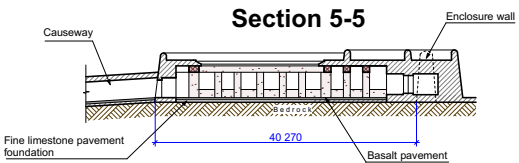
Plan View.
Upper Temple
(reconstruction)



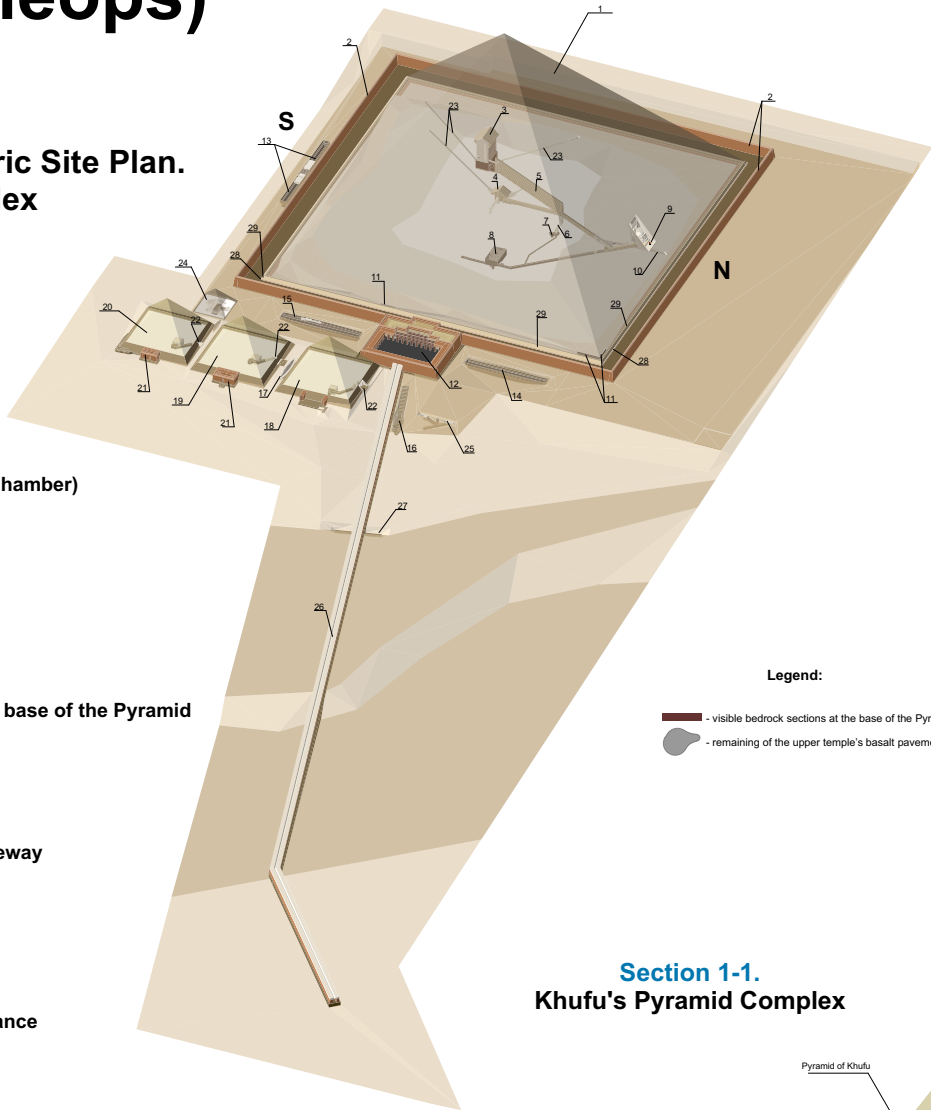
Section 4-4



Section 5-5



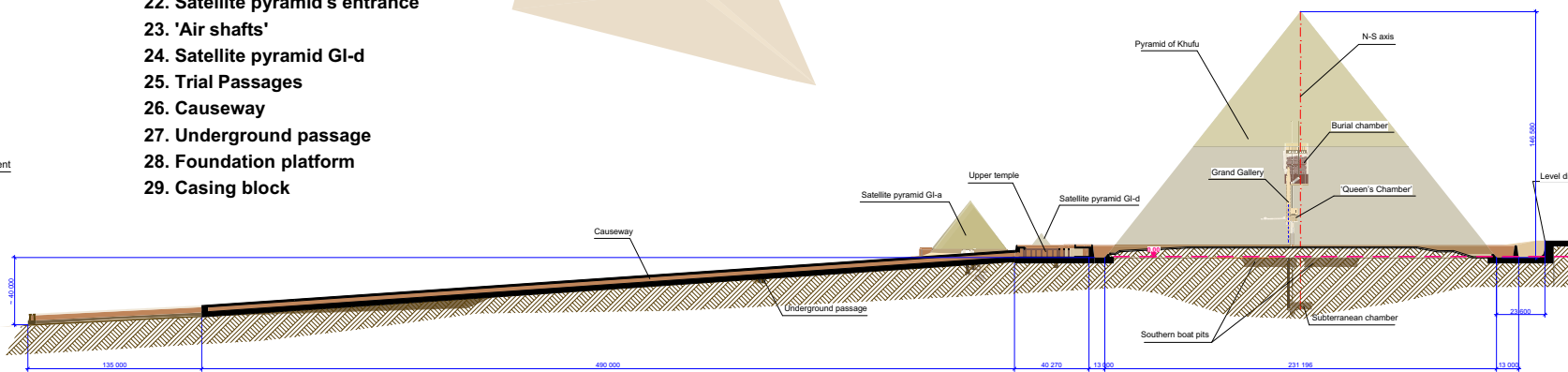
Axonometric Site Plan.
The Complex



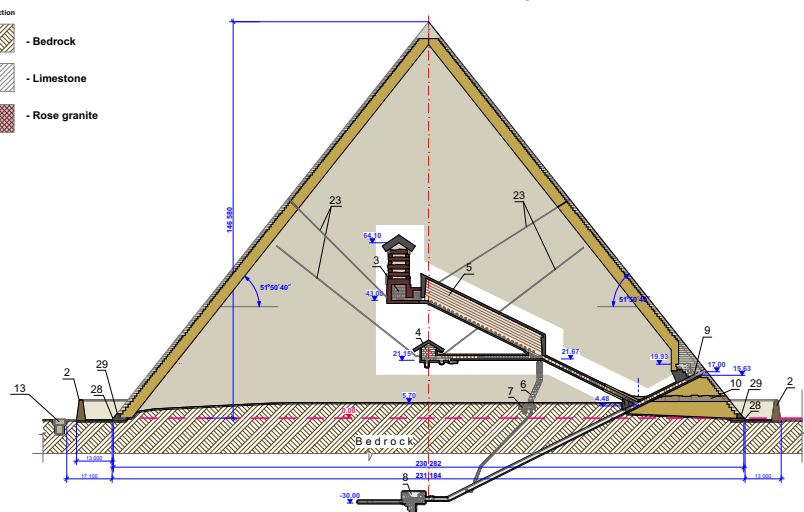
Legend:

1. Pyramid of Khufu
2. Enclosure wall
3. Burial chamber (King's Chamber)
4. 'Queen's Chamber'
5. Grand Gallery
6. 'Service shaft'
7. Grotto
8. Subterranean chamber
9. Entrance
10. Al-Mamun's tunnel
11. Bedrock sections at the base of the Pyramid
12. Upper temple
13. Southern boat pits
14. Northeastern boat pit
15. Southeastern boat pit
16. Boat pit along the causeway
17. Boat pit
18. Satellite pyramid GI-a
19. Satellite pyramid GI-b
20. Satellite pyramid GI-c
21. Eastern temple
22. Satellite pyramid's entrance
23. 'Air shafts'
24. Satellite pyramid GI-d
25. Trial Passages
26. Causeway
27. Underground passage
28. Foundation platform
29. Casing block

Section 1-1.
Khufu's Pyramid Complex



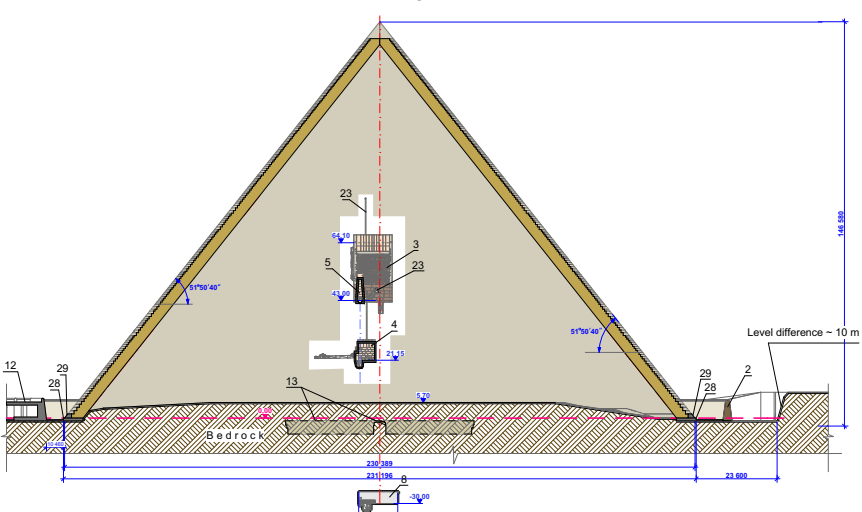
Section 2-2. Khufu's Pyramid Complex



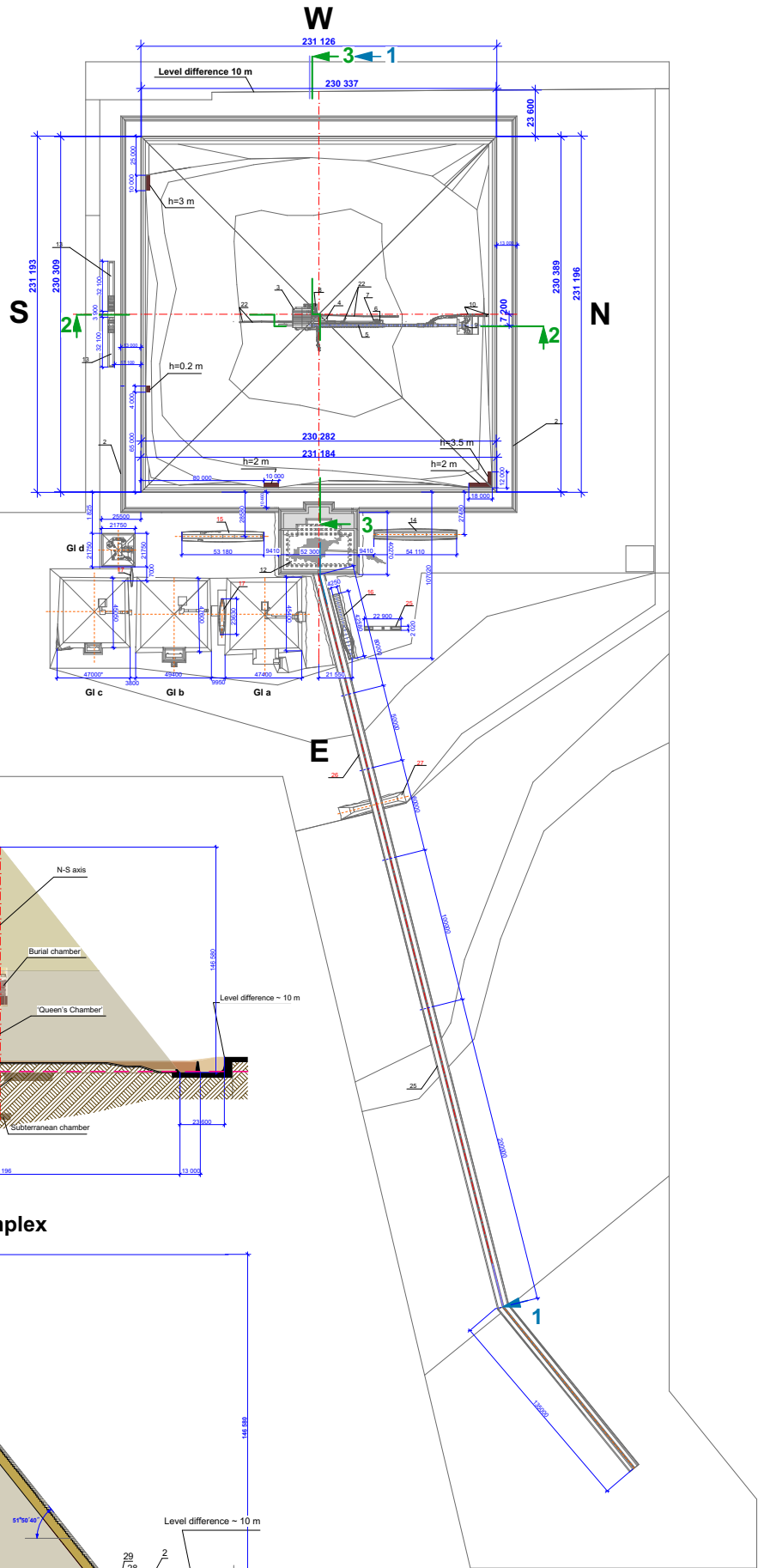
Legend:

- granite
- fine limestone
- limestone

Section 3-3. Khufu's Pyramid Complex



Site Plan of the Khufu's Pyramid Complex

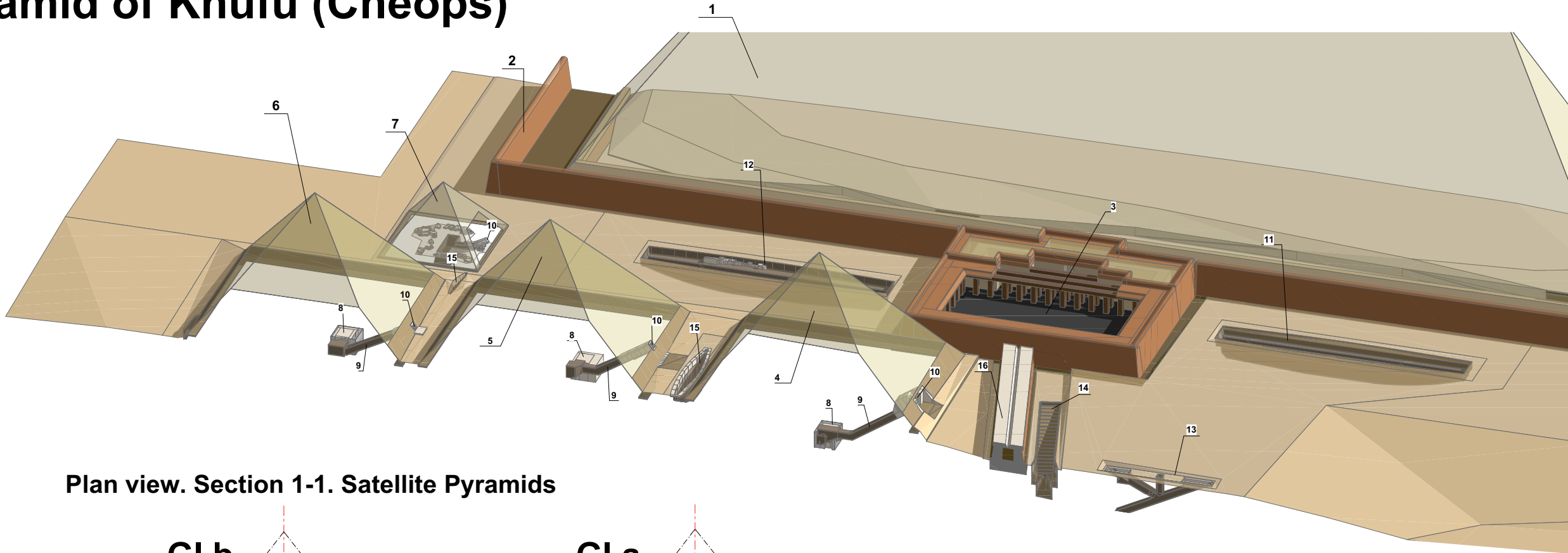


The Great Pyramid of Khufu (Cheops)

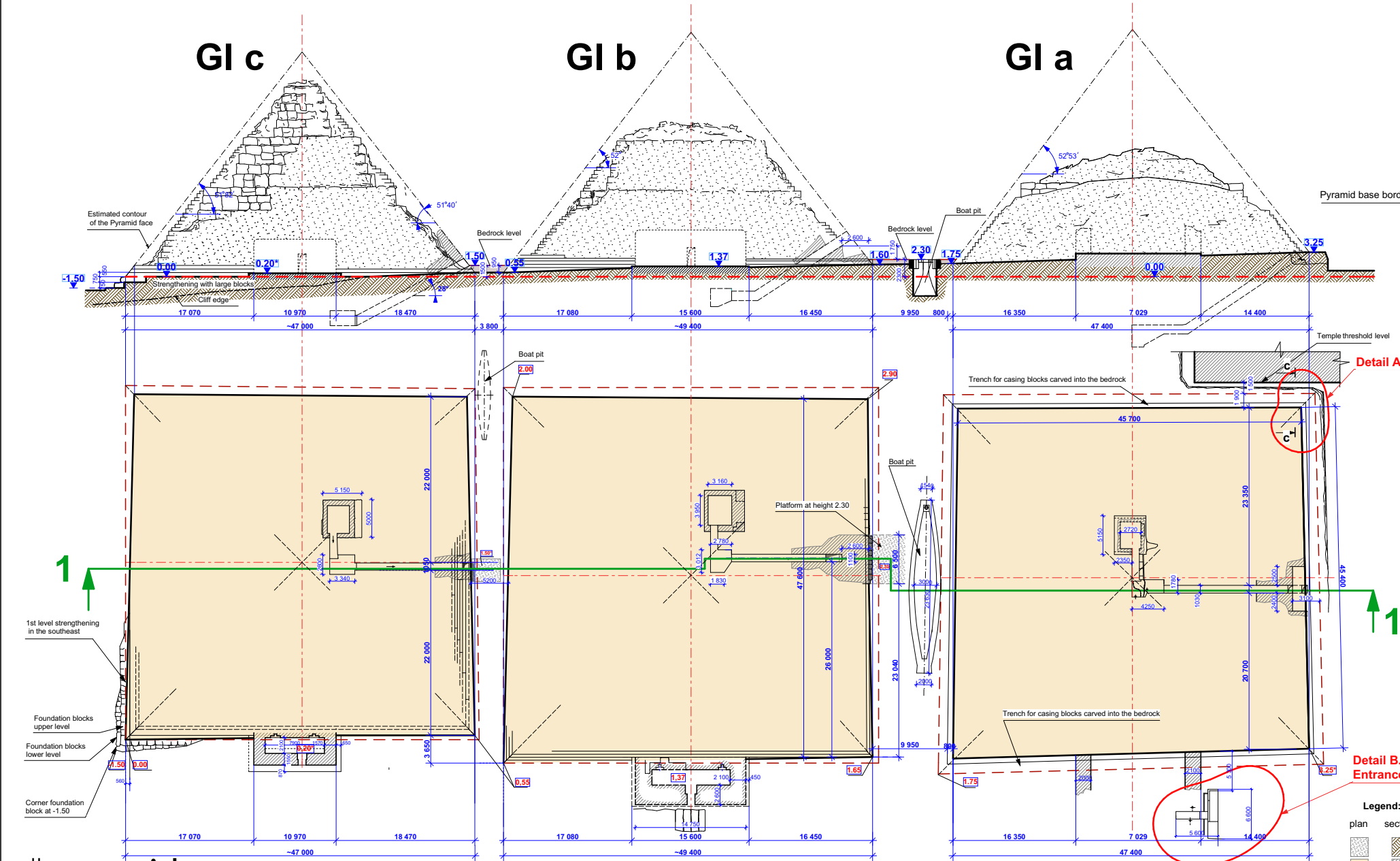
Satellite Pyramids

Legend:

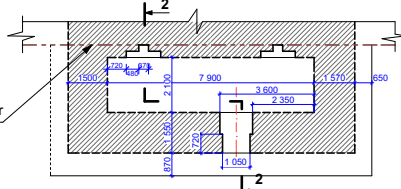
- 1. Pyramid of Khufu
- 2. Enclosure wall
- 3. Upper temple
- 4. Satellite pyramid GI-a
- 5. Satellite pyramid GI-b
- 6. Satellite pyramid GI-c
- 7. Satellite pyramid GI-d
- 8. Burial chamber
- 9. Descending corridor
- 10. Entrance
- 11. Northeastern boat pit
- 12. Southeastern boat pit
- 13. Trial Passages
- 14. Boat pit along the causeway
- 15. Boat pit
- 16. Causeway



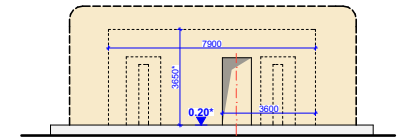
Plan view. Section 1-1. Satellite Pyramids



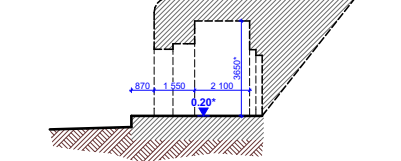
Plan View.
Temple of Satellite Pyramid GI-c



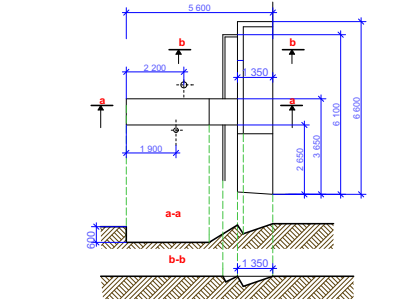
Temple Facade. Satellite Pyramid GI-c



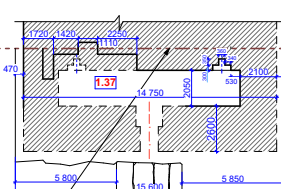
Section 2-2



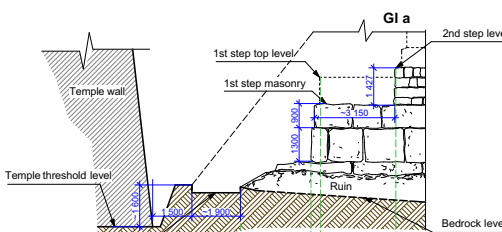
Detail B.
Entrance



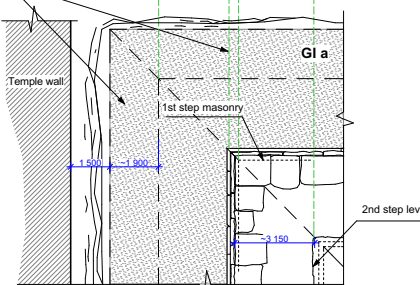
Plan View.
Temple of Satellite Pyramid GI-b



Detail A
Section c-c



Plan View. Detail A

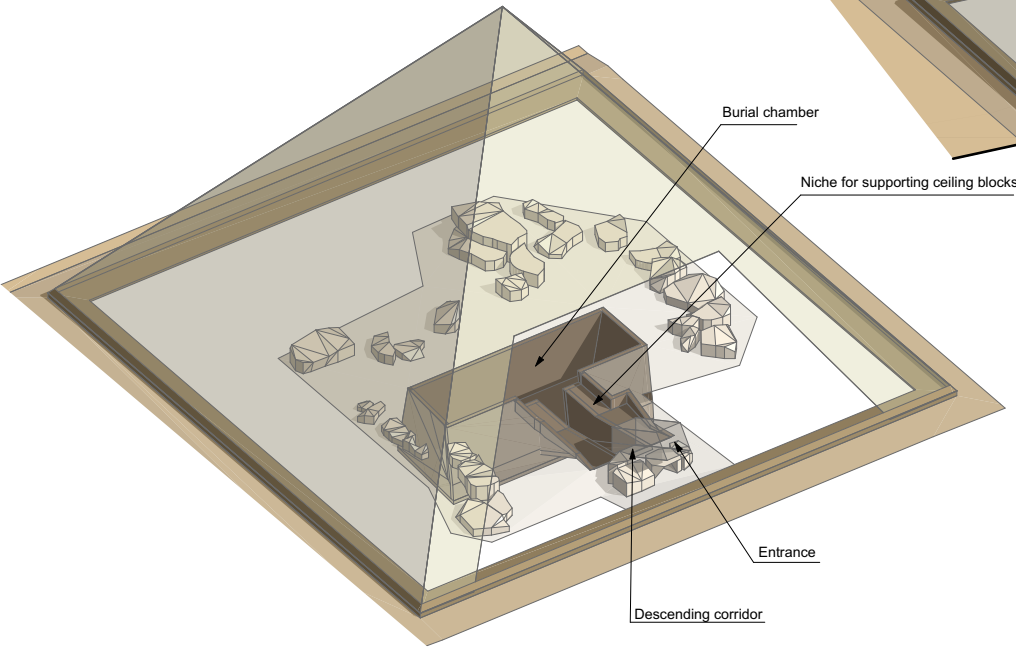


- Legend:**
- plan section
 - Bedrock
 - Limestone

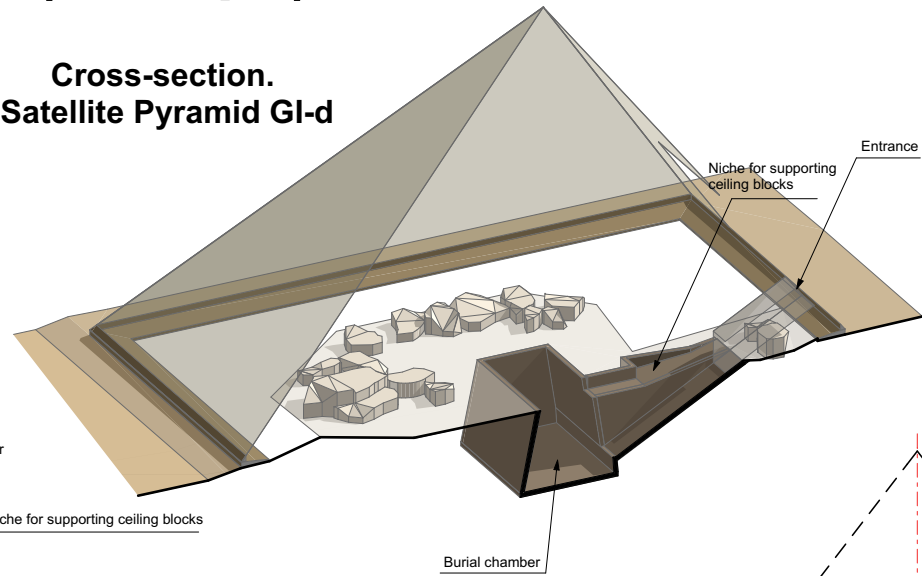
The Great Pyramid of Khufu (Cheops)

Satellite Pyramids

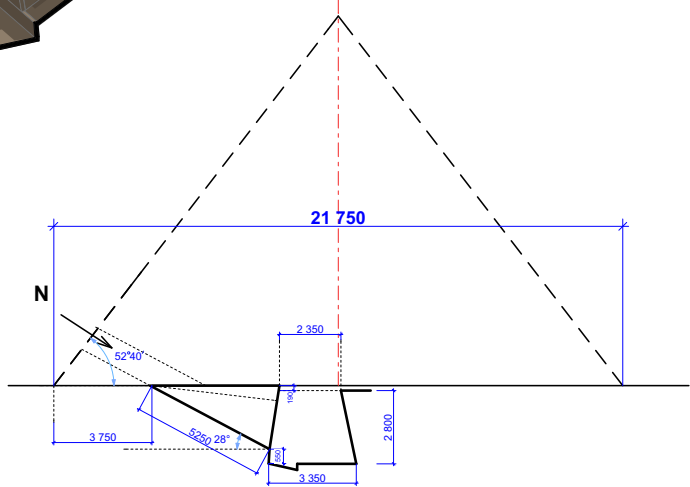
Axonometric Projection.
Satellite Pyramid GI-d



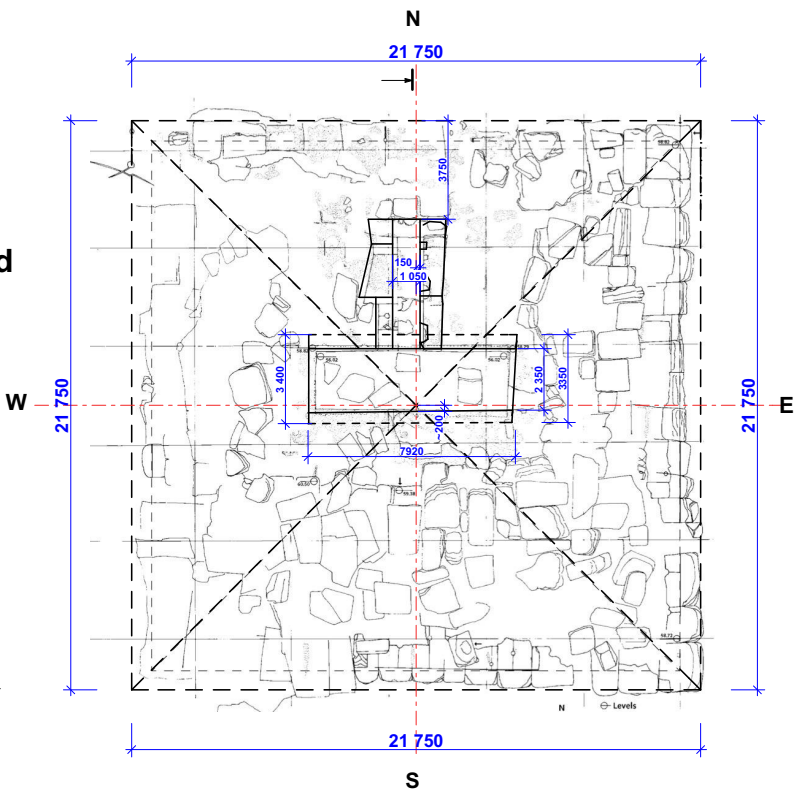
Cross-section.
Satellite Pyramid GI-d



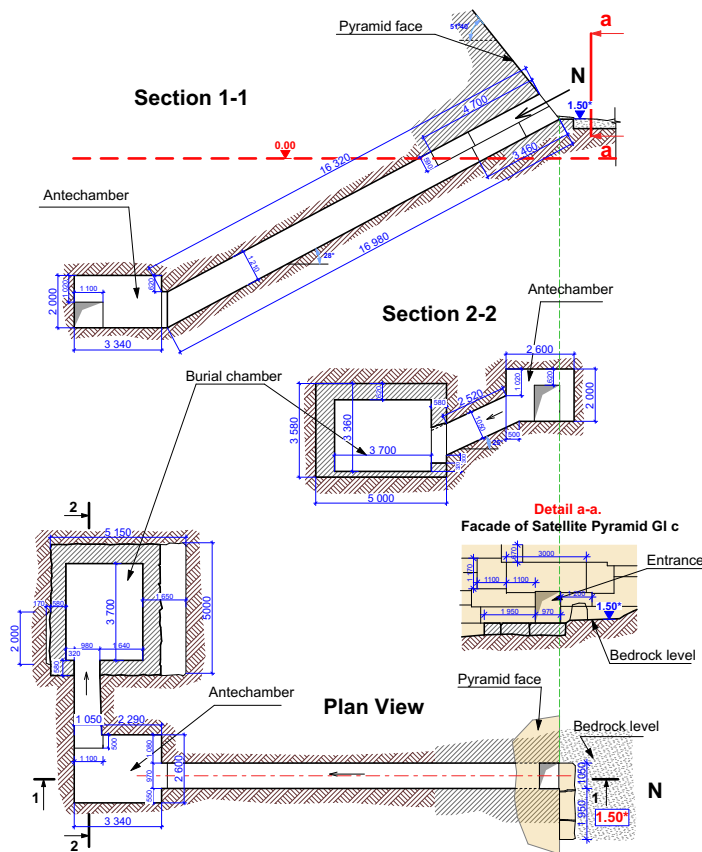
Section.
Satellite Pyramid GI-d



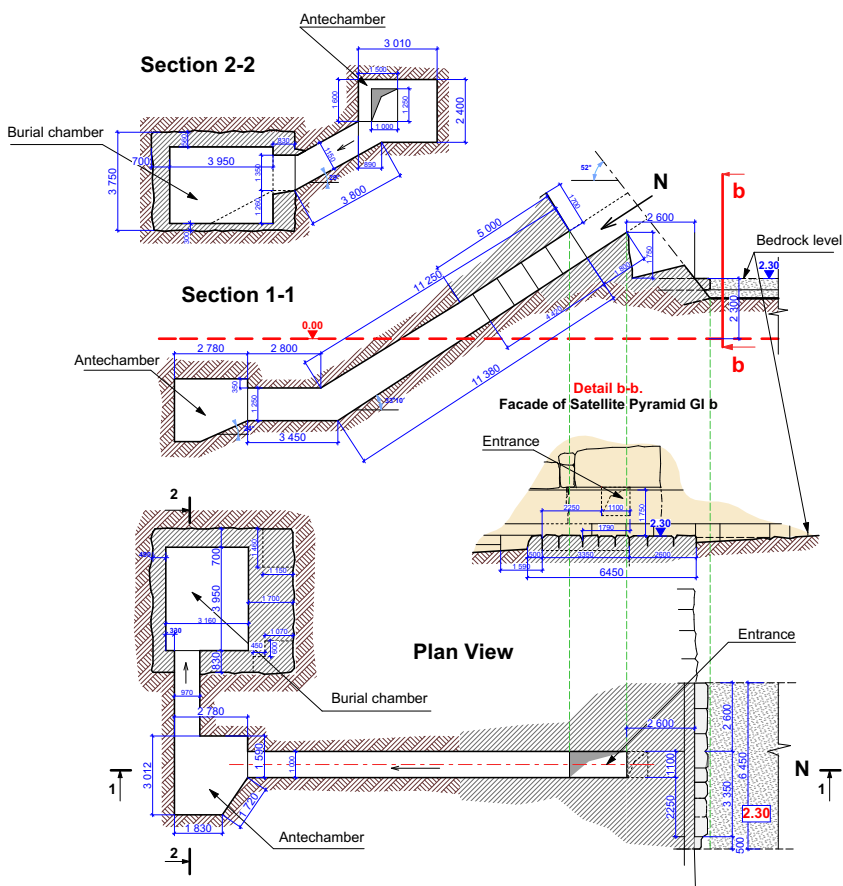
Plan View. Satellite Pyramid GI-d



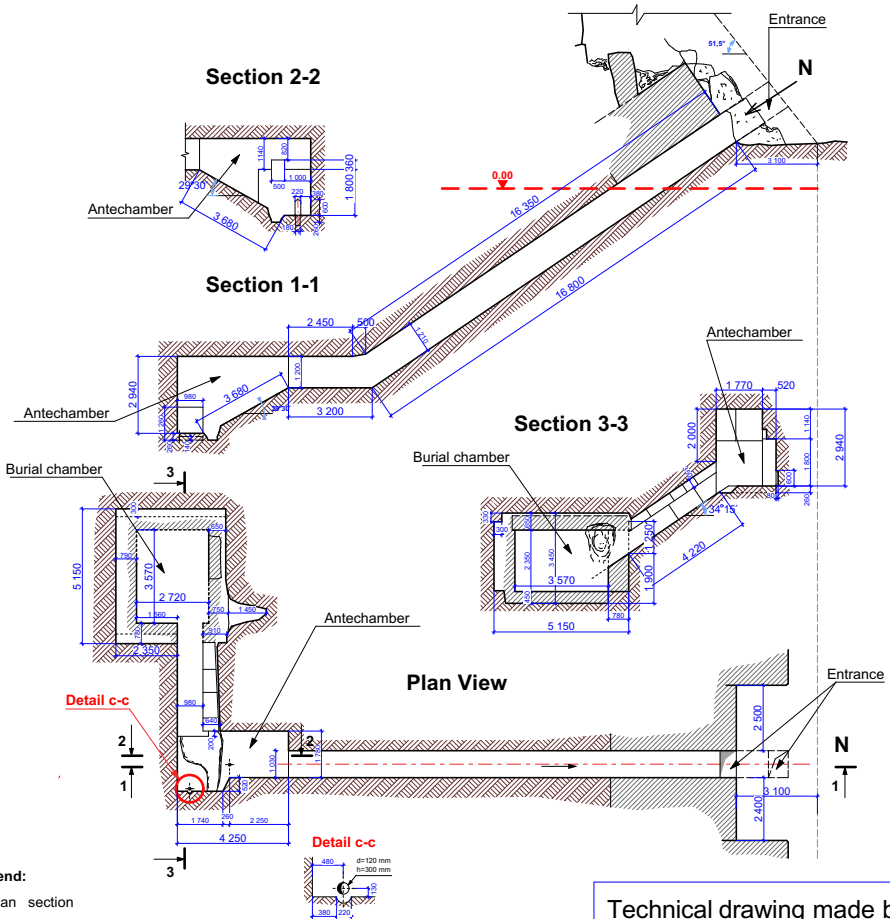
Pyramid Interior. Satellite Pyramid GI-c. Plan View and Sections



Pyramid Interior. Satellite Pyramid GI-b. Plan View and Sections



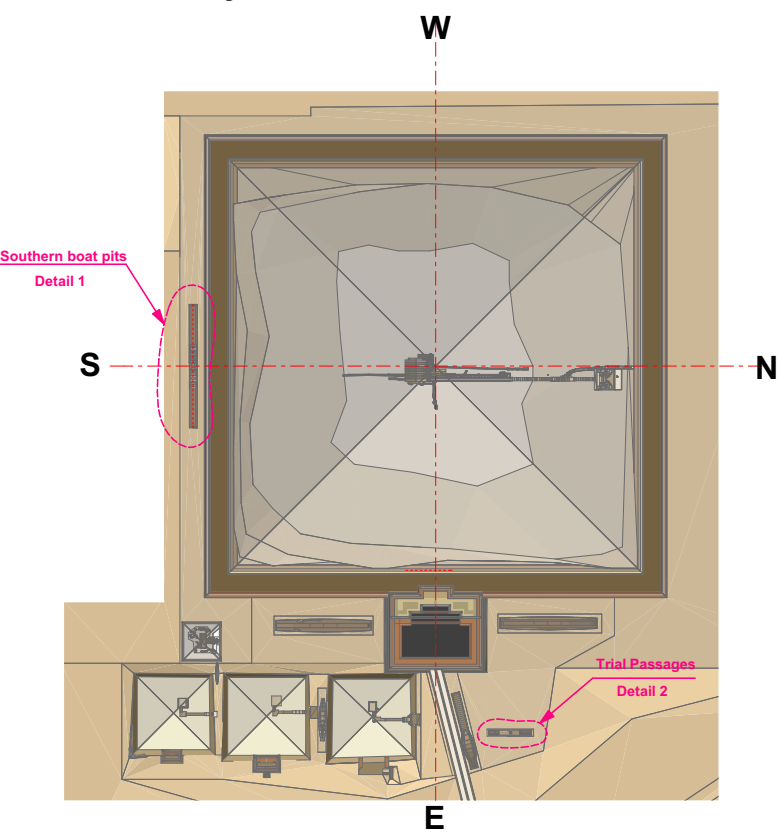
Pyramid Interior. Satellite Pyramid GI-a. Plan View and Sections



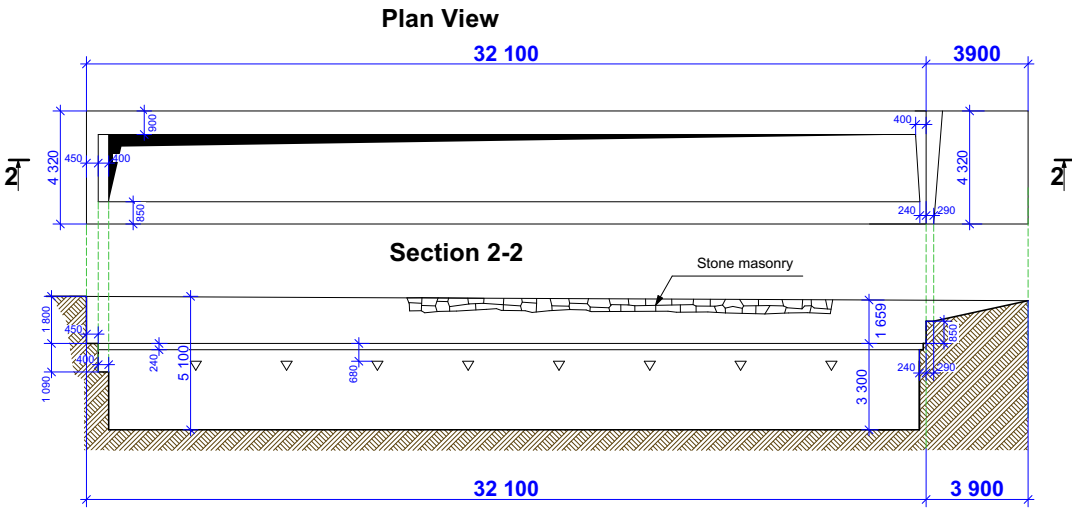
The Great Pyramid of Khufu (Cheops)

Southern Boat Pits and Trial Passages

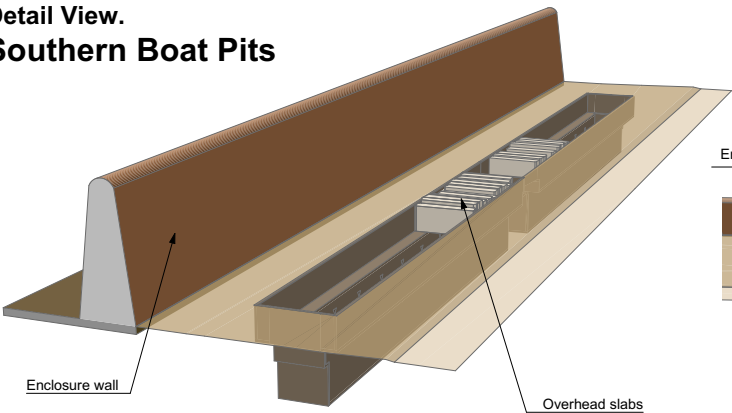
Layout of Elements on the Site Plan



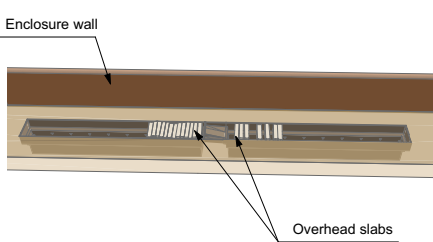
Detail 1. Southern Boat Pits



Detail View. Southern Boat Pits

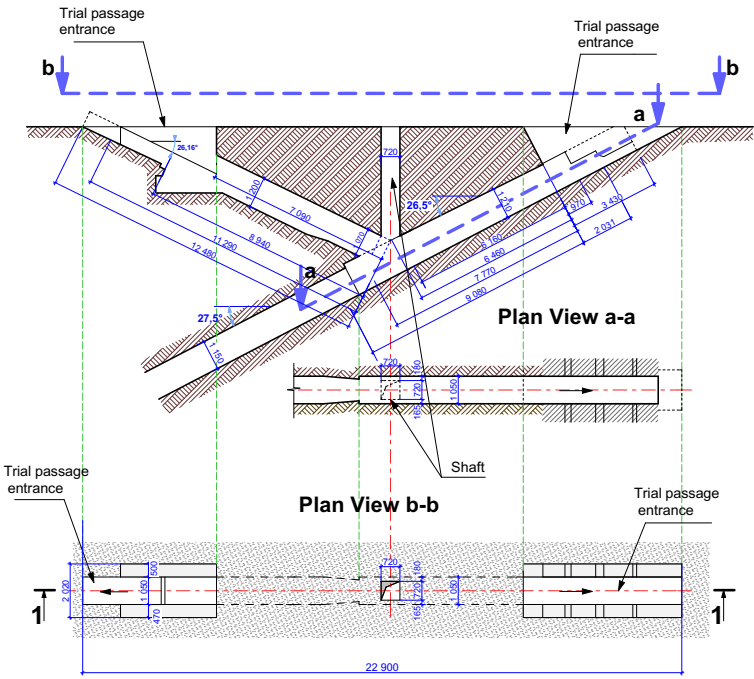


Detail View. Southern Boat Pits



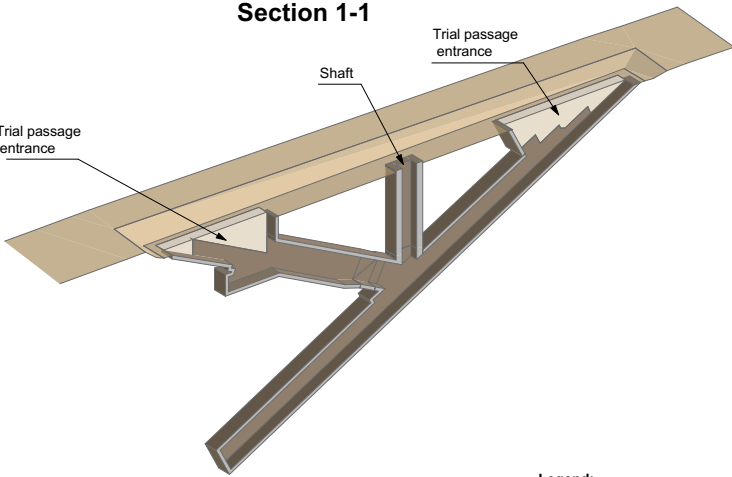
Detail 2. Trial Passages

Section 1-1



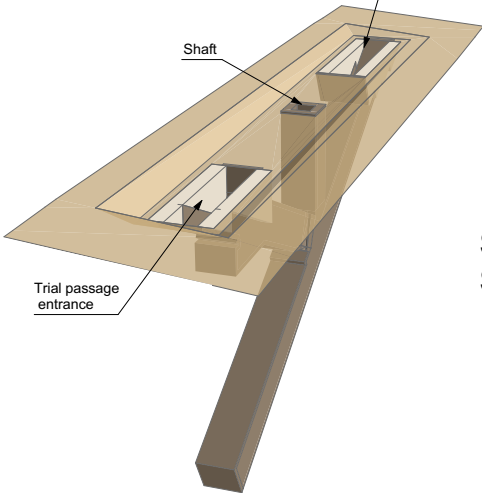
Trial Passages

Detail View. Section 1-1

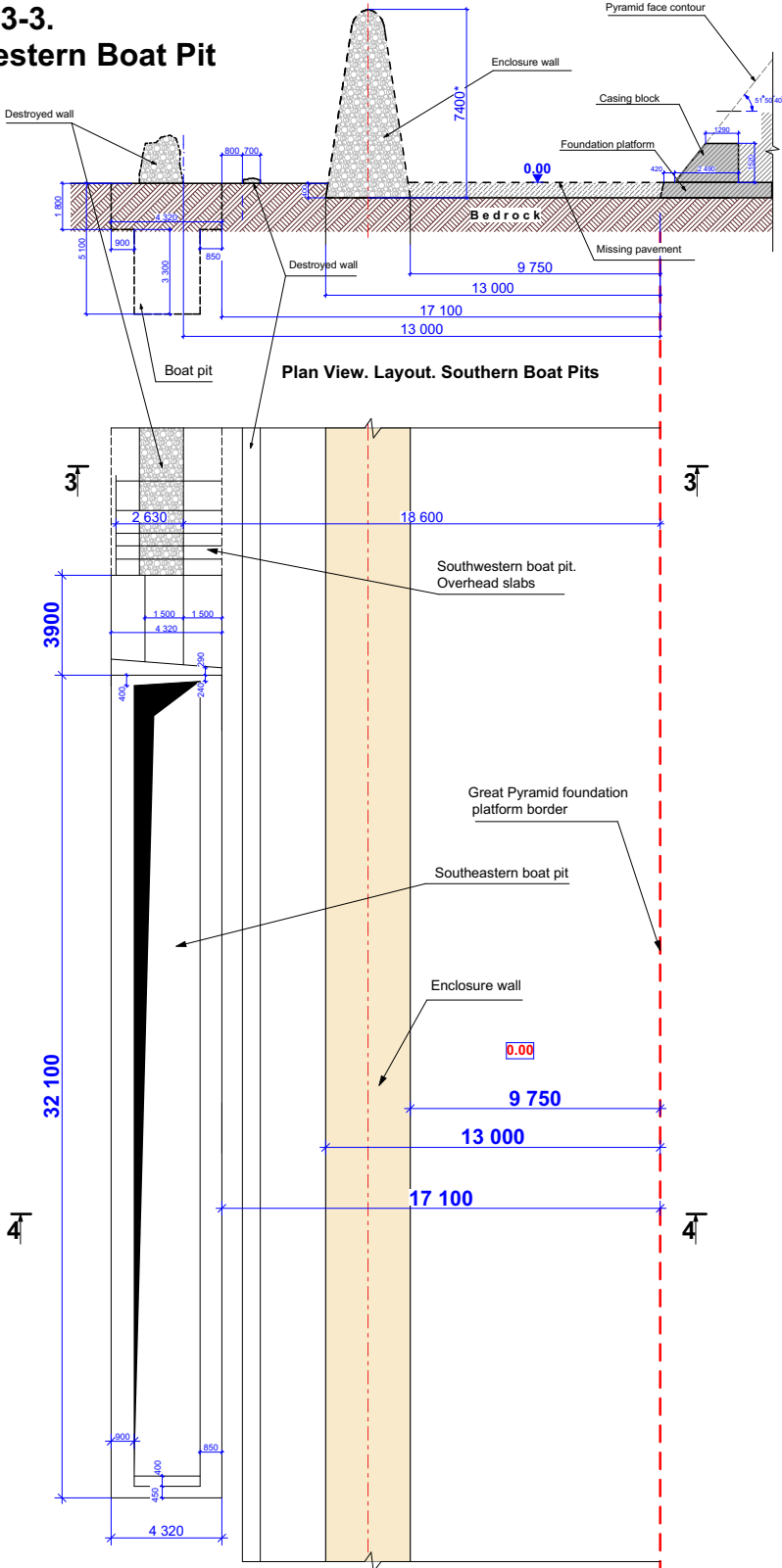


Trial Passages

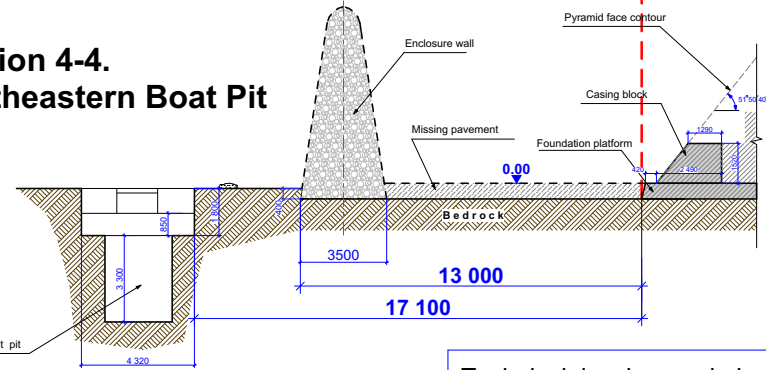
Detail View.



Section 3-3. Southwestern Boat Pit



Section 4-4. Southeastern Boat Pit



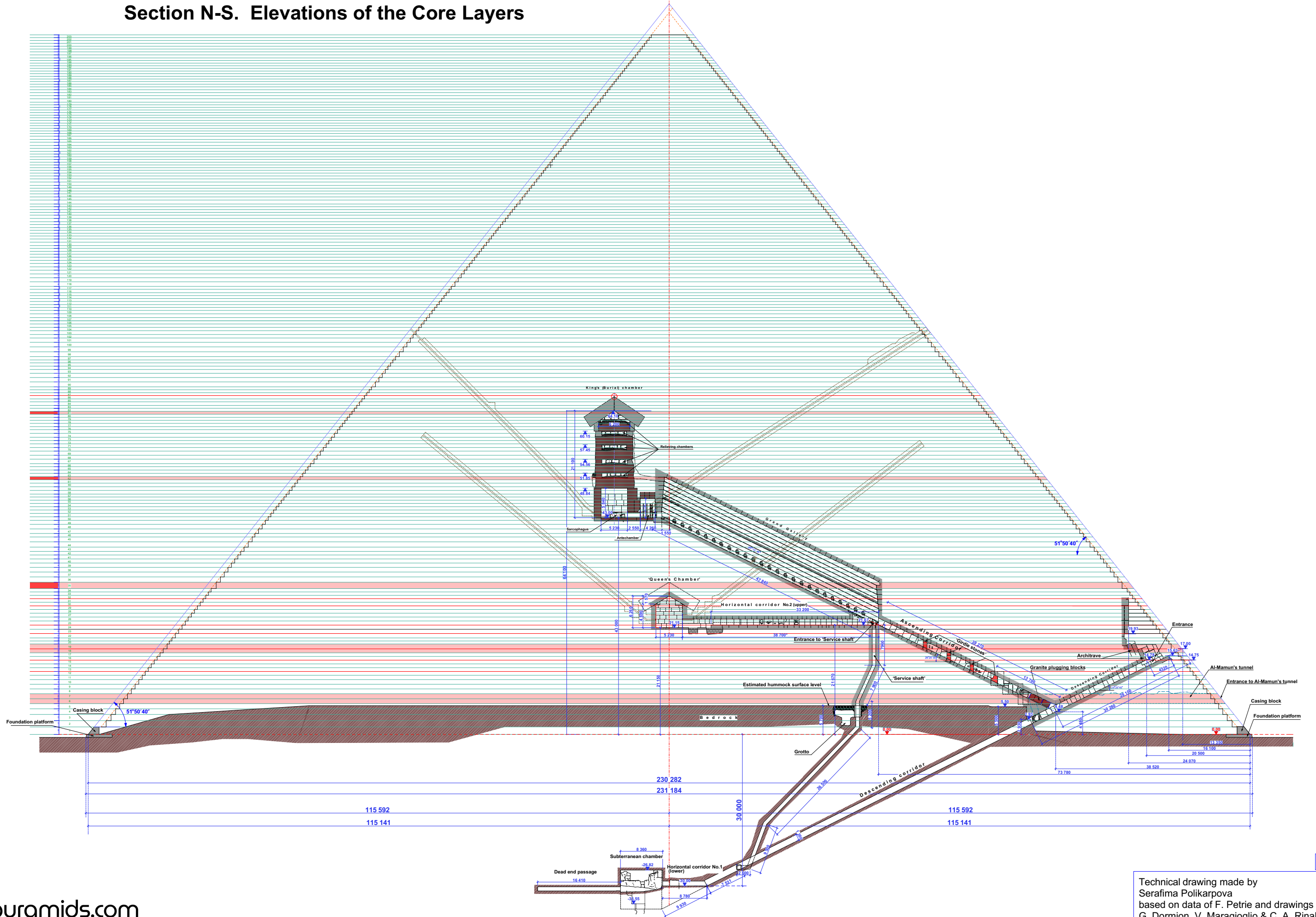
Legend:

model	plan	section	
			- Bedrock
			- Limestone
			- Fine limestone

Technical drawing made by
Serafima Polikarpova
based on drawings by G. Dormion,
V. Maragioglio & C. A. Rinaldi

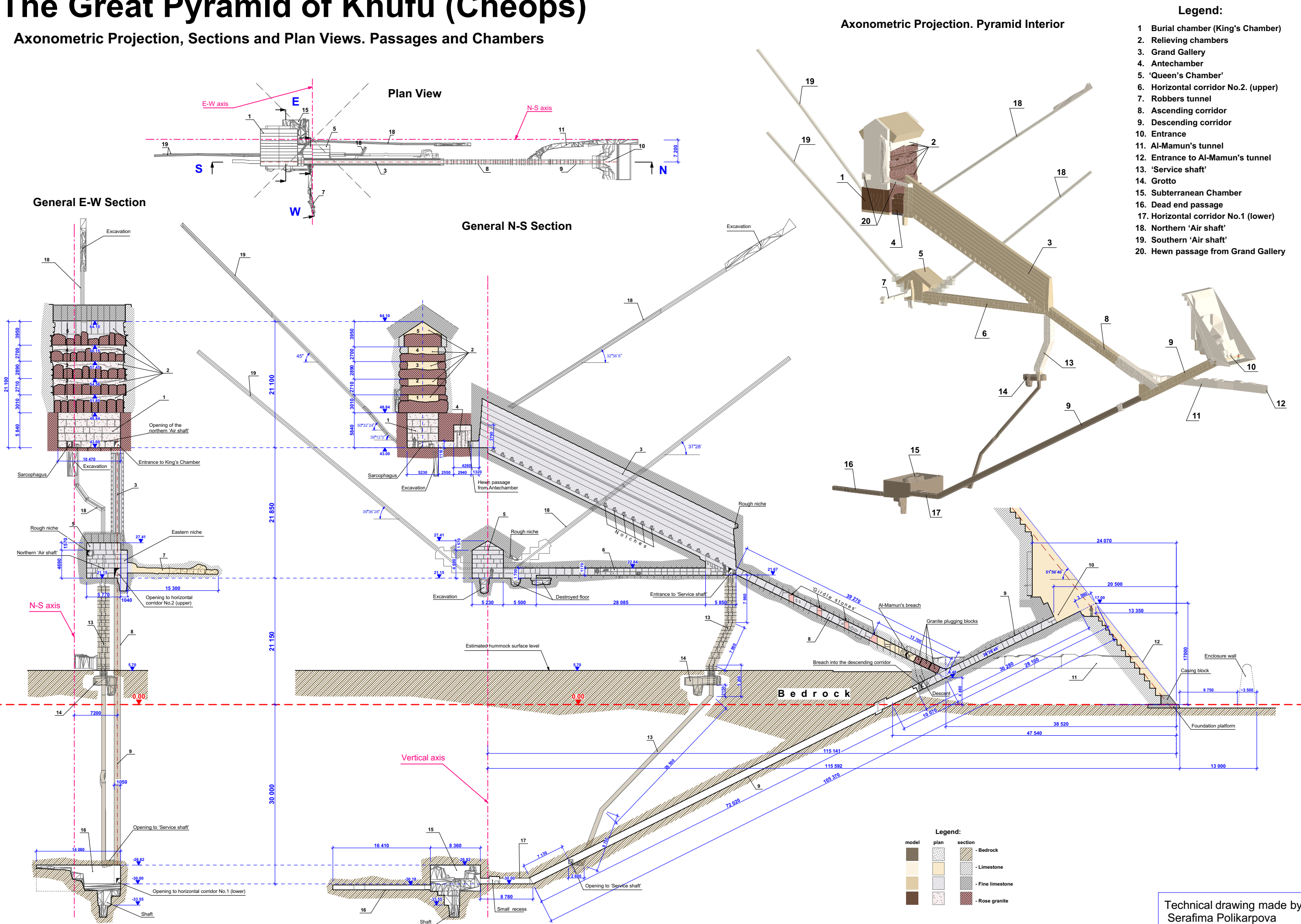
The Great Pyramid of Khufu (Cheops)

Section N-S. Elevations of the Core Layers



The Great Pyramid of Khufu (Cheops)

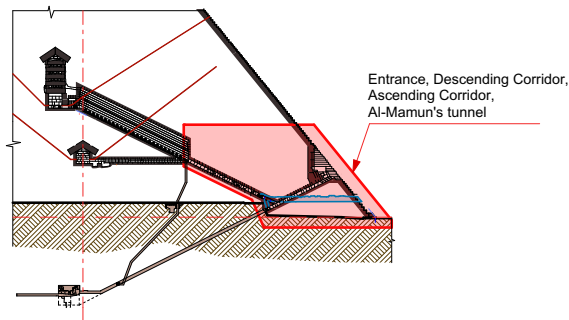
Axonometric Projection, Sections and Plan Views. Passages and Chambers



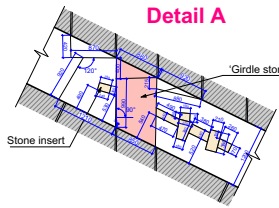
The Great Pyramid of Khufu (Cheops)

Entrance, Descending Corridor, Ascending Corridor, Al-Mamun's tunnel

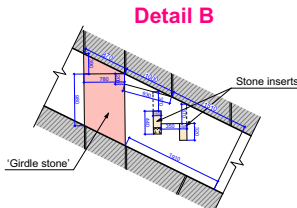
Detailed Sectional View.
Great Pyramid's Chambers and Passages



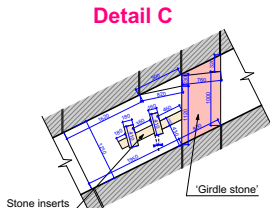
Detail A



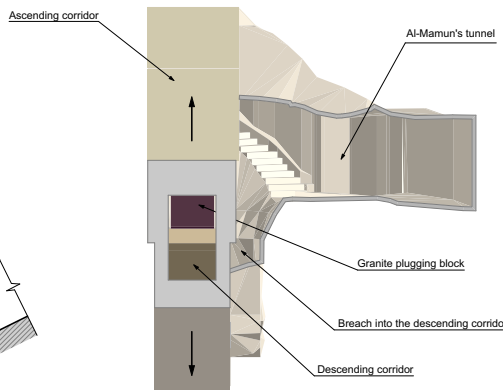
Detail B



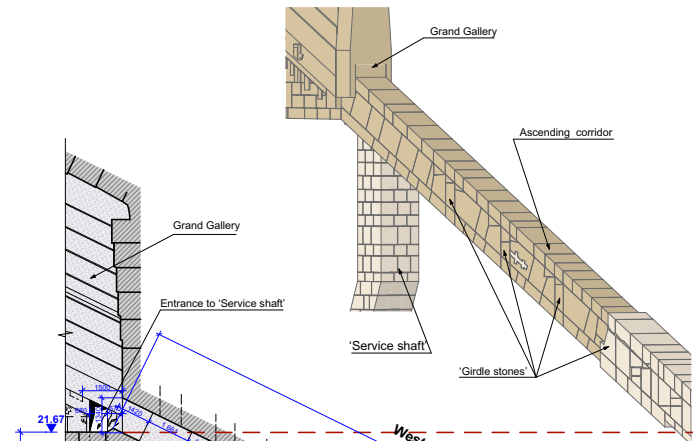
Detail C



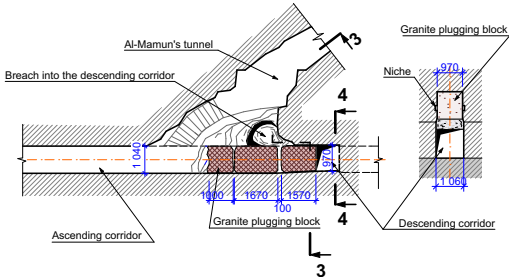
Axonometric Projection.
Section 3-3
Detail D



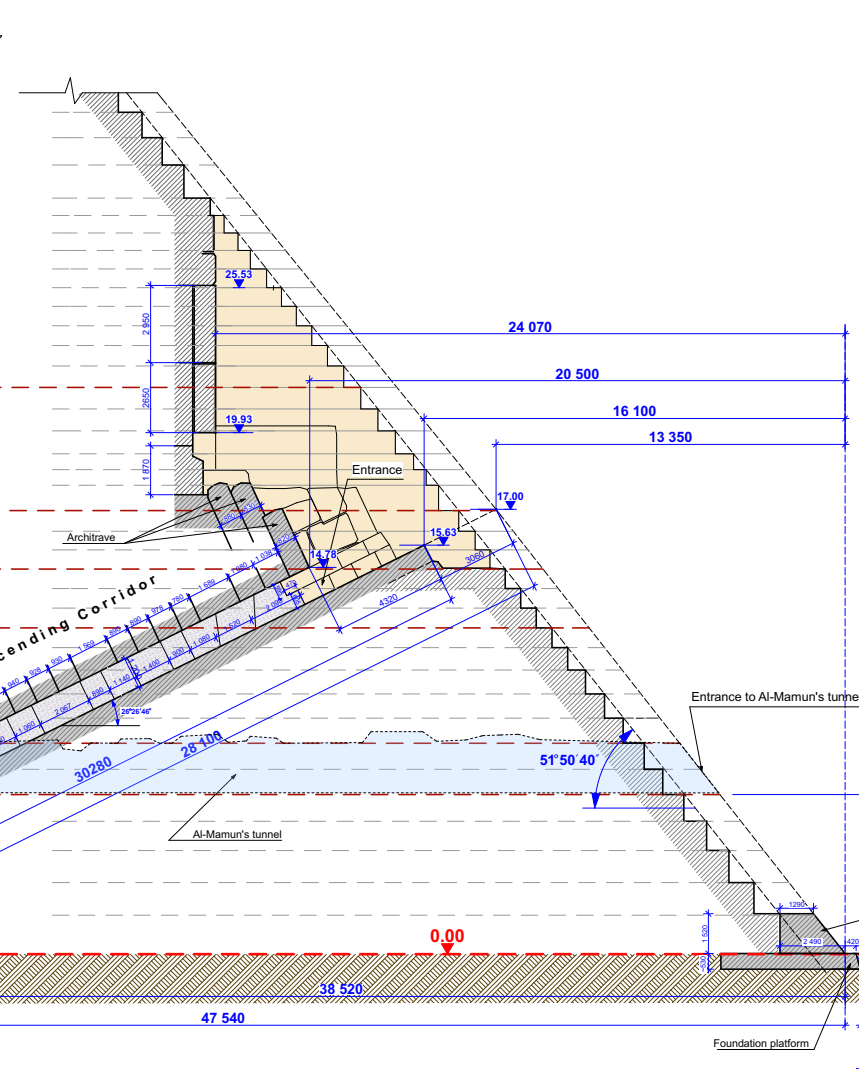
Axonometric View.
Ascending Corridor with 'Girdle Stones'



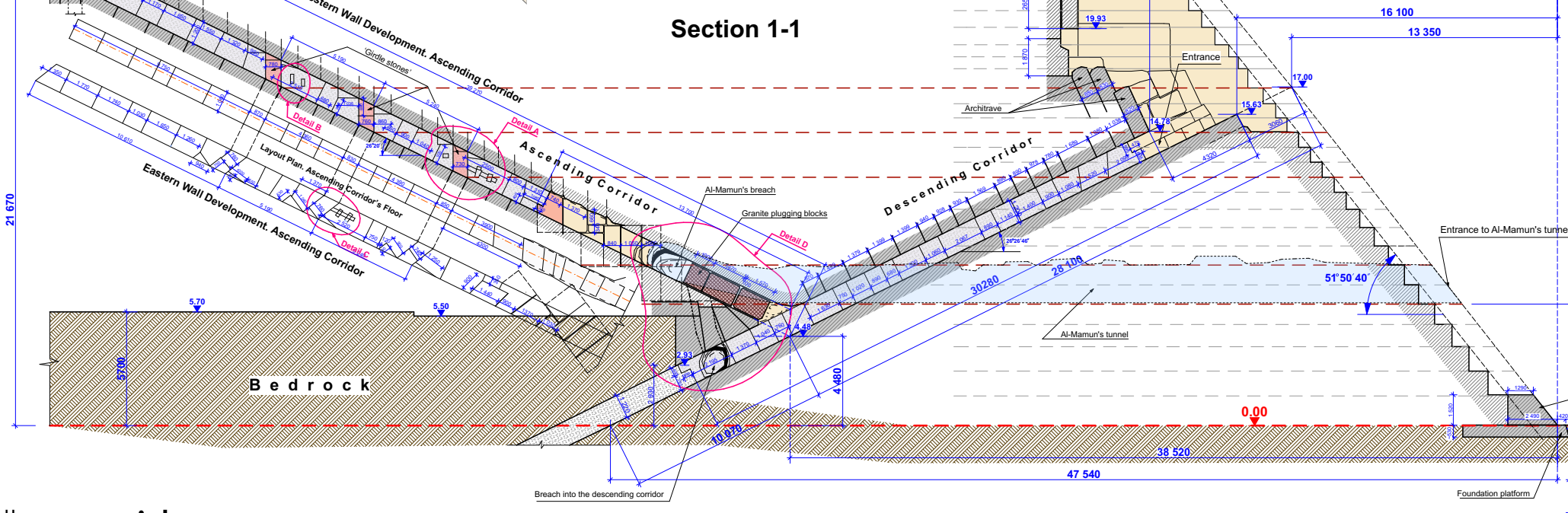
Detail D
Plan View



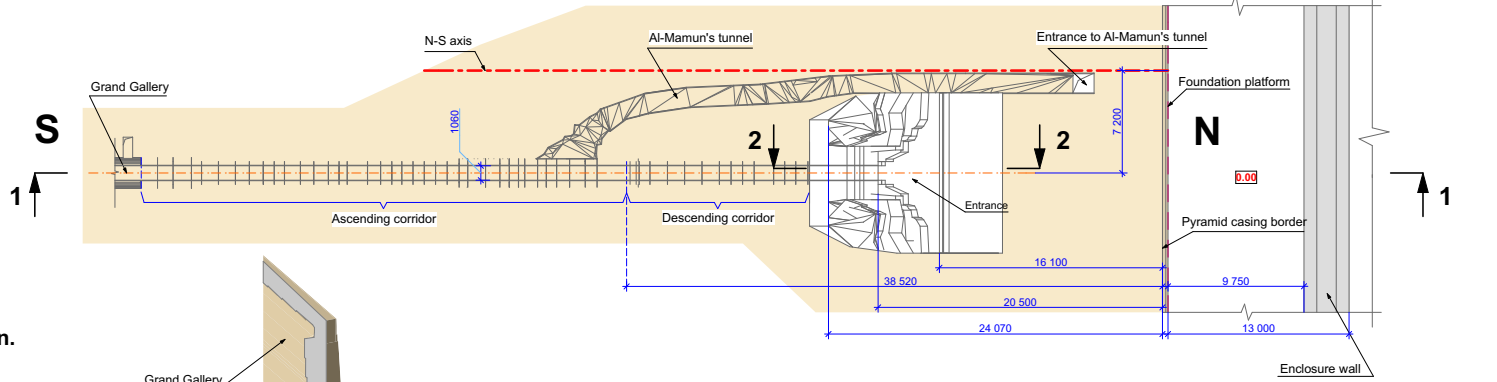
Section 4-4



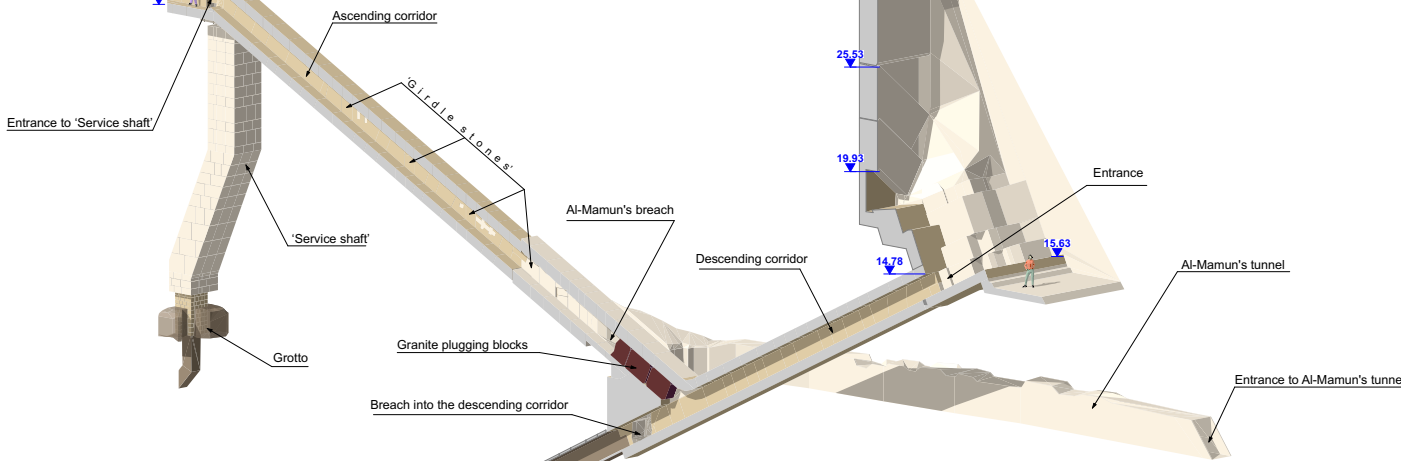
Section 1-1



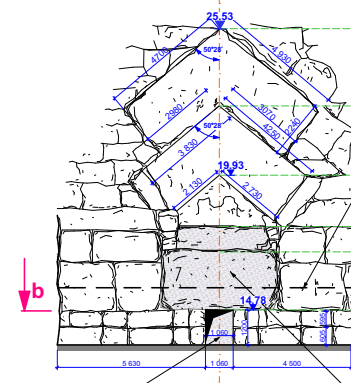
General Plan View



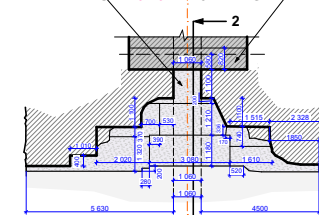
Axonometric Projection.
Section 1-1



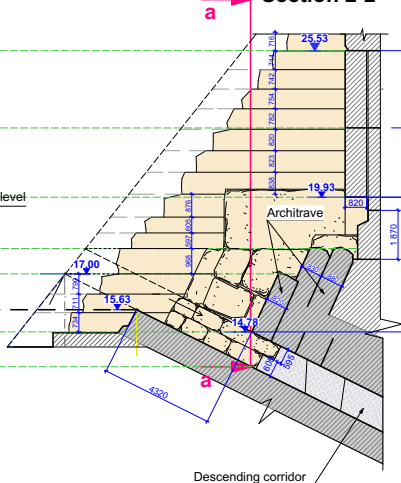
Detailed View. Entrance
View a-a. Facade



View b-b. Plan View



Section 2-2

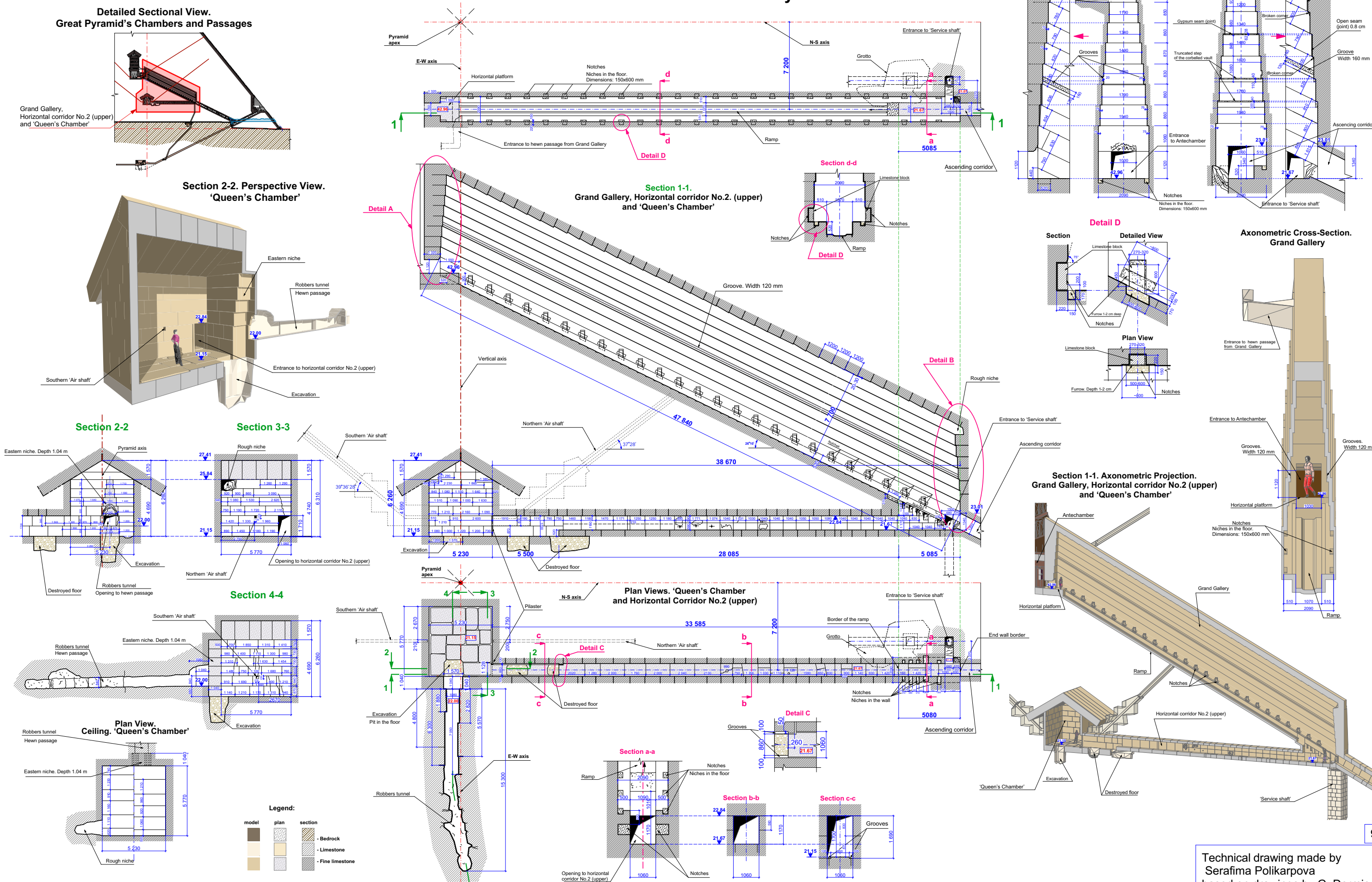


Legend:

model	plan	section	
Bedrock			
Limestone			
Fine limestone			
Rose granite			

The Great Pyramid of Khufu (Cheops)

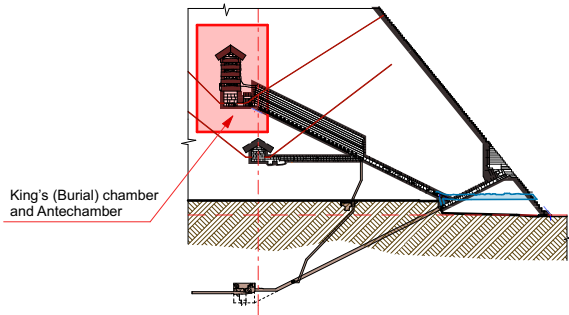
Grand Gallery and 'Queen's Chamber'



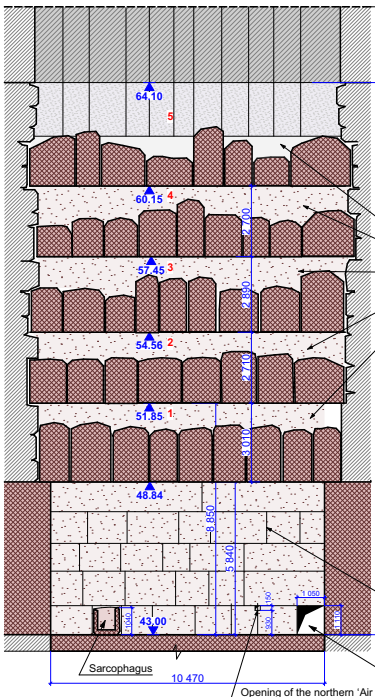
The Great Pyramid of Khufu (Cheops)

King's (Burial) Chamber and Antechamber

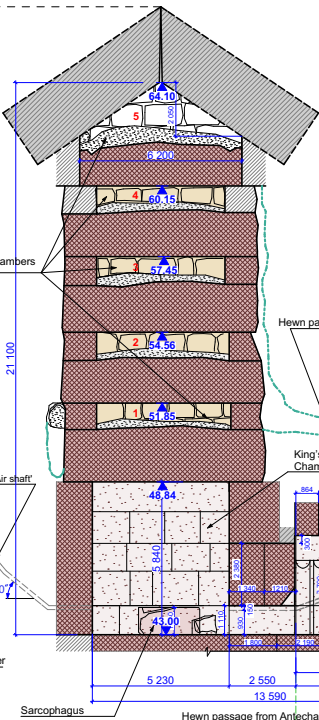
Detailed Sectional View.
Great Pyramid's Chambers and Passages



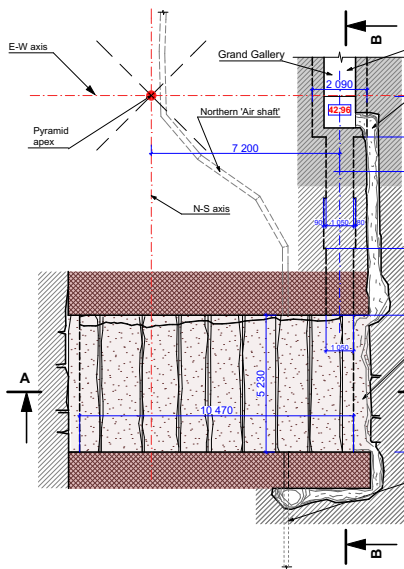
Section A-A
King's (Burial) Chamber



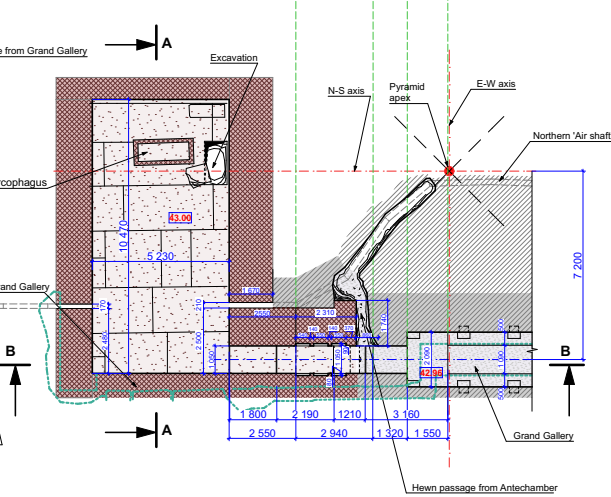
Section B-B
King's (Burial) Chamber



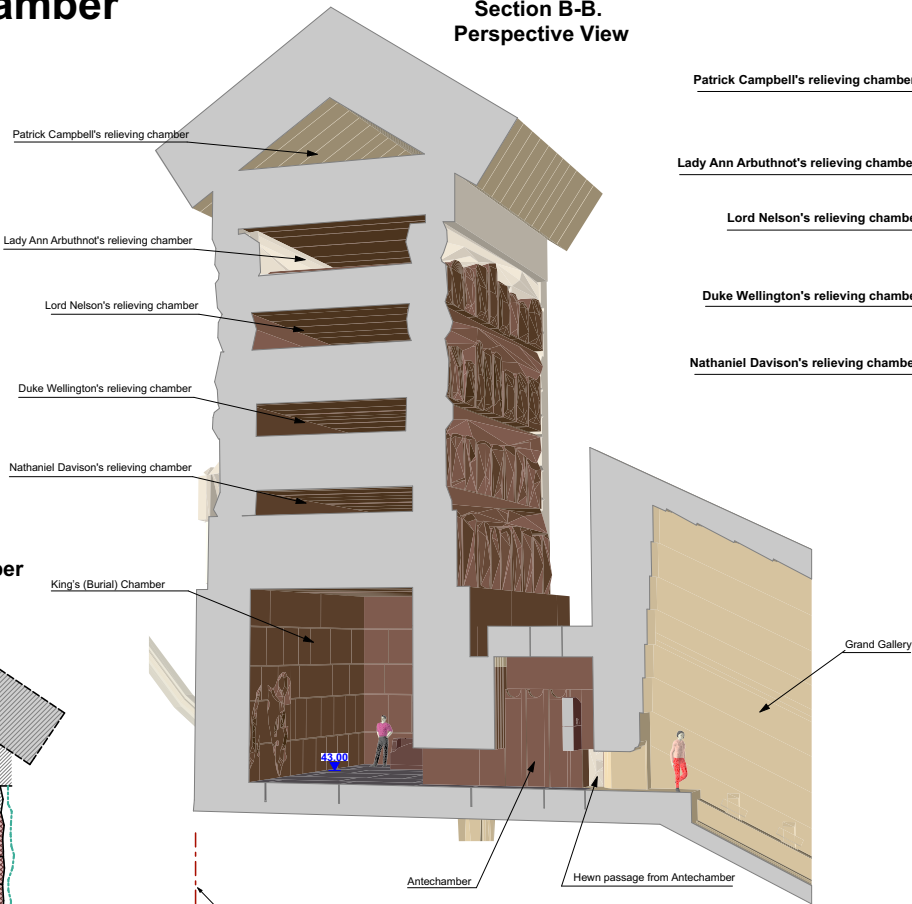
Plan View.
Nathaniel Davison's Relieving Chamber
and Hewn Passage from Grand Gallery



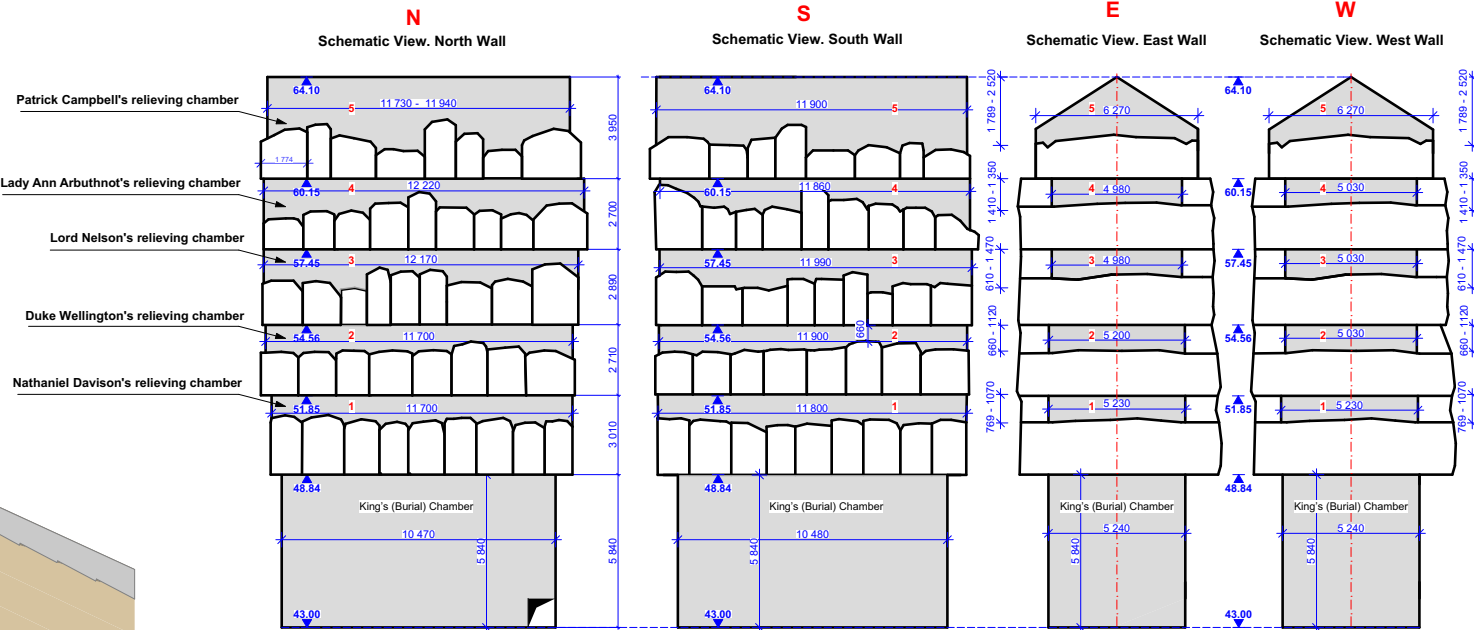
Plan View.
King's (Burial) Chamber and Antechamber



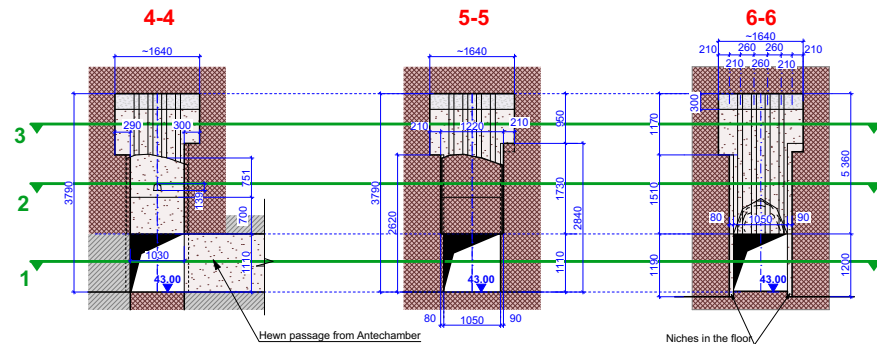
Section B-B.
Perspective View



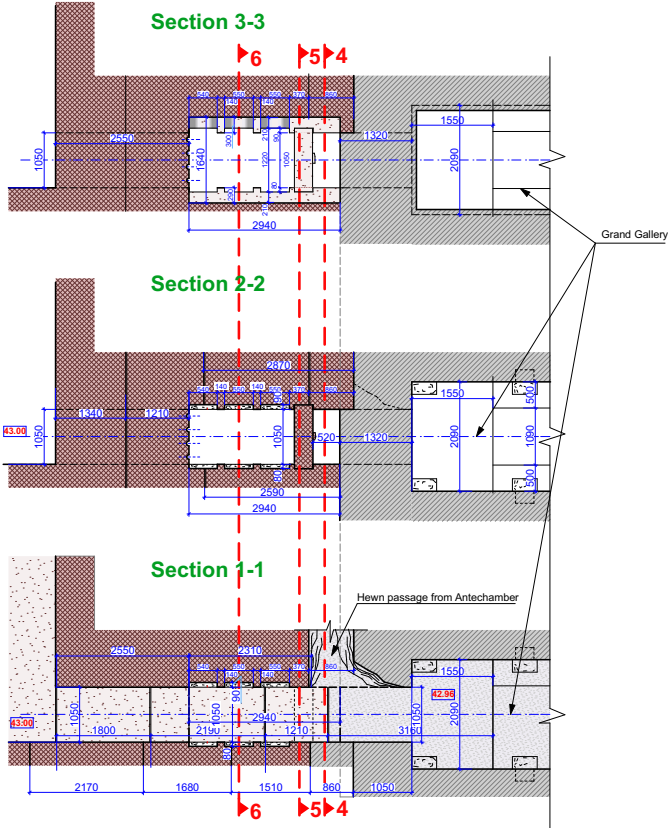
Relieving Chambers



Vertical Sections. Antechamber



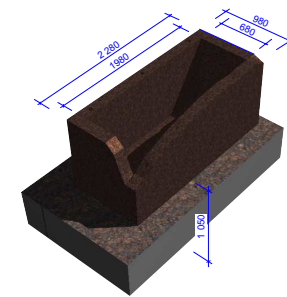
Horizontal Section Plans. Antechamber



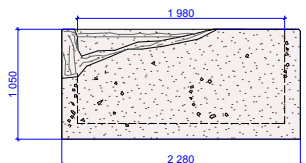
Internal View. King's Chamber



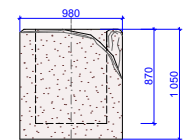
Sarcophagus



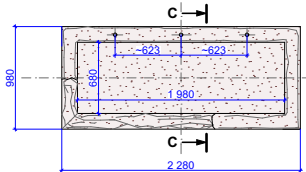
East Facade View



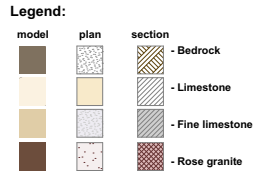
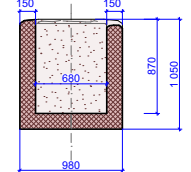
South Facade View



Plan View



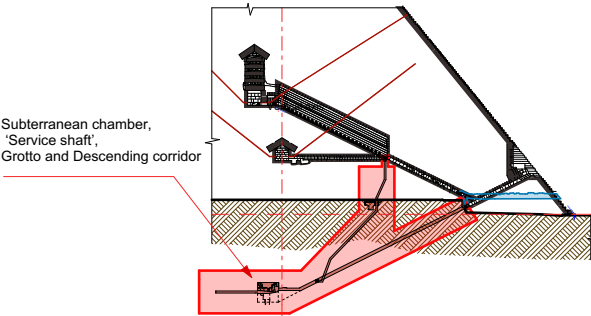
Section C-C



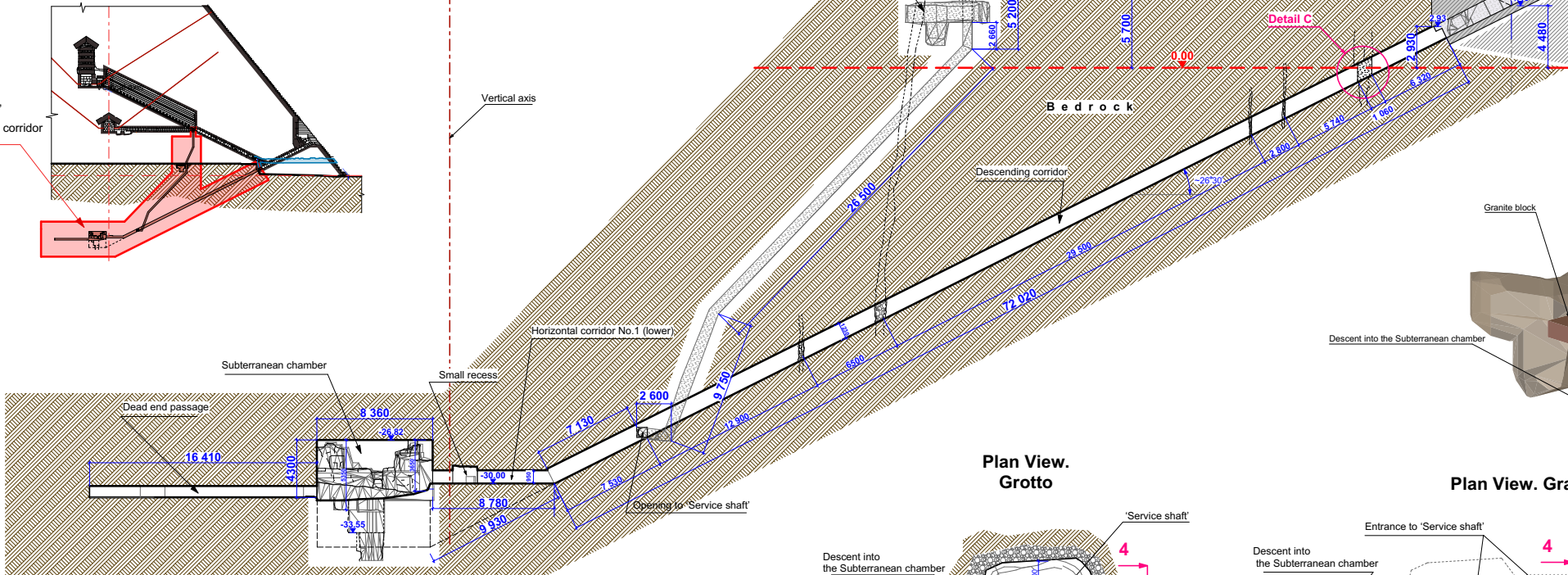
The Great Pyramid of Khufu (Cheops)

Subterranean Chamber, 'Service Shaft', Grotto and Descending Corridor

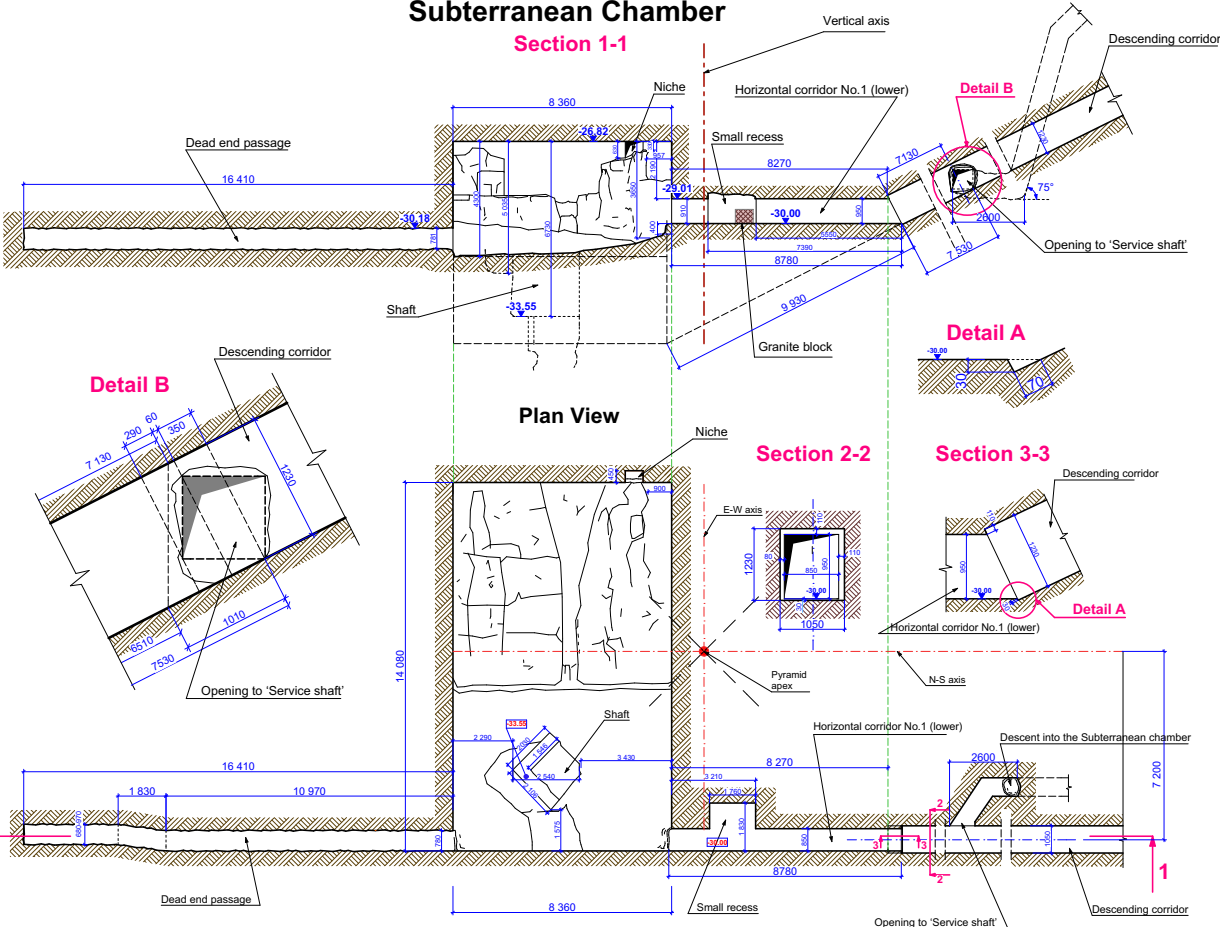
Detailed Sectional View.
Great Pyramid's Chambers and Passages



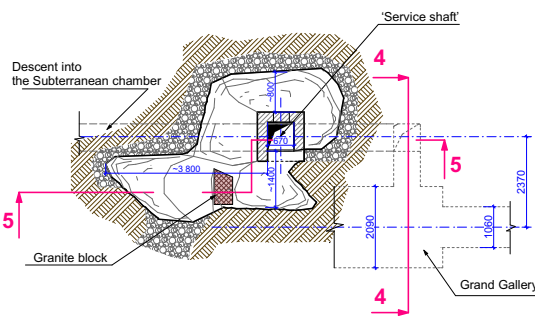
Detailed Sectional View.
Lower Internal Arrangement



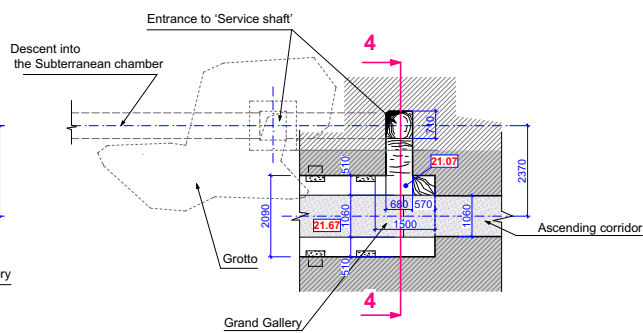
Subterranean Chamber
Section 1-1



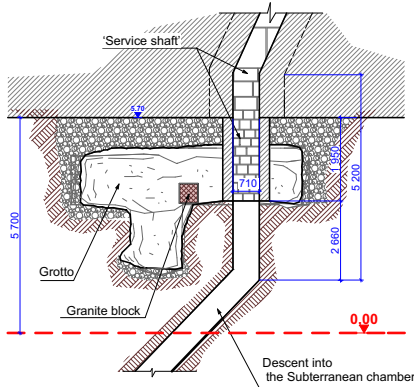
Plan View.
Grotto



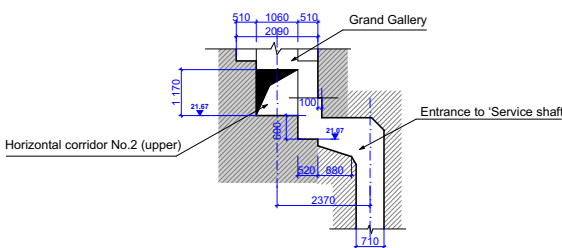
Plan View. Grand Gallery Level



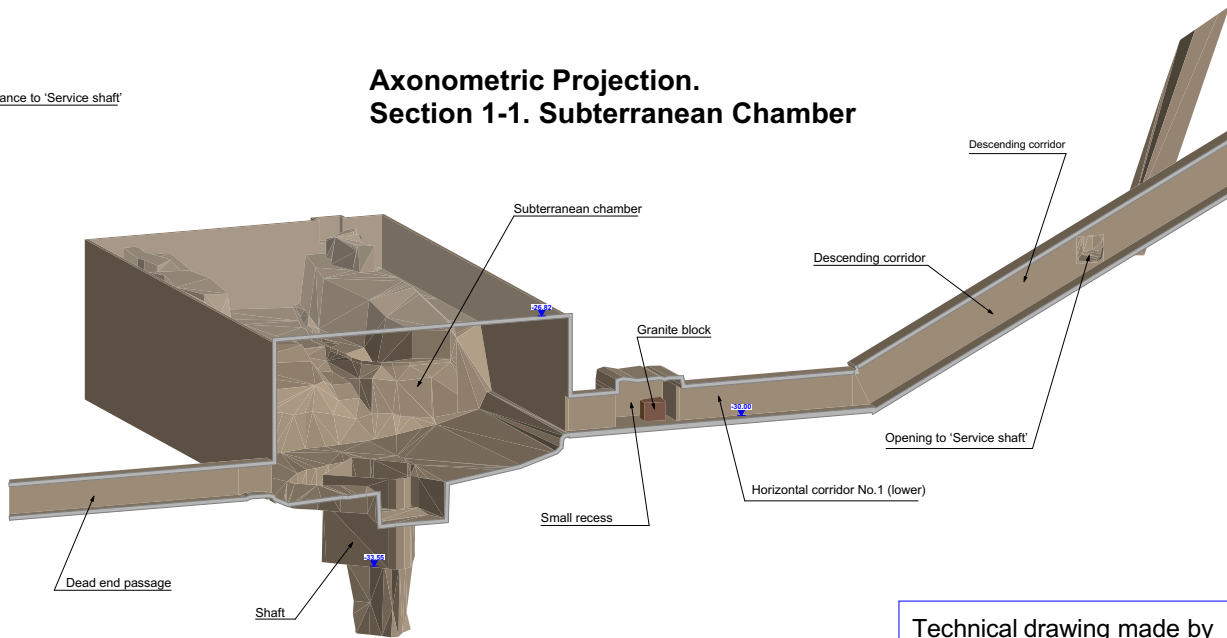
Section 5-5



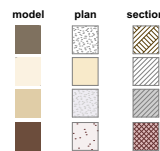
Section 4-4



Axonometric Projection.
Section 1-1. Subterranean Chamber



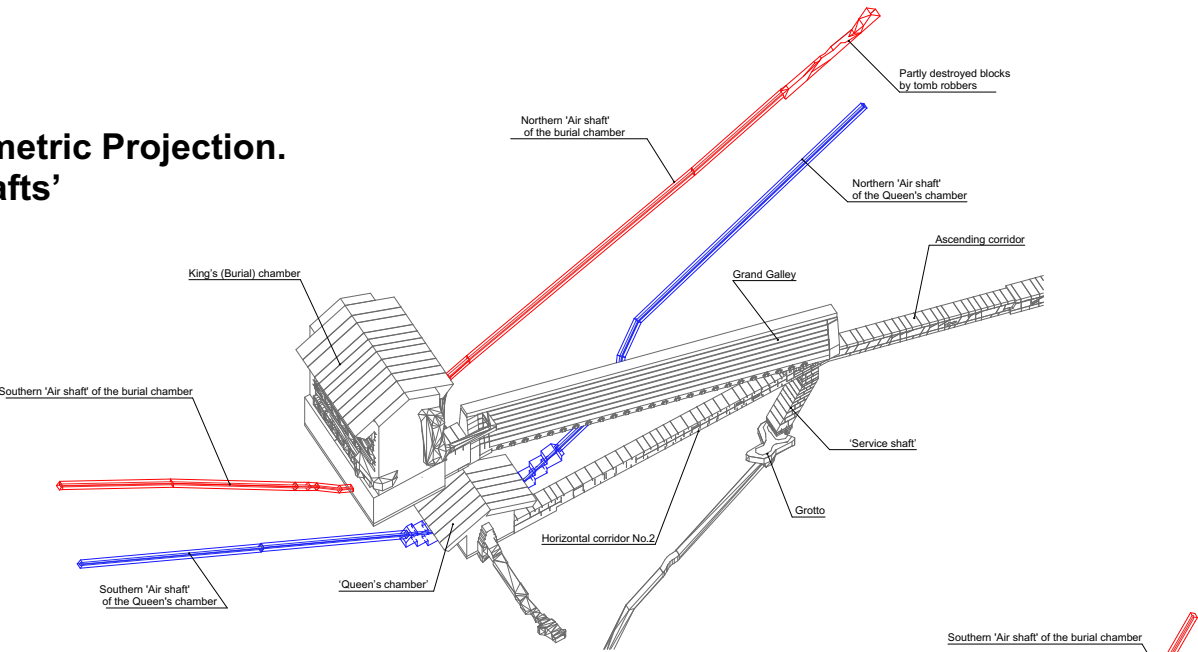
Legend:



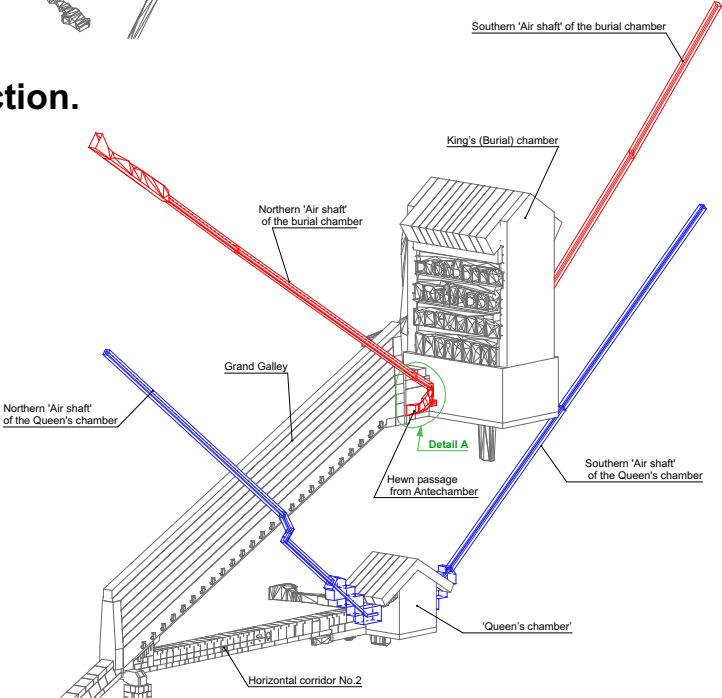
The Great Pyramid of Khufu (Cheops)

'Air Shafts'

Axonometric Projection. 'Air Shafts'

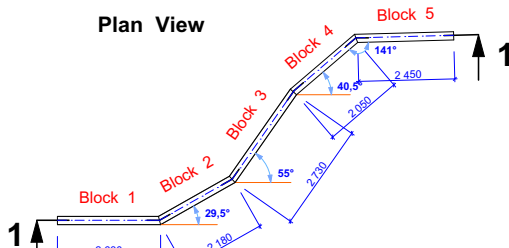


Axonometric Projection. 'Air Shafts'

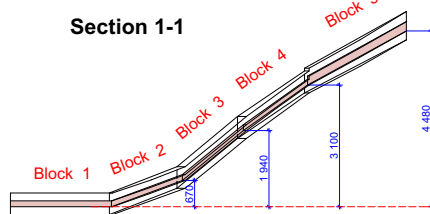


Detail A. Burial Chamber's Northern 'Air shaft'

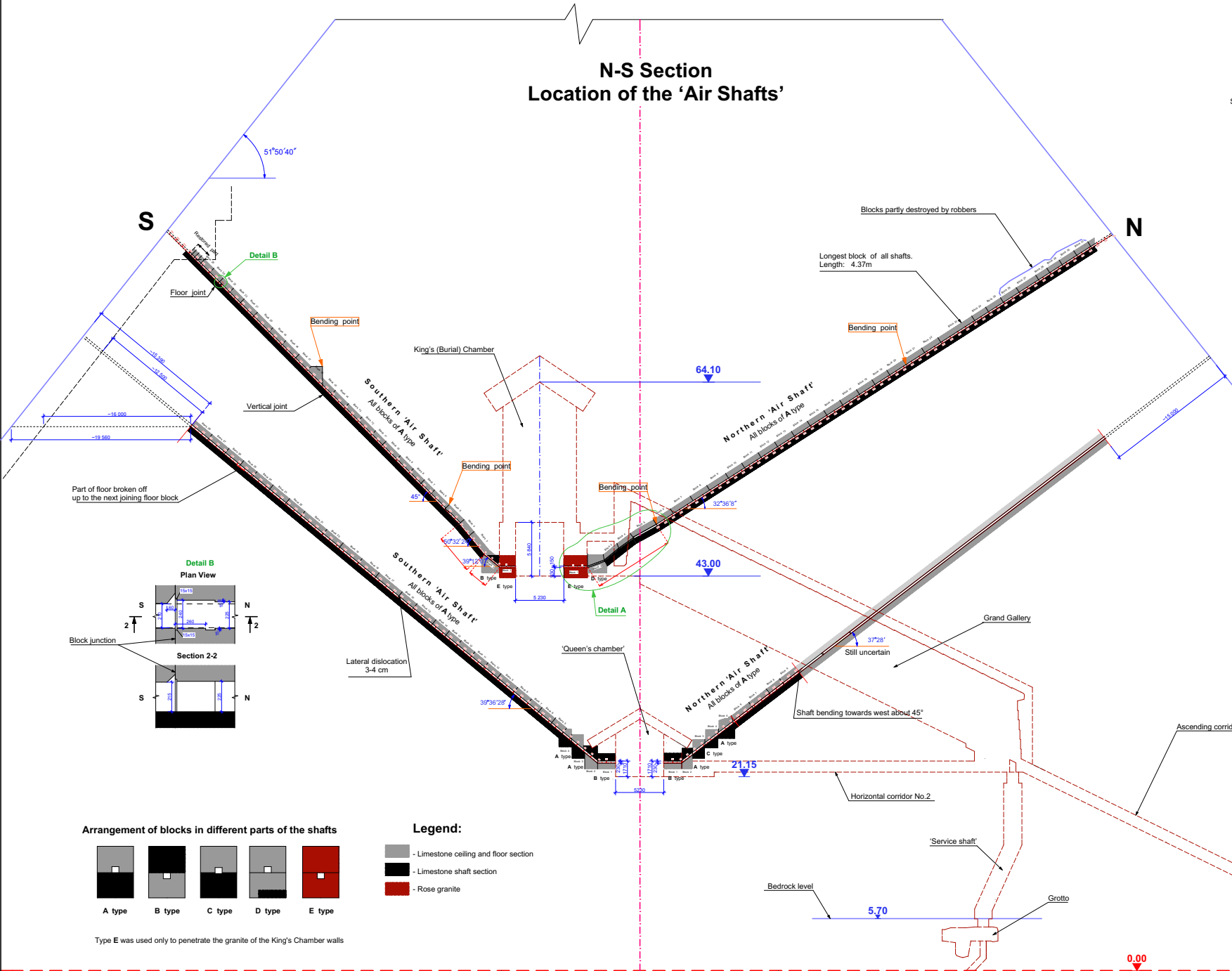
Plan View



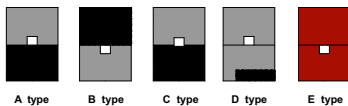
Section 1-1



N-S Section Location of the 'Air Shafts'



Arrangement of blocks in different parts of the shafts



Legend:

- Limestone ceiling and floor section
- Limestone shaft section
- Rose granite

Type E was used only to penetrate the granite of the King's Chamber walls

Plan View. Location of the 'Air Shafts'

