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Non-Destructive Pyramid Investigation (2)

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WASEDA UNIVERSITY

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Non-Destructive Pyramid Investigation (2)

by

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1988

WASEDA UNIVERSITY

TOKYO-JAPAN

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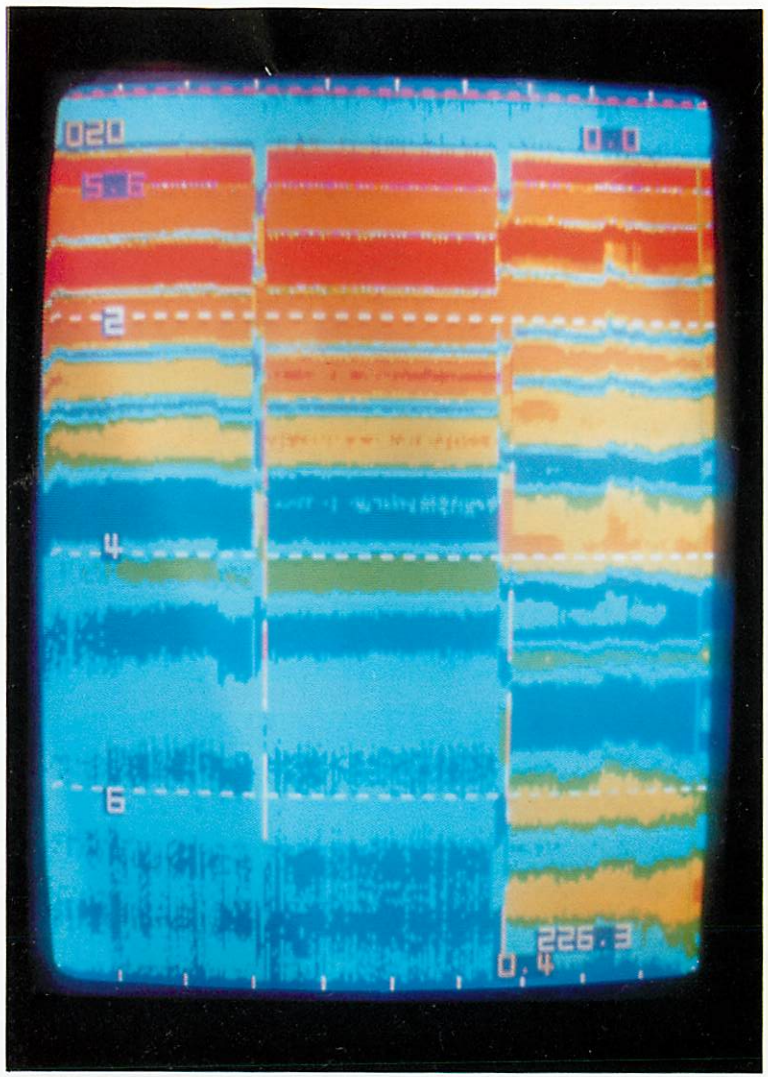
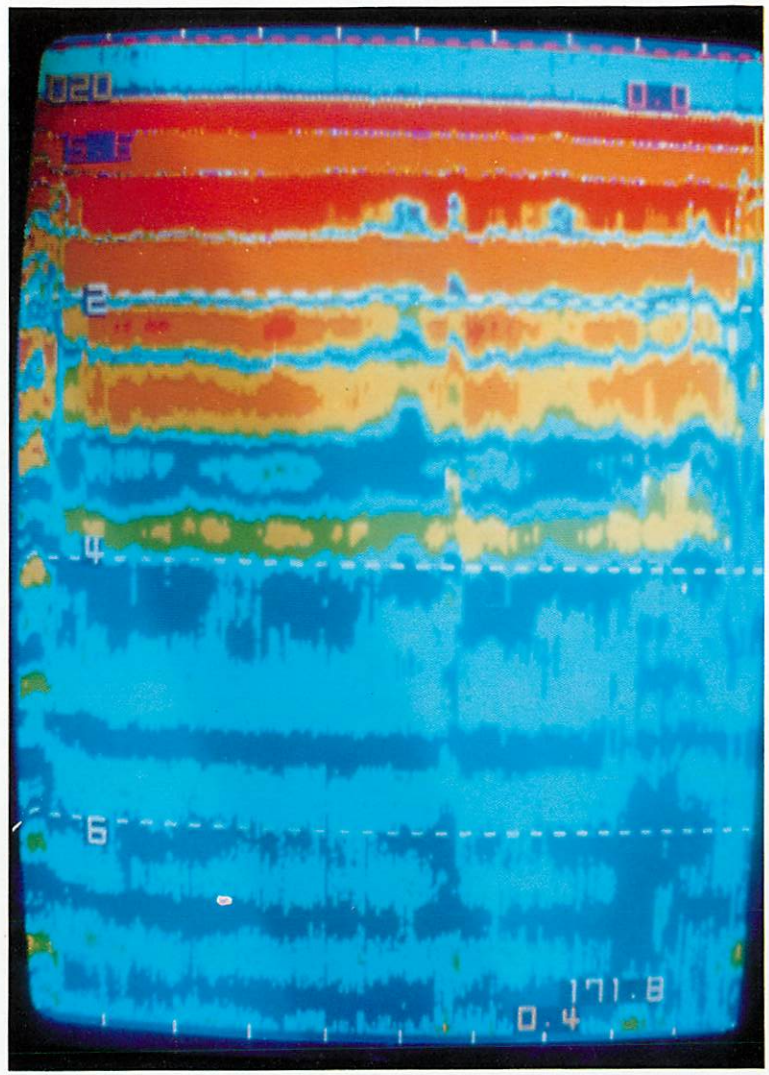
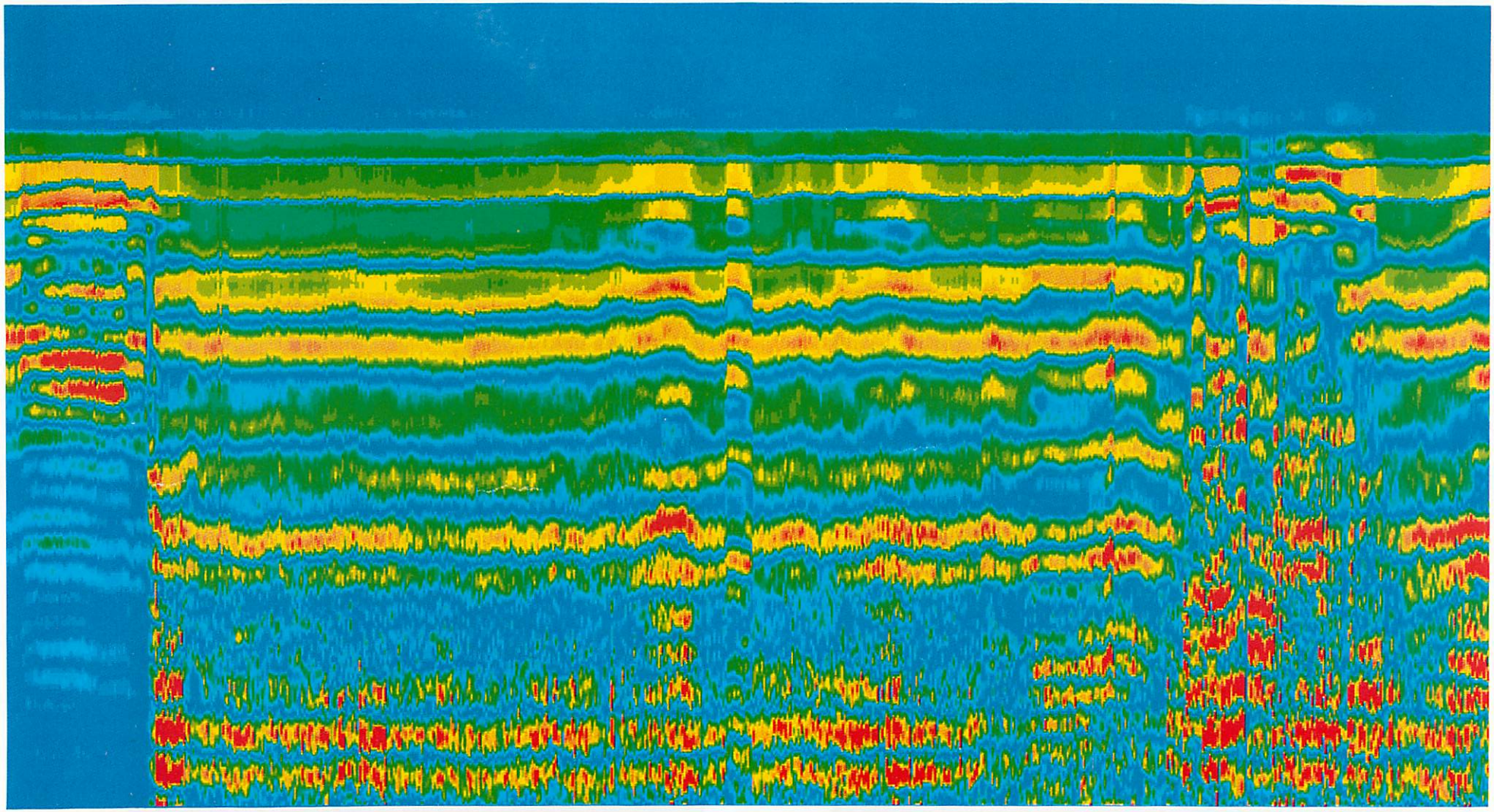


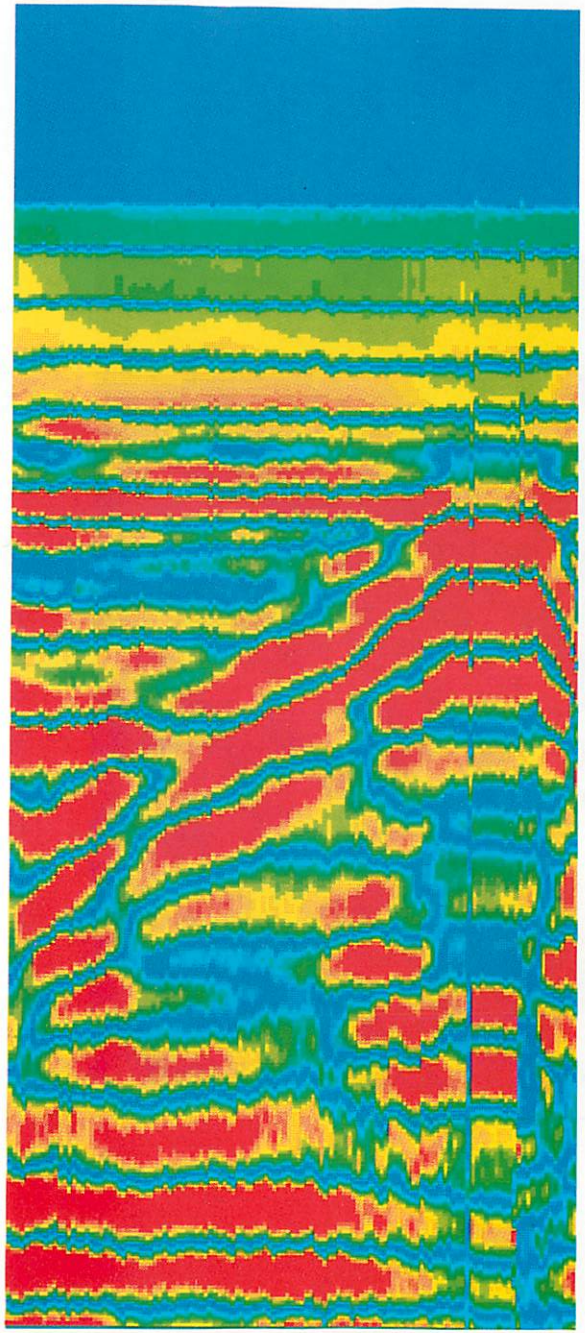
Pl.2 Measurement line on the west wall of Horizontal Passage to Queen's Chamber



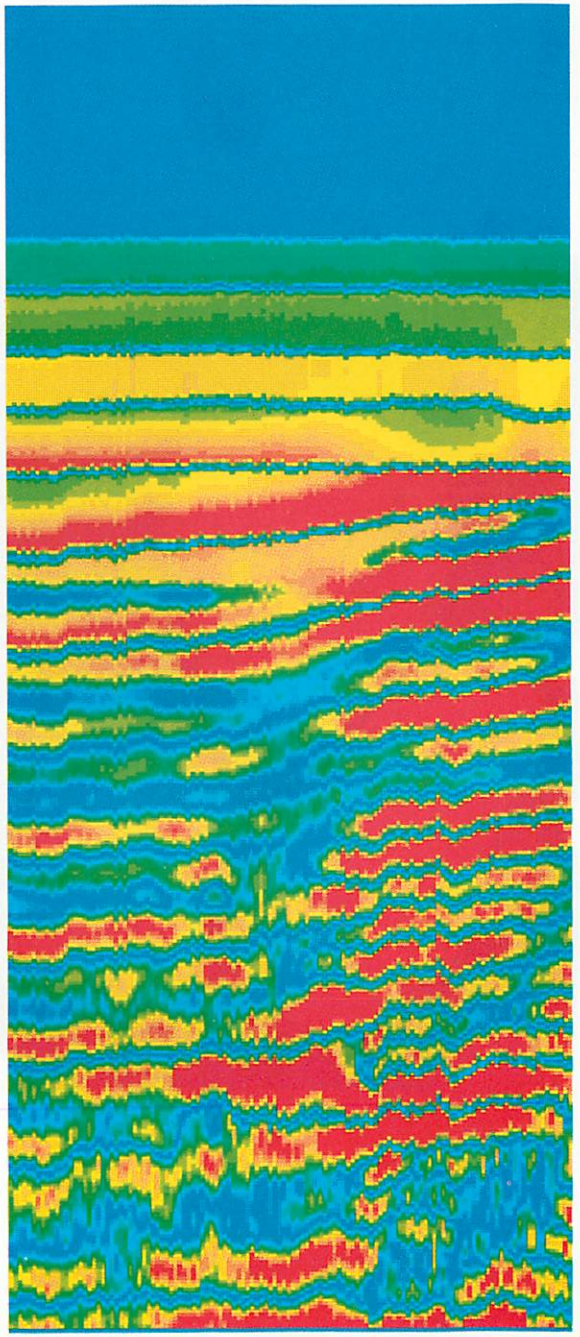
Pl.1 Measurement line on the west wall of Horizontal Passage to Queen's Chamber



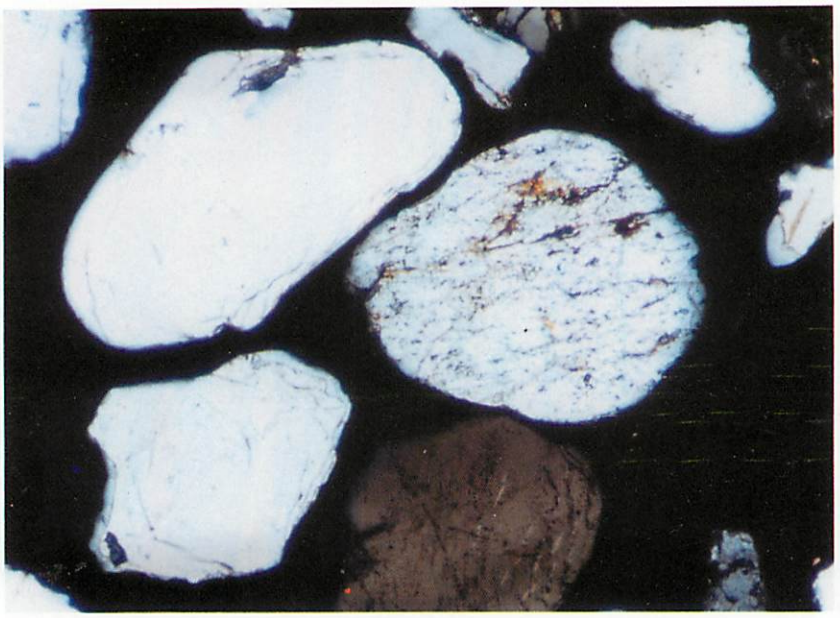
Pl.3 The drawing colored by a plotter after calculated by a computer on the west wall of Horizontal Passage to Queen's Champer



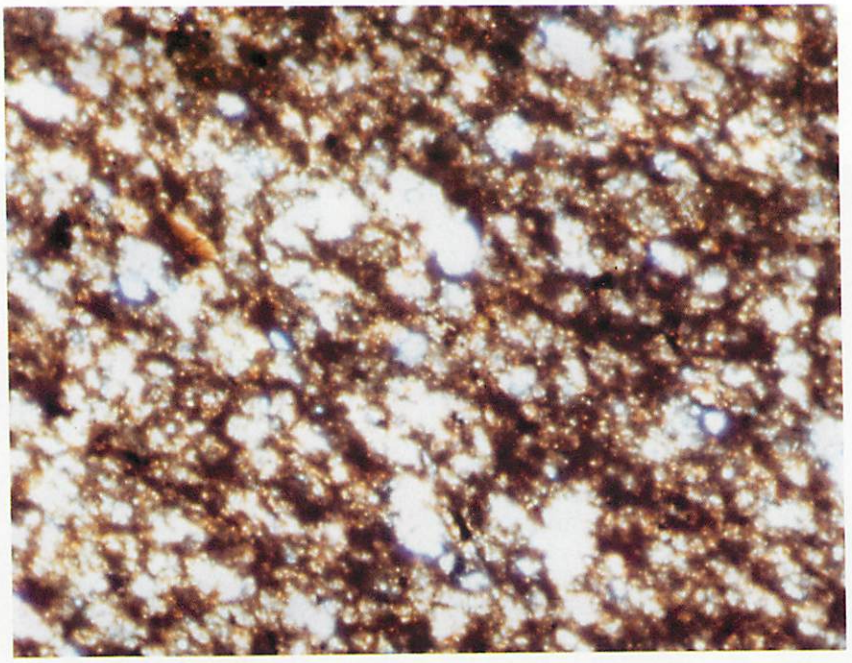
Pl.4 The drawing colored by a plotter after calculated by a computer at the nee of Great Sphinx, utilizing 80MHz antenna



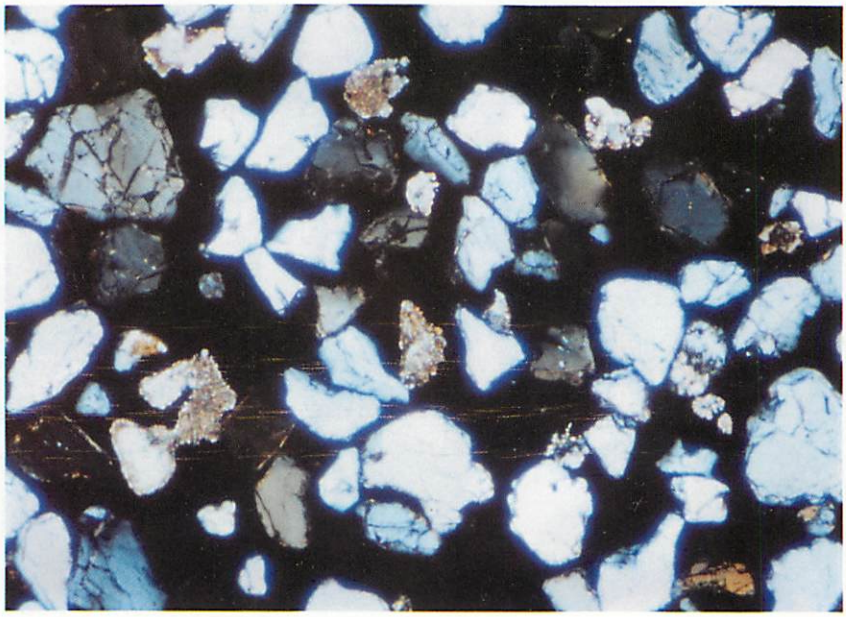
Pl.5 The drawing colored by a plotter after calculated by a computer near the sarcophagus in King's Chamber



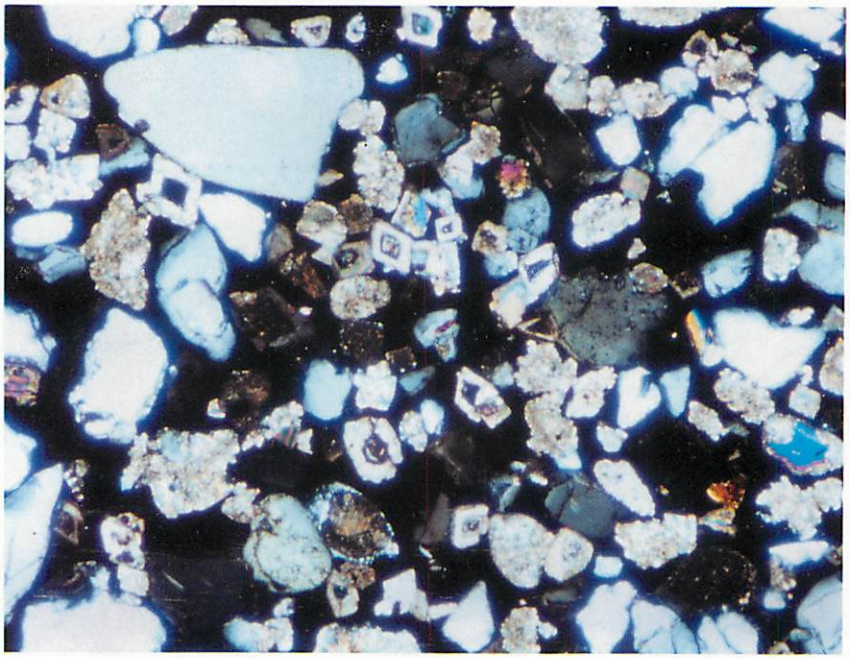
Pl.6 Microscopic photograph of the sand sampled by French Mission



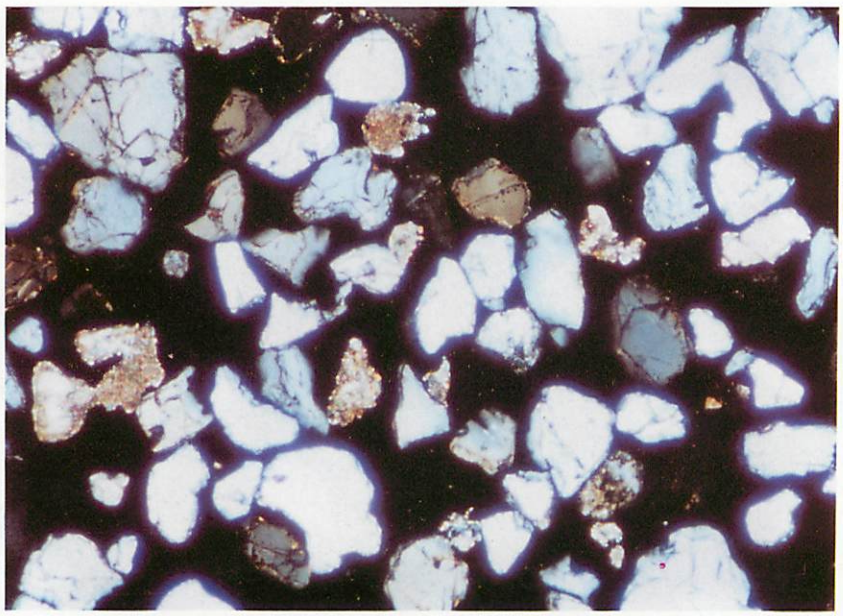
Pl.7 Microscopic photograph of limestone



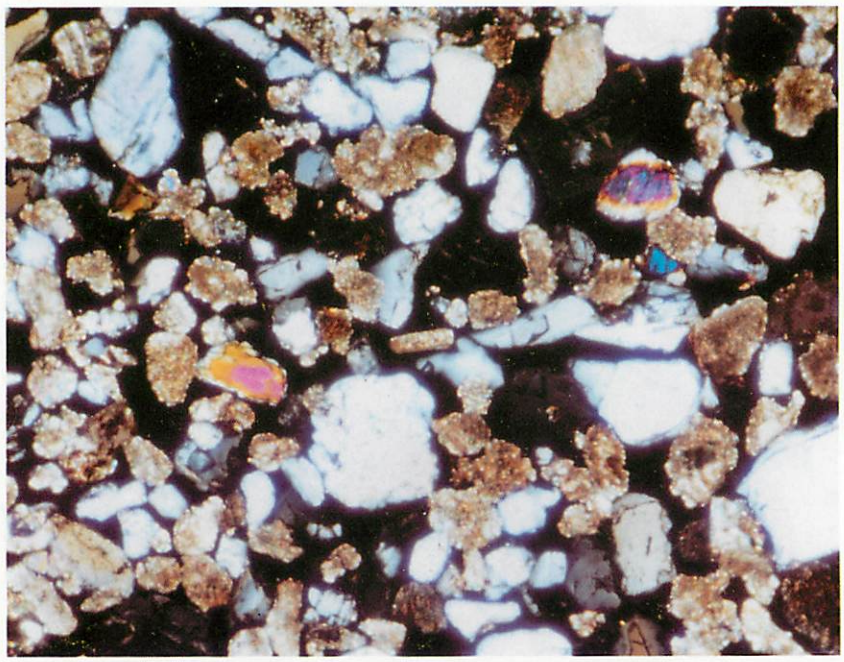
Pl.8 Microscopic photograph of the sand sampled from the eastern part of Great Sphinx



Pl.9 Microscopic photograph of the sand sampled from the south of Great Pyramid



Pl.10 Microscopic photograph of the sand sampled from the western terrace of Great Sphinx



Pl.11 Microscopic photograph of the sand sampled from the northern part of Great Pyramid

LIST OF PLATES

FORWARD

One year has already passed since we, Waseda University Pyramid Investigation Mission conducted the investigation in the Giza Plateau. The investigations were conducted twice, in January and September, 1987. This Pyramid Project is coming from investigations that were conducted every year at Luxor since the first general survey in Egypt in 1966. In fact, we would and could never thought of investigating the pyramid, if we did not have the achievements of investigations for twenty years. We, Japanese, started the investigation of the pyramid behind Europe and the United States by a hundred or more years. However, I hope that it might be possible for us to make clear the Japanese culture, which is a typical mixed one, through knowing the Egyptian culture. Late Professor Kiichi Kawamura, who was our pioneer, and who died ten years ago, intended to get a hint for thinking over the origin of the Japanese civilization by exploring the origin of the Egyptian civilization. Now, I intend to recognize the pattern of our culture through the ancient Egyptian culture.

Although we Japanese started late in the exploration of the Egyptian culture with the conventional approach, we now rank with the world in the scientific technology that the modern civilization provides. It is our method to make clear the ancient culture with such technologies. Conventionally, it is said that archaeology cannot be attained without excavation. One of our intent of the pyramid survey is to apply such technologies to archaeology as well as to space and the deep sea. We have reached our CT scanner by an electromagnetic wave. We are still engaged in the development of equipment and the innovation of technology with all our knowledge and energy. The developed equipment is tested in Japan for a long period of time and then sent to Egypt. Therefore, this requires an interval of six months at the shortest, sometimes one year. We think of the pyramid project as taking 10 to 20 years, and believe that all will be clarified. However, we do not intend to conduct treasure hunting by using the high technology. Our survey has a wider objective. It intends to eventually grasp the layout of the pyramids, mastabas and temples scattered at the Giza Plateau, to identify that it was planned as a necropolis, and to know the living and the life of the pyramid era from its cultural background and the religious aspects.

Our survey has just started. Although views from various standpoints may arise, the culture and the scholarship should be pure, and should be apart from the profit-and-loss calculation. We should never allow an attempt to determine the scholarship and the culture particularly from a political viewpoint or intention. Based on this viewpoint, we wish to attain a good investigation that will become noted in human history with the understanding of the government and the nation of Egypt, as well as the Japanese people.

Finally, we express deep thanks to the sensible people of Egypt for supporting and continuing

to fully back up Waseda University Pyramid Investigation Mission for such a long period of 20 or more years, and particularly the coleagues of Egyptian Antiquities Organizations of the Ministry of Culture, the Ministry of Foreign Affairs, the Egyptian Embassy at Tokyo, the Ministry of Information, the Ministry of Turism, as well as the Ministry of Foreign Affairs of Japan, and the Japanese Embassy at Cairo. We wish to continue their support in the future.

April, 1988

Sakuji Yoshimura
Director of Waseda University Pyramid
Investigation Mission
Associate Professor,
School of Human Science

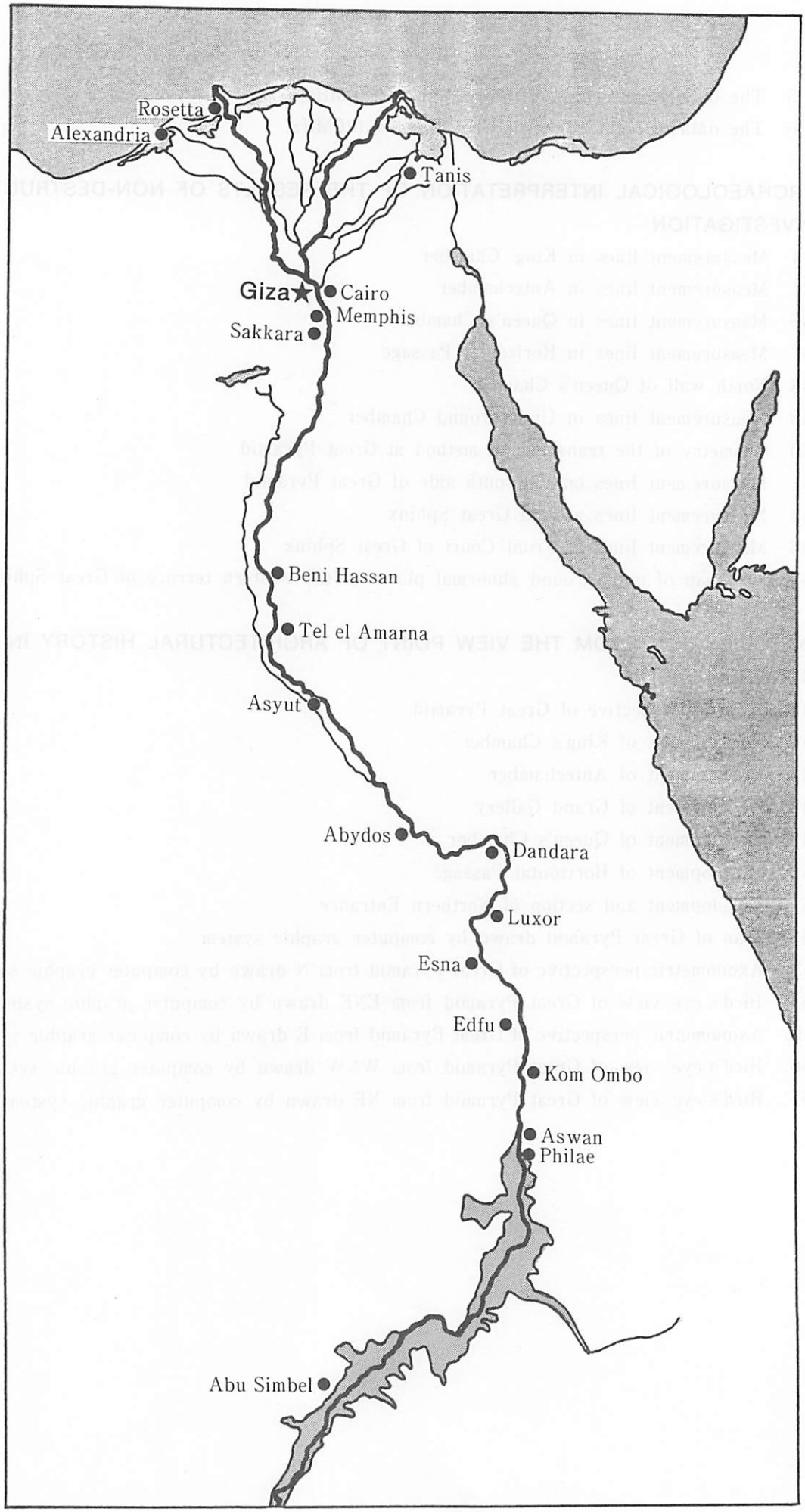
CONTENTS

LIST OF FIGURES AND TABLES

Ⅱ NON-DESTRUCTIVE INVESTIGATION IN THE SECOND SURVEY

Ⅲ ARCHAEOLOGICAL INTERPRETATION OF THE RESULTS OF NON-DESTRUCTIVE INVESTIGATION

Ⅳ INVESTIGATION FROM THE VIEW POINT OF ARCHITECTURAL HISTORY IN THE SECOND SEASON


Rosetta
Alexandria
Tanis
Giza★
Cairo
Memphis
Sakkara
Beni Hassan
Tel el Amarna
Asyut
Abydos
Dandara
Luxor
Esna
Edfu
Kom Ombo
Aswan
Philae
Abu Simbel

I BACKGROUND AND PROCESS

Sakuji Yoshimura
Jiro Kondo
Izumi Harigai

(1) Background

During the period from January 22 through February 9, 1987, the Waseda University investigation mission carried out the first investigation of pyramids area at Giza in the Arab Republic of Egypt. The investigation was initiated upon request by Dr. Ahamed Kadry, the Chairman of Egyptian Antiquities Organization, the Arab Republic of Egypt. From the beginning, we started our investigation in Giza Area for the final purpose of clarification of the history in Giza Plateau and of revelation of the whole aspect of the Giza necropolis. In order to achieve the purpose, the first pyramid investigations were performed with the following four objectives:

① To clarify the inner structure of Great Pyramid
② To clarify why Great Pyramid was constructed
③ To clarify the structure of Great Sphinx including that around it
④ To determine the age when Great Sphinx was built

We tried to introduce some up to date scientific techniques for the investigation, since it was a major prerequisite for us to perform our investigation without damaging the historic remains, as requested. A new technique, which was introduced for the first pyramid investigation, was mainly the radar system utilizing electromagnetic wave. The radar system utilizing the electromagnetic wave was adopted for the first pyramid investigation only after it had been proven effective for the exploration in Giza Area and the basic data had been gathered, by performing various tests such as performance, functioning and response in several locations in both Japan and Egypt before the actual investigation started in the Giza Area. By means of this system, we carried out the explorations of various locations for the first pyramid investigation, such as Horizontal Passage leading to Queen's Chamber, Queen's Chamber, King's Chamber, the south side of Great Pyramid, the south side of Great Sphinx, the north side of Great Sphinx and the front court of Great Sphinx. For example, through those investigations we obtained some results reasonable enough to ascertain the existence of the cavity and sand, which were discovered by the French investigation team. Furthermore, the results enabled us to infer not only that some cavity existed at the north side at the west end of the north wall in Queen's Chamber, but also that a cavity existed under the limestone lids of the second Khufu's Boat Pit, and that various sorts of materials were included in the inner part of the cavity.

Another investigation was also conducted in the inside of Great Pyramid in terms of architectural history. First, we reviewed the assumption raised by the French team, which led us to clarification of such problems as the symbolization of Great Pyramid and the traditional investigation method.

Those results of the first pyramid investigation are described in the report titled "Non-Destractive Pyramid Investigation (1) - By Electromagnetic Wave Method" (Studies in Egyptian Culture No. 6, Waseda University, 1987)

Our mission produced several excellent results through the first pyramid investigation, but at the same time it discovered some problems to be further investigated in the future. Starting on September 3, 1987, the second pyramid investigation was carried out under the careful new plan, taking these problems into consideration.

(2) Purpose and method

The second pyramid investigation by Waseda University was conducted with the following objectives, following the first pyramid investigation:

① To clarify the inner structure of the great pyramid

② To clarify why the great pyramid was constructed.

③ To clarify the structure of the great sphinx including that around it

④ To determine the age during which the great sphinx was built

Some new investigation were required in addition to the results of the first pyramid investigation so that we could get a final conclusion on the significant themes as described above. Therefore, we decided to perform each investigation by dividing our mission into 3 groups - scientific investigation team, architecture team and archaeology team.

1. Scientific investigation team

The exploration team had the followng two objectives, and continued to conduct the non-destructive investigation by means of a scientific techniques.

① To clarify the inner structure of Great Pyramid

② To clarify the structure of Great Sphinx including that around it

We conducted the first pyramid investigation by means of reflection method of electromagnetic wave system with the frequency of 150 MHz and the power of 100V, which had transmitter and recevier in the unit, but as for the second pyramid investigation we tried to perform the following investigations with some new facilities and equipment provided additionally.

A) To investigate the areas which were not explored at the time of the first pyramid investigation.

Since some portions such as the wall west of Horizontal Passage, the side wall of Grand Gallery, Underground Chamber and the terrace west of Great Sphinx still remained unexplored at the

time of the first pyramid investigation, we decided to explore these unexplored parts in the second pyramid investigation.

B) Investigation using an 80 MHz, 100V antenna

We sometimes failed to get favorable exploration effects at the time of the first pyramid investigation, because the exploration distance of the electromagnetic wave system using 150 MHz, 100V which was used for the investigation was comparatively short. Therefore, we added some improvements to the electromagnetic wave system for the second pyramid investigation. We finally succeeded in making the exploration distance approx. 2 times longer by adding an 80 MHz antenna system to the 150 MHz electromagnetic wave system and increasing the voltage from 100V to 140V. Thus, for the second pyramid investigation we decided to repeat explorations with the new system even on the parts which had been already explored at the time of the previous investigation.

C) Investigation using transmission method

Since the short exploration distance of reflection method set a limit to our investigation capability, we developed a separation-type antenna equipped with an independent transmitter and receiver, which enabled us to use the transmission method permitting electromagnetic wave to transmit between two points. For the second pyramid investigation, we decided to explore the basic parts, such as the location between Queen's Chamber and King's Chamber, the location between north wall of Grand Gallery and Northern Entrance, and the location between Horizontal Passage leading to Queen's Chamber and Grand Gallery by means of the transmission method which is provided with a longer exploration distance.

D) Investigation by gravity measuring method

For the first pyramid investigation we used the electromagnetic wave system only. For the second pyramid investigaion we introduced a deviation microgravity meter to supplement and ascertain the exploration results already obtined by the electromagnetic wave system through another different method. For this investigation, we decided to explore with this gravity meter the basic parts such as Queen's Chamber, King's Chamber, and Horizontal Passage in Great Pyramid and the location around Great Sphinx where some cavity was assumed to exist through the exploration by electromagnetic waves.

2. Architecture team

The architecture team had the following objectives, and had been engaged in the investigation in the Giza Area since we started the first pyramid investigation.

① To clarify the inner structure of Great Pyramid

② To clarify why Great Pyramid was constructed

For the second pyramid investigation, however, we decided to conduct the following investigations, taking into consideration the results of the first pyramid investigation which was

made from a viewpoint of architecture history.

A) Detailed measurement investigation of Great Pyramid

As a result of the first pyramid investigation, we came to think it was necessary to perform a detailed measurement of Great Pyramid for architectural examination. In addition, it was mandatory for us to know the accurate locations and sizes of the spaces in Great Pyramid. Therefore, for the second pyramid investigation we planned to conduct the measurement investigation for the purpose of working out accurate plans of the inner parts of Great Pyramid. In this case, we also planned to perform precise measurement, using a electric distance meter, which could be utilized even in the narrow space of Great Pyramid.

3. Archaeology team

The archaeology team aimd at clarifying the history in Giza Plateau and finding out the whole aspect of the buried city planning. Since we started the first pyramid investigation, we also had been engaged in the study of the investigation results which were obtained in the past in Giza Area, the archaeological materials, and the archaeological interpretation on the investigation results derived from each investigation team.

We planned to conduct the following investigations in Giza Area for the second pyramid investigation based upon the results of the first pyramid investigation.

A) Drawing of plans of the area near Great Pyramid

We planned to draw plans of the area around Great Pyramid, since there were a number of areas around the Great Pyramid on which no accurate measurement or report was yet made. The drawing should be designed to be useful enough to allow the scientific investigation team to record their exploring positions.

B) Drawing of plans of the area around Great Sphinx

We planned to draw plans of the areas around Great Sphinx, since no accurate plans have been published in the past.

C) Archaeological interpretation on the investigation results derived from each investigation team

We planned to examine the results of the first and second pyramid investigation derived from each investigation team from an archaeological viewpoint by collating them with the traditional interpretation of Egyptology.

(3) Organization of the investigation mission

The Waseda University investigation mission, let by Associate Professor Sakuji Yoshimura, School of Human Science, Waseda University consisted of 3 investigation teams, -scientific investigation team, architecture team and archaeology team. the investigation recording stuffs, and public relation The members are as follows:

Director: Sakuji Yoshimura
(Associate Professor, School of Human Science, Waseda University)

Architecture Team:

Director; Takeshi Nakagawa
(Doctor, Professor, Dept. of Architecture, School of Science and Engineering, Waseda University)

Members; Kazuaki Seki
(Associate Professor, Dept. of Architecture, School of Science and Engineering, Kanto-gakuin University)

Shinichi Nishimoto
(Assistant, Dept. of Architecture, School of Science and Engineering, Waseda University)

Takeshi Ikeda
(Researcher, History Architecture, E.C.C.W.U.)

Scientific investigaion Team:

Director; Shoji Tonouchi
(Doctor of Science, Chief Researcher, E.C.C.W.U.)

Members; Hiroyuki Kawamura
(Researcher, E.C.C.W.U.)

Hiroyuki Kasai
(Researcher, E.C.C.W.U.)

Archaeology Team:

Director; Jiro Kondo
(Assistant, Dept. of Archaeology, School of Literature, Waseda University)

Members; Nobuo Takahashi
(Chief Curator, Iwate Prefectural Museum)

Izumi Harigai
(Researcher, Egyptian Architecture, E.C.C.W.U.)

Kichisaburo Hirota
(Researcher, Egyptian Architecture, E.C.C.W.U.)

Recording Staffs:

Director; Osamu Kumasegawa
(Photographer)

Members; Shoji Arai
(Engineer)
Toshihiro Ogawa
(Editor)
Masao Kishida
(Video Cameraman)

Public Relation Staffs: Eiji Saito
Keiko Hirabayashi

N.B. Egyptian Culuture Center, Waseda University called E.C.C.W.U for short.

(4) Process

The investigation by the second Waseda University pyramid investigation mission was carried out from September 12 through September 23, 1987. The actual investigation process was as follows:

Sept. 11

Equipment and materials were arranged and adjusted in the city of Cairo.

Sept. 12

The actual investigation started in Giza.

〈Scientific investigation Team〉

They conducted their investigations at the south side of Great Pyramid.

1. They carried out an underground exploraion at the south side of Great Pyramid, on the second Khufu's boat pit and around the location 10 m away from the south side of Great Pyramid by mans of the electromagnetic wave system reflection method.
2. They measured the gravity at the south side of Great Pyramid, on the second Khufu's boat pit and around the location 10 m away from the south side of Great Pyramid with a microgravity meter.

〈Architecture Team〉

They investigated the outside of Great Pyramid.

1. They measured the length of lines at the east side and west side of Great Pyramid from its north side with electric distance meter.

〈Archaeology Team〉

They investigated the south side of Great Pyramid.

1. They conducted the measurement at the area from Great Pyramid to the second Khufu's boat pit at the south side of Great Pyramid.

Sept. 13, 14 and 15

〈Scientific investigation Team〉

They performed their investigations at the south side of Great Pyramid and around Great Sphinx.

1. They conducted their underground explorations at the front court and between front paws of Great Sphinx by means of the electromagnetic wave reflection method.
2. They carried out an electromagnetic wave transmission experiment between both front paws of Great Sphinx by means of the electromagnetic wave transmission method.
3. They conducted an underground exploration at the north side of the left front paw of Great Sphinx by means of the electromagnetic wave reflection method.
4. They conducted an underground exploration at the north side of Great Sphinx body by means of the electromagnetic wave reflection method.
5. They measured the gravity at the south side of Great Pyramid and on the second Khufu's boat pit with a microgravity meter.
6. They measured the gravity at the left front paw of Great Sphinx and at the north side of its body with a microgravity meter.
7. They measured the gravity at the right front paw of Great Sphinx and at the south side of its body with a microgravity meter.
8. They conducted underground explorations at the western terrace of Great Sphinx.

〈Architecture Team〉

They conducted their investigations at the outside of Great Pyramid.

1. They measured the south and north axis of Great Pyramid from its north side with electric distance meter.
2. They figured out the center axis of Great Pyramid.
3. They measured the deviation from the center axis at Northern Entrance of Great Pyramid.

〈Archaeology Team〉

They conducted their investigations at the south side of Great Pyramid and around Great Sphinx.

1. They measured the level ranging from Great Pyramid to the second Khufu's boat pit at the south

side of Great Pyramid.

2. They worked out drawings of depresion including Great Sphinx, and measured the level.
3. They surveyed the stone arrangement of the platform made of limestone blocks which forms the front court of Great Sphinx.
4. They worked out drawing of the western terrace of Great Sphinx.

Sept. 16 and 17

〈Scientific investigation Team〉

They conducted their investigations at Queen's Chamber and along Horizontal Passage in Great Pyramid.

1. They explored the four walls and the floor in Queen's Chamber by means of the electromagnetic wave reflection method.
2. They explored the walls and floor along Horizontal Passage by means of the electromagnetic wave reflection method.
3. They measured the gravity in Queen's Chamber with a microgravity meter.
4. They measured the gravity along Horizontal Passage with a microgravity meter.

〈Architecture Team〉

They conducted their investigations in King's Chamber and Antechamber in Great Pyramid.

1. They carried out the measurement of the various subjects including the stone structure and major stone cracks in King's Chamber except the Devison's room.
2. They carried out the measurement of the various subjects including the stone structure and major stone cracks in Antechamber.

〈Archaeology Team〉

They conducted their investigations in Queen's Chamber and along Horizontal Passage in Great Pyramid.

1. They worked out a ground plan of Queen's Chamber and measured the level.
2. They worked out a ground plan of Horizontal Passage and measured the level.
3. They surveyed the stone structure of the north wall of Queen's Chamber.
4. They surveyed the stone structure of the both side walls along Horizontal Passage.

Sept. 19 and 20

〈Scientific investigation Team〉

They mainly conducted their investigations in King's Chamber, Antechamber and Grand Gallery in Great Pyramid.

1. They explored the floor in King's Chamber by means of the electromagnetic wave reflection method.
2. They explored the floor in Antechamber by means of the electromagnetic wave reflection method.
3. They explored the wall surfaces in Grand Gallery by means of the electromagnetic wave reflection method.

4. They conducted a transmission experiment on limestone between King's Chamber and Antechamber by means of the electromagnetic wave transmission methd.
5. They conducted an exploration between King's Chamber and Queen's Chamber by means of the electromagnetic wave transmission method.
6. They conducted an exploration between the north wall along Grand Gallery and Northern Entrance by means of the electromagnetic wave transmission method.
7. They conducted an exploration between Grand Gallery and Horizontal Passage by means of the electromagnetic wave transmission method.

Sept. 21

〈Scientific investigation Team〉

They conducted their investigations mainly in Underground Chamber in Great Pyramid.

1. They explored the north wall, the west wall and the floor in Underground Chamber by means of the electromagnetic wave reflection method.
2. They measured the gravity in the King's Chamber with a microgravity meter.

〈Architecture Team〉

They conducted their investigations in Underground Chamber in Great Pyramid.

1. They conducted an abridged measurement in Underground Chamber in Great Pyramid.

〈Archaeology Team〉

They conducted their investigations in King's Chamber and Underground Chamber in Great Pyramid.

1. They continued to work out a ground plan and measured the level of King's Chamber.
2. They conducted an abridged measurement of Underground Chamber.

Sept. 22

〈Scientific investigation Team〉

They conducted their experiments at Serapeum, Saqqara.

1. They carried out an underground hollow response experiment from the ground on the Serapeum by means of the electromagnetic wave reflection method.
2. They conducted their underground investigation in Serapeum by means of the electromagnetic wave reflection method.

〈Archaeology Team〉

1. They conducted their abridged measurement of Serapeum.

Sept. 23

Equipment and materials were arranged and adjusted.

In addition to the above works, the architecture team and the archaeology team investigated and collected the data of related materials and the related literature at the Egyptian Museum Cairo.

Ⅱ NON-DESTRUCTIVE INVESTIGATION IN THE SECOND SEASON

Shoji Tonouchi

(1) Objective

The purpose of this survey is to investigate undiscovered passages and hollows in Pyramids other than the rooms and passages which have already been discovered so far and to explore relics that are buried under the ground around pyramids and Great Sphinx. As pyramids are important world-wide cultural asserts, non-destructive investigation is an absolute condition. That is an investigation method that can damage to the pyramids in any way should not be used. For this purpose, under-ground radar system (the electromagnetic wave prospecting method) and microgravity method used this time. In our pyramid survey two electromagnetic wave methods were used. They were the reflection method, generally called the underground radar method, and the transmission method. The electromagnetic wave method and gravity method are now first stage. The development of the machines used for this survey are going at the same time.

(2) Electromagnetic Wave Method

1. Basic concept of the electromagnetic wave method

Gabillard and others found that in the propagation of electromagnetic waves in earth and base rocks, there are areas of small propagation losses in the frequency bands under 10KHz and 10MHz. These areas are respectively called "low frequency window" (LFW) and "high frequency window" (HFW). This underground radar system is a device to explore earth and base rocks through these frequency windows. The LFW is used in what is called an Magnetotelic method (MT method) for deep-layer physical exploration. The HFW is used for the radar exploration in our pyramid survey. For a historic relic survey, it is absolutely necessary to use a non-destructive, non-vibrating exploration method. The underground radar exploration method that uses VHF band waves is suitable in this respect because of its high accuracy near the ground surface ensured by the high frequency used, its speedy exploration performance and its being a non-destructive method. Attempts to use electromagnetic waves for the exploration of the ground and base rocks have been made since early in the 1900s. The underground radar system that emits electromagnetic waves into the ground and detects the reflected waves from the target object was first used in 1937. But full-fledged into the exploration method using VHF band waves were started late in the 1960s by Morey and others. Since then, many reports have been made on

developments of the method and on exploration experiments.

In our pyramid survey, two radar exploration methods were used. They were the reflection method, generally called the underground radar system method, and the transmission method. In the reflection method, electromagnetic pulse waves were emitted to the earth and the surface of the base rocks and the ground surface, and the echo waves were used to detect the target objects in the earth and the base rocks. In the transmission method, a transmitting antenna was attached to one side of a rock mass and a receiving antenna to the other side and the speed, time and attenuation of the electromagnetic waves that passed through the information in the rock between the antennas was obtained to calculate cavities, etc. by the tomography method. The performance of these radar exploration methods varies with the form of electromagnetic waves, the characteristics of antenna, the electrical constant of the earth, the underground structure and the materials and shapes of target objects.

Especially great care should be taken of the dielectric constant of the material explored because it is substantially affected by the rock quality and the moisture content.

The frequencies of the electromagnetic waves used for the reflection method and the transmission method in our servey were 400MHz, 150MHz, 80MHz and 30MHz. They were used for suitable purposes according to the object explored, the geology explored and the distance of exploration.

A) Principal of underground radar measurement by the reflection method

The electromagnetic waves that propagate through the air at the speed of about 300,000km/sec were generally considered incapable of easily passing through the earth, rock mass or water. But electromagnetic waves in certain frequency bands pass through these substances, though they are somewhat attenuated, and cause reflected waves from the border of different substances. The underground radar methods use these reflected waves of primarily VHF waves or microwaves.

When electromagnetic waves are emitted from an antenna to an object to be explored, they are reflected at the border of substances with different electrical propagation speeds (defined by dielectric constants).

The speed of electromagnetic waves that propagate through a substance with the dielectric constant of εr is simply given by;

$$V = \frac{C_0}{\sqrt{\varepsilon r}}$$

Where C_0 represents a beam of light in a vacuum. The distance to the surface of the border can be calculated by measuring the time required for the reflected waves to return to the antenna and by measuring the time required for them to reach the surface of the border.

At the same time, the intensity and the phase of the reflected waves which differ from one

border surface to another, are calculated. . The results, together with the distance calculated, are processed as data, and the cross section of the object explored at each border surface is displayed. This is the basic operating principal of the underground radar. In the reflection method, the underground radar has the following characteristic:

① The non-destructive exploration method permits continuous exploration without physical contact.
② The radar reflection method enables exploration of non-metalic substances and the geological environment. It also provides good directivity.
③ Data on cross sections are obtained as images on a real-time basis, and some on-the-spot analysis is possible.
④ The high frequencies provide an excellent exploration accuracy or resolving power.

B) Electromagnetic wave measurement by the transmission method

The method in which two boring holes are employed has recently been used. In this method, a transmitting antenna is set on one of the opposite walls and a receiving antenna on the other, and electromagnetic waves are transmitted between the two antennas. The earth between the antennas can be explored by measuring the propagation and the attenuation.

This method is unique in analysis. Computed tomography (CT) is used for analytical processing. In this method, the structure is analyzed on the basis of the transmission speed and the attenuation rate of electromagnetic waves at various parts of an object explored. This method is widely used in the medical field to take tomograms of a human body.

The frequencies of electromagnetic waves used in our pyramid survey are 400MHz, 150MHz, 80MHz and 30MHz. One characteristic of method is that the distance of exploration can be set long as compared with the reflection method whose exploration method is short.

2. Equipment to be used for this investigation

Measurement is performed with the two equipments in both the reflection method and the transmission method of the electromagnetic wave method.

A) Outline of equipment

The reflection method is generally called the underground radar method that utilizes electric waves for the investigation from the surface of the earth without digging up gas pipes and water pipes buried under the ground. The schematic drawing of this equipment is shown Fig. 4.

This equipment is used to obtain the location of the target by emitting electromagnetic waves into the ground from the antenna placed on the surface of the earth and receiving echoes reflected from the target under the ground and by processing signals and displaying the antenna section on a

color CRT.

In the transmission method, a transmitting antenna was attached to one side of a rock mass and a receiving antenna to the other side and the speed, time of the electromagnetic waves that passed through the information in the rock between the antennas was obtained to cavities, etc. by the geotomography method. This equipment was shown in Fig. 5.

B) Major specification

Reflection method

Display	:	Displays antenna scanning on a color CRT
Scanning	:	1.0 m/s (max)
Power requirement	:	AC100V, 50/60Hz, 200VA
Ambient temperature	:	0℃～+60℃

Transmission method

Frequency range	:	80～400MHz
Dynamic range	:	150 dB
Ambient temperature	:	0℃～+60℃
Power requirement	:	AC100V, 50/60Hz, 200VA
Number of stacks	:	1～256

C) Configuration

This equipment is composed of the following parts.

Reflection method

Antenna section	:	1 unit
Display section	:	1 unit
Accessaries	:	1 set

Transmission method

Antenna section	:	2 sets
Control unit	:	1 unit
Digital storage osciloscope	:	1 set
X-Y recorder	:	1 set

3. Field experiments in Japan

This pyramid investigation in Egypt is second stage, therefore, it is necessary to do various foundmental experiment.

The field experiments were conducted at Uto Limestone Mine and Une Limestone Mine in Japan for the purpose of examining survey distance and resolution.

Fig. 7 and Fig. 8 show Uto Mine and the entrance of the tunnel. The experiments were conducted in the tunnel in using 80MHz, 150MHz and 400MHz short-pulse antennas.

The transmitting antenna put up the one side of the mass, and receiving antenna put up the other side (Fig. 9). The interval of the two antennas were variously changed as Fig. 13 and experimental equipment is shown in Fig. 12. The relationship of the travel time and received level in the air. The results from Une and Uto Mines are shown in Fig. 16 and 17. At the same time the experiment of the reflection was done at Uto Mine. A cave (about 3m) could be detected in about 12.3m distance.

From the results of the experiments relative dielectric constant was calculated and the mean value was 7.45 . In this experiment propagation distance for 80MHz antenna is more than 33.8m.

4. Field experiments in Egypt

The field experiments were conducted at the area of the Solar Boat museum, inside Khufu pyramid and Great Sphinx in Egypt. At first time transmissive experiment of limestone which covered Khufu Boat pit was executed with 80MHz and 150MHz antennas. Fig. 19 shows the experimental method and the pulses obtained at it. The experiment was conducted in using 80MHz and 150MHz short-pulse antennas.

The transmitting antanna put up the one side of the limestone and receiving antenna put up the other side. The distance between transmitter and receiver changed variously. (Fig. 19) The results of it were shown in Table 3 and Table 4. From the results of these experiments, the mean relative dielectric constant was calculated and the mean value shows 6.73 and 5.60 in 150MHz and 80MHz antenna respectively.

In the same way, the transmissive experiment was executed for the purpose of the geotomography analysis of Great Sphinx in not future. The propagation test was done at the both legs of Great Sphinx.

The situation of the test at the two legs and the pulses obtained from it was shown in Fig. 20, 21 and 22. The result of it were shown Table 5 and Table 6.

The Great Sphinx was formed from the alteration of strata (sandstone, mudstone and limestone). It is considerd that the propagation route of the electromagnetic wave is sandstone, therefore, relative dielectric constant is small mean value. The mean value is 2.47.

In the future, our survey for Great Pyramid will be adopted the transmission method and

computed tomography (CT) is used for analytical processing. The structure is analyzed on the basis of the transmission speed and the attenuation rate of electromagnetic waves.

Above mentioned purpose the transmission test was executed inside Great Pyramid. The frequency of electromagnetic waves used in this test were 150MHz and 80MHz. The tests were done at the place between Horizontal Passage and Ground Gallery. But it is seemed that the used frequency (150MHz and 80MHz) is high in this test. In next survey we intend to use 30MHz antenna. Fig. 23 shows the place in this test.

Another test was done the place between Megalithic Mansory of Northern Entrance and the north wall of Grand Gallery for the purpose of the confirmation of the fact whether the passage runs between the two places or not. The thickness of the covered limestone of both sides is about 2m respectively and the distance of propagation through the limestone is small, it is considered that electromagnetic waves emitted from one side can reaches at another side. But we could not obtain the signal. It seems that the passage does not exist. It is necessary that the test executes in next survey with another low frequency antenna.

The test place is shown in Fi.g 24.

(3) Gravity Measurement

1. Basic concept of gravity measurement

J. Richer of France found in 1672 that a pendulum clock lost 2 minutes 30 seconds a day in the equatorial region. This meant that the gravity that varies from place to place could be measured by the use of a pendulum clock. It marked the beginning of gravity exploration. Attempts to measure the gravity were initially made for the purpose of geodesy to learn the precise shape of the earth from the distribution of gravity on the earth surface. Later the comparative gravity measurement was required to attain a higher accuracy. In the comparative measurement, the absolute value of the gravity is not measured but the difference of the gravity at point B from the gravity at reference point A is measured. This is the origin of the deviation difference gravimeter used in our pyramid survey. Later in the 1900s, H.V.Boeckh and others developed highly accurate deviation difference gravimeters usable for mine prospecting and oil prospecting. This method is suitable for exploring comparatively small underground cavities, etc.

The gravity works on everything around us on the earth. We feel it as weight. According to the universal gravitation, everything on the earth is affected by the attracting force of all of the substances that constitute the earth. At the same time, everything on the earth is subjected to the centrifugal force because of the rotation of the earth. As a result, the combination of the attracting force of the earth and the centrifugal force caused by the rotation acts on everything on the earth. This combined force is the gravity of the earth. The direction in which the gravity works is called "under". The magnitude of the gravity that acts on an object at a point on the earth is proportional to its mass, m. When the constant of proportion is represented by g, the magnitude of the gravity is given by ng. The constant, g is generally called gravitational acceleration. The acceleration of 1 cm/sec^2 is called 1 gal. The gravitational acceleration g is 980 cm/sec^2, or 980 gal.

When the underground structure is to be estimated from the comparison of the magnitudes of the gravity at many points, the comparison must be made under equal conditions by eliminating the effects of the local conditions like the altitude of the observation point and the geography. Such a process is called a reduction of gravity. Reductions of gravity include a free air reduction, a topographic correction and a bouguer reduction. The exploration of a small area demands a tidal correction and a drift correction as well.

A) Free air reduction

This is the process of correcting the difference between the altitude of one

observation point and that of another. When the gravity is measured at the altitude of h (i.e. at a point so distant from the center of the earth), the reduction of 0.3086 mgal per meter is required in accordance with the law of inverse proportion to the square of the distance.

B) Topographic correction

When the topography near the observation point is uneven, the value of the gravity measured must be converted into the value of the gravity at the even topography. An upward attracting force must be given for that part of the topography below the observation point. For that part of the topography below the observation point, a downward, or negative, attracting force must be given because of the absence of a substance that causes an attracting force.

C) Bouguer reduction

Even after the free air reduction and the topographic correction, the effect of the attracting force of the mass existing between the geoid and an observation point differs from one observation point to another. Therefore, the attracting force of the mass existing between the geoid and each observation point must be calculated and eliminated.

D) Tidal correction

When a charge of 0.1 mgal or less is to be measured, as by use of a gravimeter, the attracting force (tidal power) of the sun, etc. must be taken into consideration. It must be corrected.

E) Drift correction

This is the value that automatically changes with time. This value also has to be considered and corrected.

An abnormal value of the gravity measured by a deviation difference gravimeter and given the reductions and corrections described above does not include the effects of the altitude, the latitude, the topography, etc. Therefore, the abnormality is considered attributable to the abnormality of the underground density distribution. When an underground cavity is explored, calculations are made on various models and the calculated values are compared with the measured values to determine the shape and the depth of the underground cavity.

2. Equipment to be used for investigation

We used the 410-T Series Thermostatic, Controlled Gravity Meter.

A) Outline of equipment

The gravity meter is an extremely sensitive balance; measuring and indicating a change in gravity at approximately one unit in 100,000,000.

1mg.= 1 milligal = 0.001 cm/sec./sec.

1mg. is approx. 1 part in a million of the normal gravity of the earth.

Great care must be taken in handling, operating and transporting the gravity meter. At all time, the meter has to be carried upright and during transport securely placed in an upright position. Tilting the gravity meter more than 45 off the vertical position will expose the quartz system to severe stresses which may cause loss of accuracy and permanent damage to the meter. When ever possible hand carry the instrument. For longer periods of transportation use the back with the cushioned field case.

The 410-T Series Thermostatic Controlled Gravity Meter combines the rugged yet sensitive Quartz Element Gravity Meter with a solid state electronically controlled internal heating element. With this gravity survey specialist can eliminate tharmal drift corrections without compromising on portability. By stabilizing the internal temperature, the instrument becomes immune to ambient diurnal changes which would base station reading. In addition the data becomes appreciably more accurate, contains fewer uncertainties assets in defining subtle anomalies from deeper or less obvious targets.

B) Major specification

Range (Reset)	3500–6000 mgal
Fine Counter Range	1000 div. x scale constant
Fine Counter Constant	0.09–0.11 mgal
Fine Counter Linearity	1 in 1000
Accuracy	0.1 counter div.
Drift	0.05 mgal/day or better
Level Sensitivity	40 sec./mm
Temperature coefficient less than	0.003 mgal/hr/c external change

3. Field experiment of the Microgravimeter in Japan and Egypt

Testing of the responce of the microgravimeter was executed at Oya in Tochigi prefecture in Japan and at Serapeum in Saqqara in Egypt. Tuff distributes at Oya, and there are many underground caves. The test of microgravimeter was done at the surface upper caves found the situation. A free air reduction, a topographic correction and a bouger reduction of the data were done. The result was shown in Fig. 25. Furthermore, the field test was executed at Serapeum in Saqqara in Egypt. The underground cave was also confirmed at this place. Fig. 26 shows the results of Serapeum in Saqqara. The experiment was executed upper the known cavities.

4. The results of gravity survey at Giza

A) Results in King's Chamber

The residual values range from $-40 \sim +30$ μGals. The three negative anomalies are located at the northeast corner, southeast corner and southwest corner of the King's Chamber's floor. Fig. 27 shows the residual anomaly map. The main positive anomaly is located at the center of the room. The result of electromagnetic survey shows the abnormal reflection below the floor of the southwest corner and northeast corner. The result of the electromagnetic survey agrees with it of the gravity survey at the two parts. But the electromagnetic survey does not show the abnormal reflection at the southeast corner.

B) Results in Horizontal Passage

This zone was surveyed by French team. Fig. 28 shows the results of the profile of the residual anomaly. Towards the entry of the passage, a positive zone ($+150$ μGals) shows up, while towards the Queen's Chamber, a strong negative feature (-60 μGals) is visible. Quantative analysis is very difficult because data are only available along the two tightly spaced profiles.

The results of this survey coinside with the observation made by French team. But the value of the positive anomaly of this result is lager than that of French observation.

C) Results around Great Sphinx

At first the gravity measurement was conducted at the front of Great Sphinx (Fig. 29 and 30). The residual values ranges from -30 Gals to $+40$ Gals. The main two negative anomalies are located at the north side and at the center part of this survey area ($-20 \sim -30$ Gals). The two positive anomalies is distributed at the east and west side ($-20 \sim -40$ Gals).

Next the survey was executed at the northern part of Great Sphinx. Fig. 31 shows the survey area and the result of the measurement. The main large negative anomaly (-100 Gals) is located in a long and slender area beside the trunk of Great Sphinx.

Thirdly the gravity survey was done at the southern part of Great Sphinx. The results and the survey area are shown in Fig. 32. The negative anomaly is also distributed in a long and slender area beside the trunk.

Forthly the survey was executed beside left foreleg of Great Sphinx. Fig. 33 shows the result and the measurement line. The positive anomaly at the east part and negative anomaly at the west part of the line are located. The value of the negative anomaly is about -40 Gals. The situation of the negative anomaly coinside with the place obtained the strong reflection from the electromagnetic method.

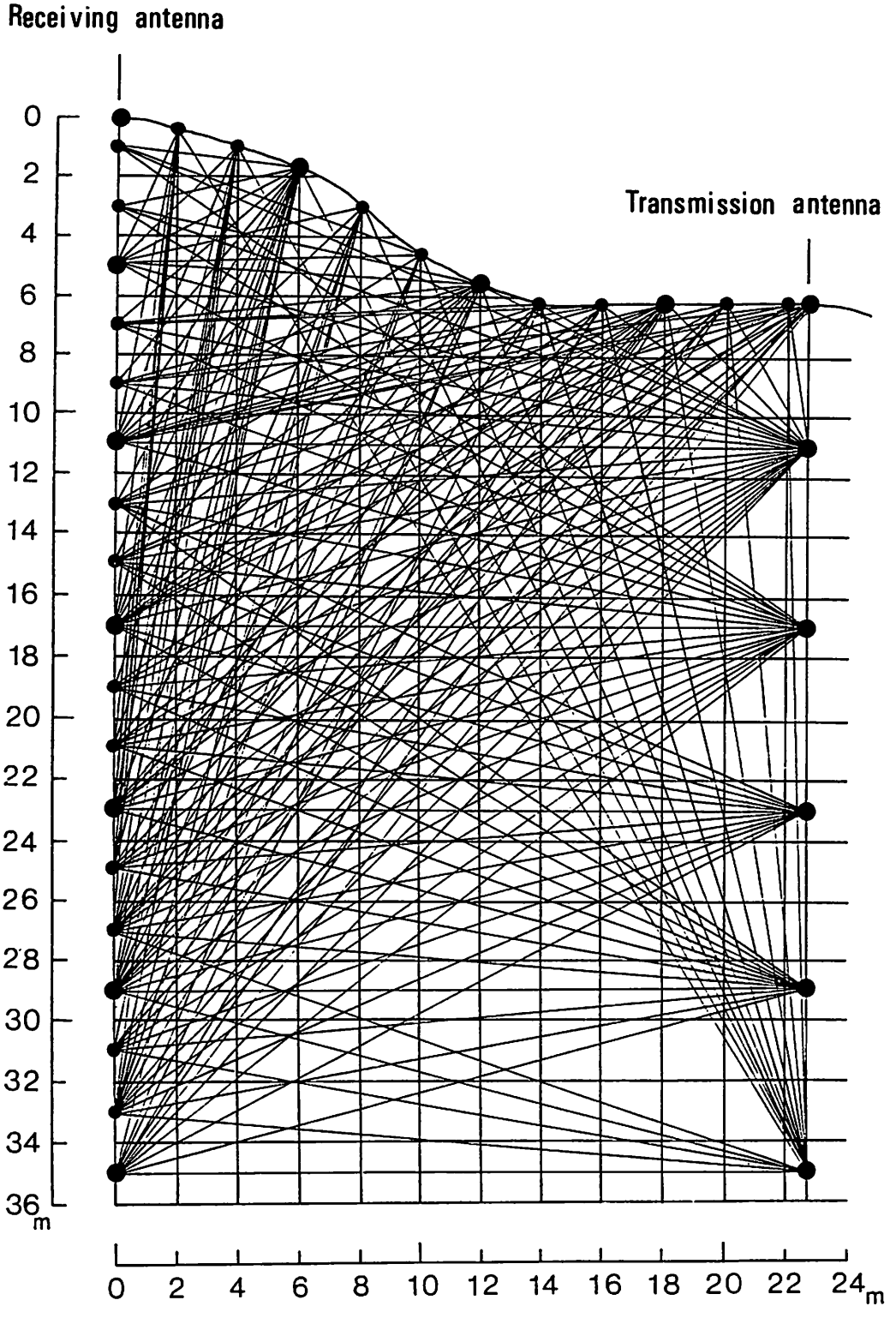


Fig. 1 An example of the paths of electromagnetic waves

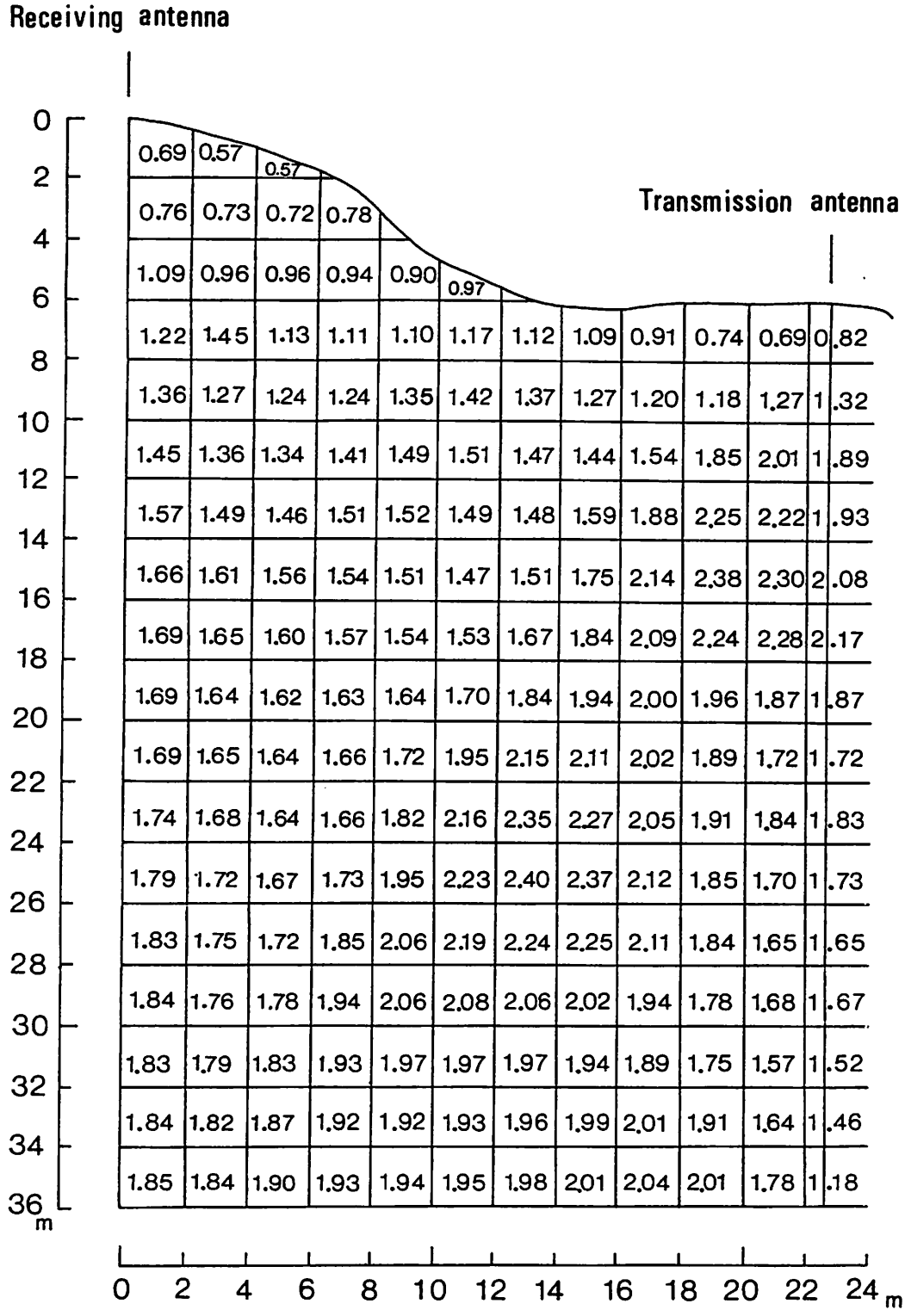


Fig. 2 The speed distribution calculated geotomography method (ART method)

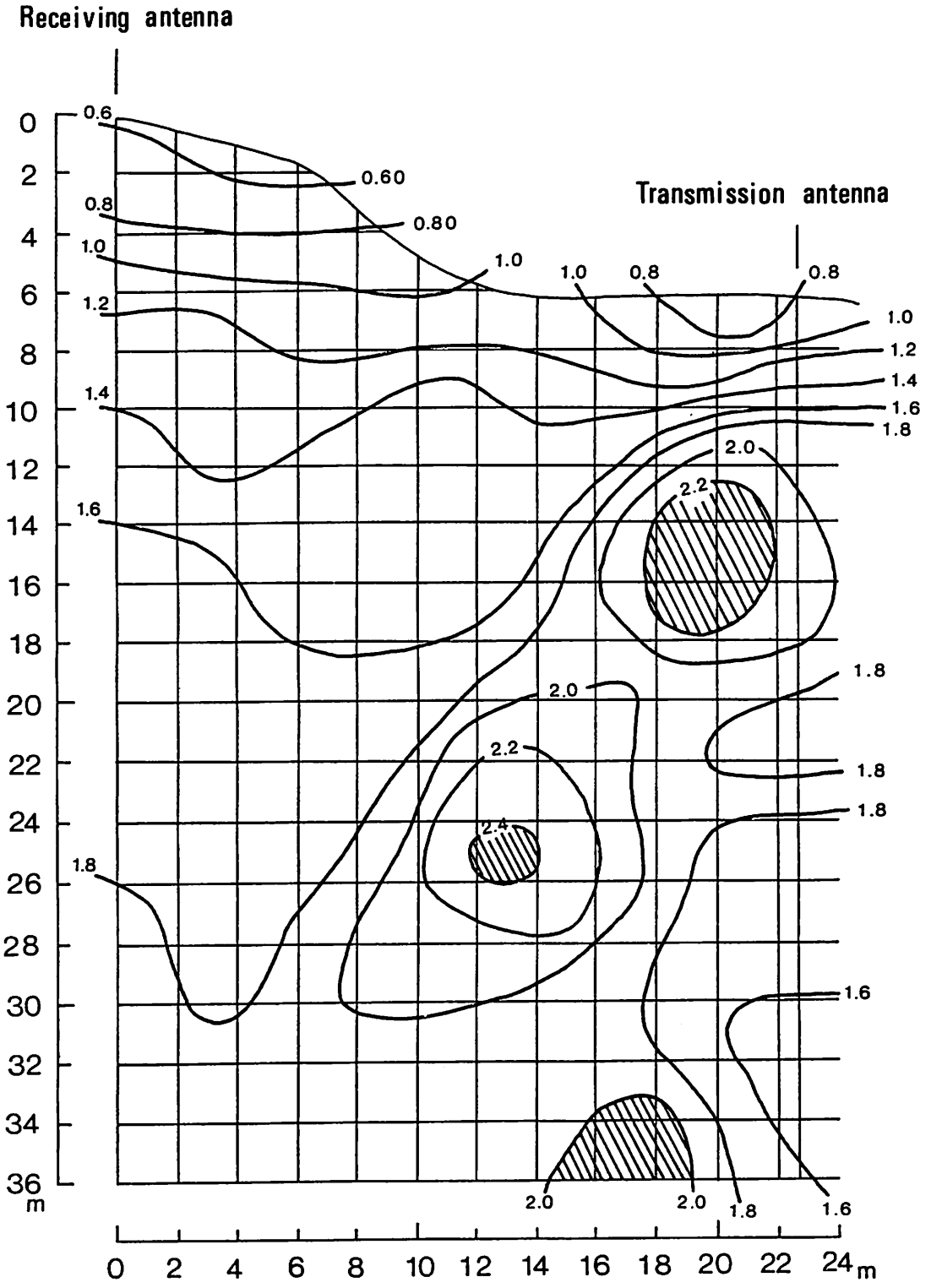


Fig. 3 Speed counter map

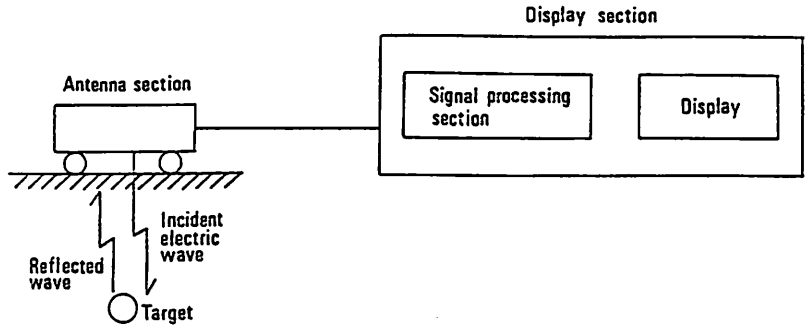


Fig. 4 Block diagram of the underground radar system

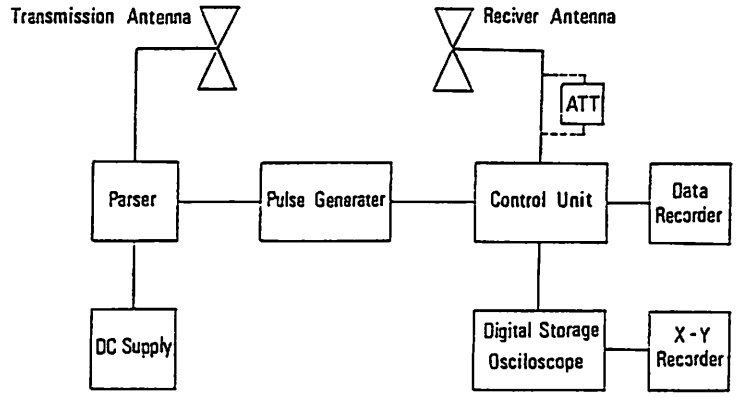


Fig. 5 Block diagram of radar system used in the transmission method

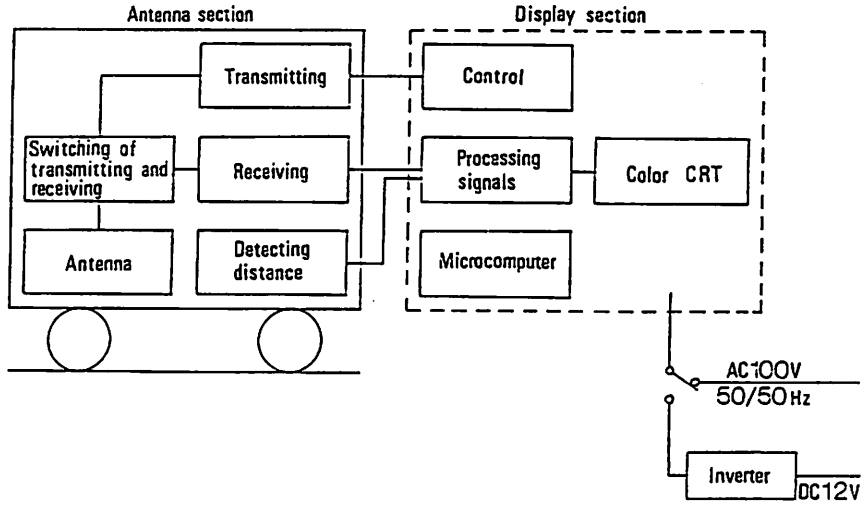


Fig. 6 The underground radar system

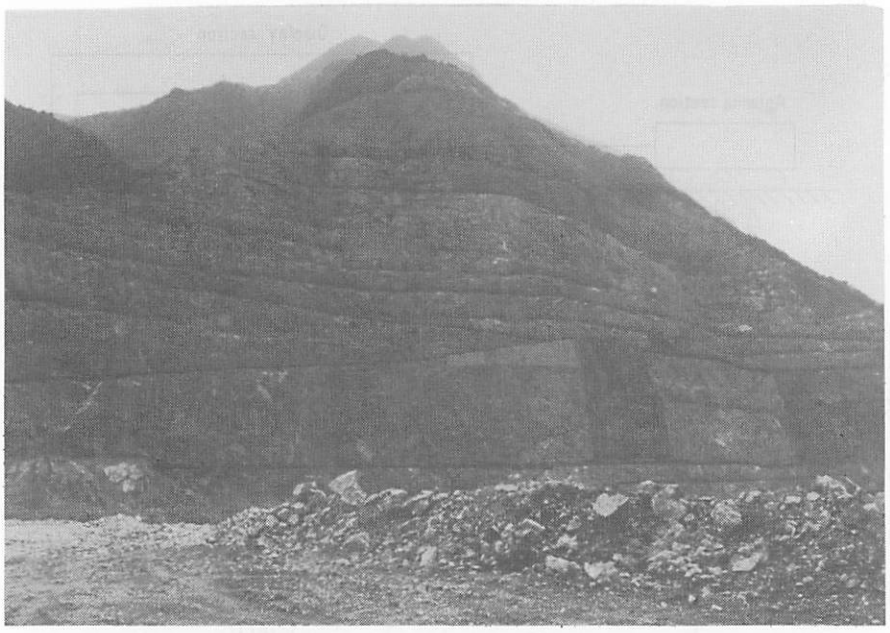


Fig. 7 The whole shape of Uto Limestone Mine

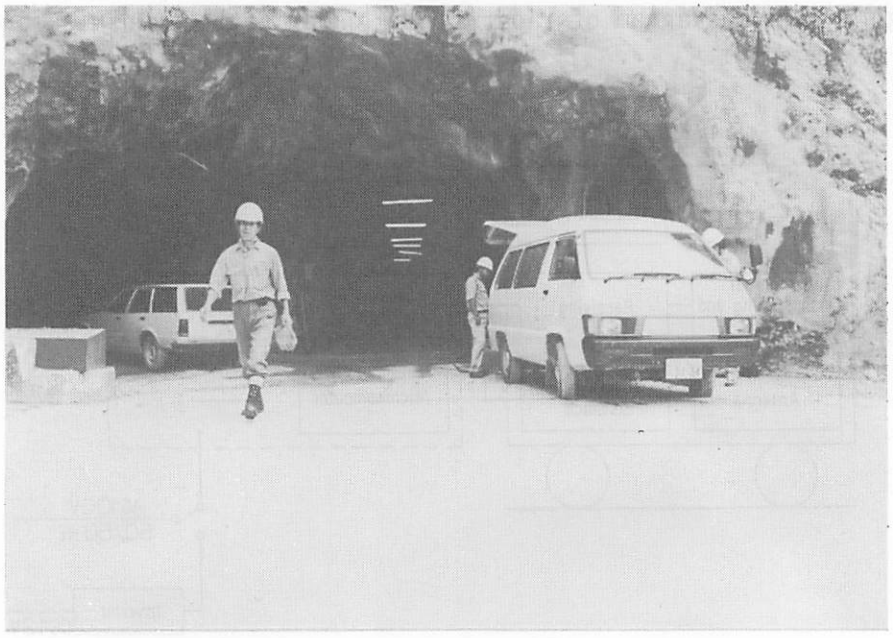


Fig. 8 An entrance of a tunnel at Uto Limestone Mine

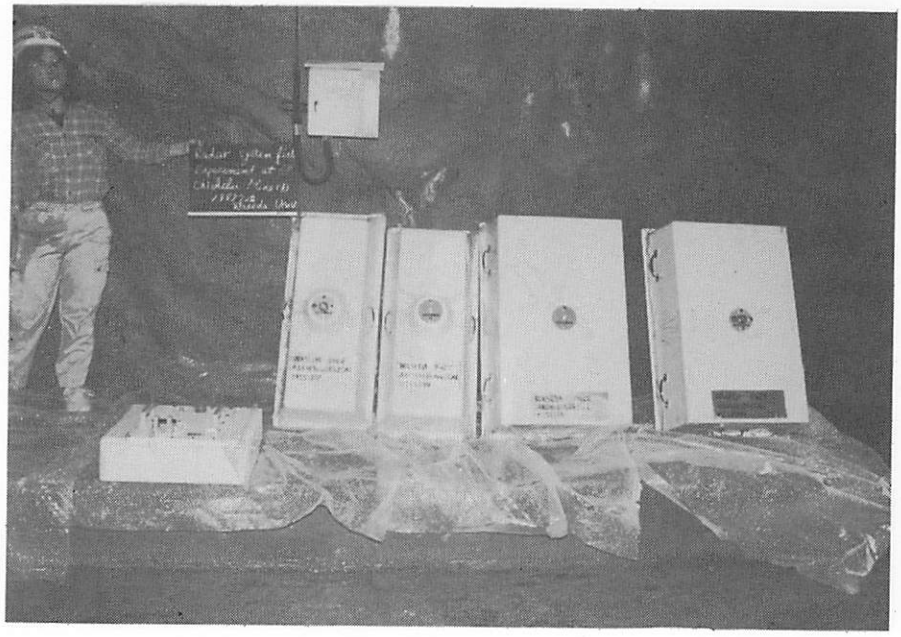


Fig. 9 Antennas used for this survey (400MHz, 150MHz, 80MHz)

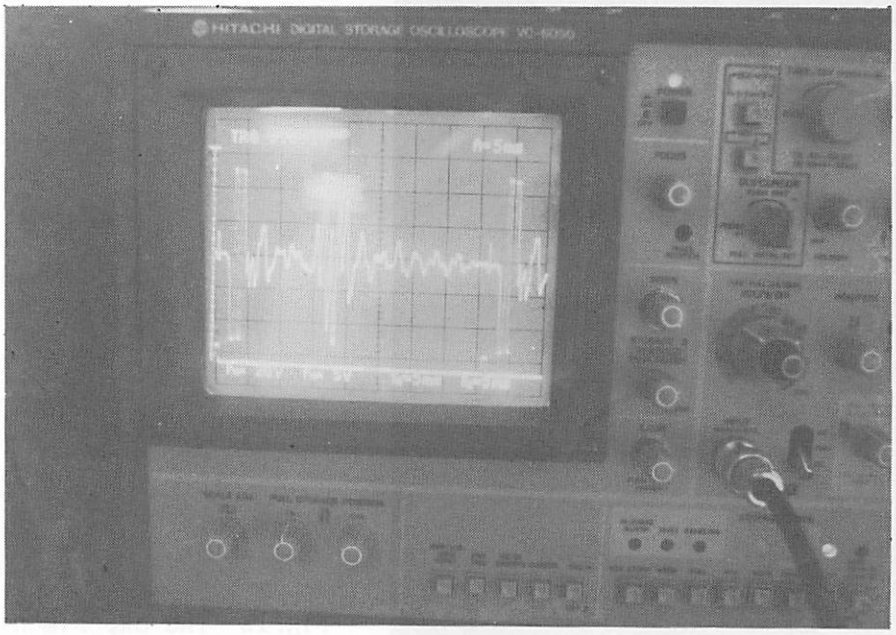


Fig.10 Typical A-scope photograph of electromangetic wave signal

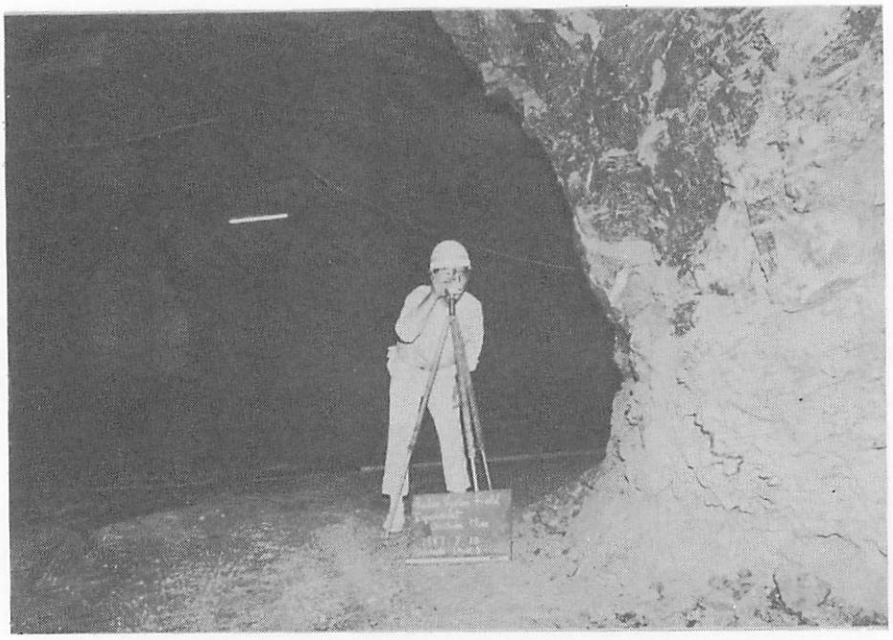


Fig.11 The measurement for this experiment at Uto Limestone Mine

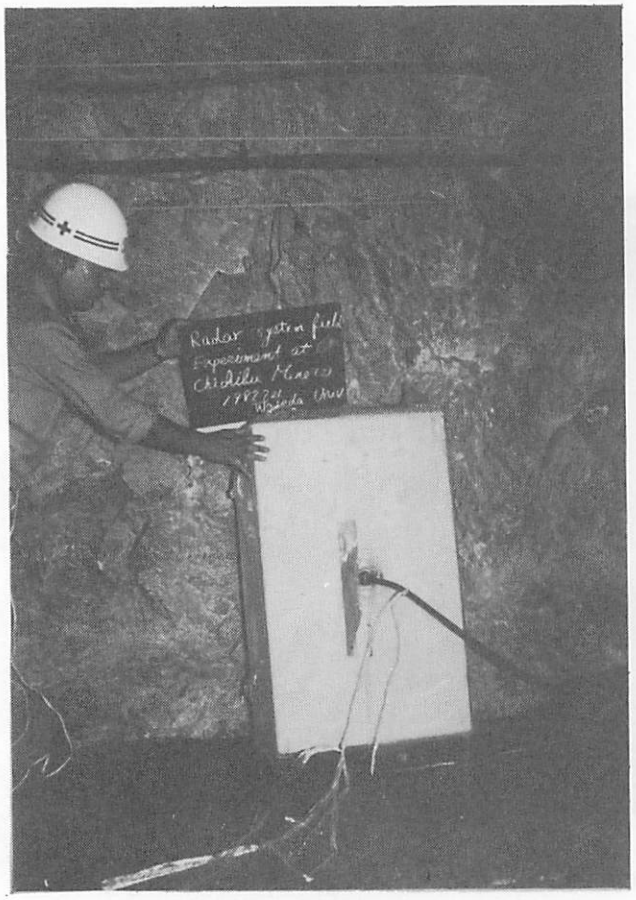


Fig.12 The experiment for 80MHz antenna at Uto Limestone Mine

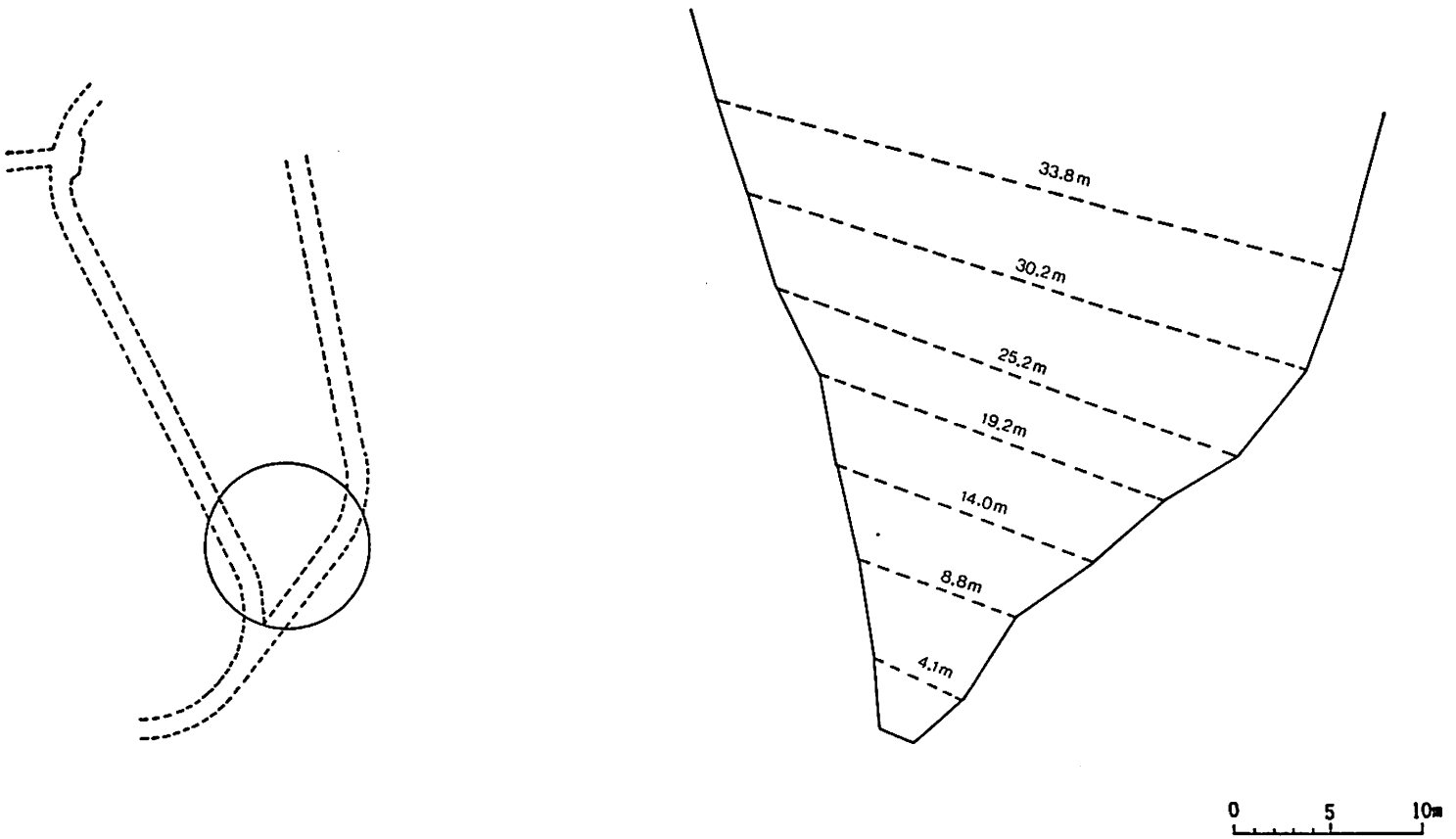


Fig.13 The experimental place at Uto Limestone Mine (Transmission method)

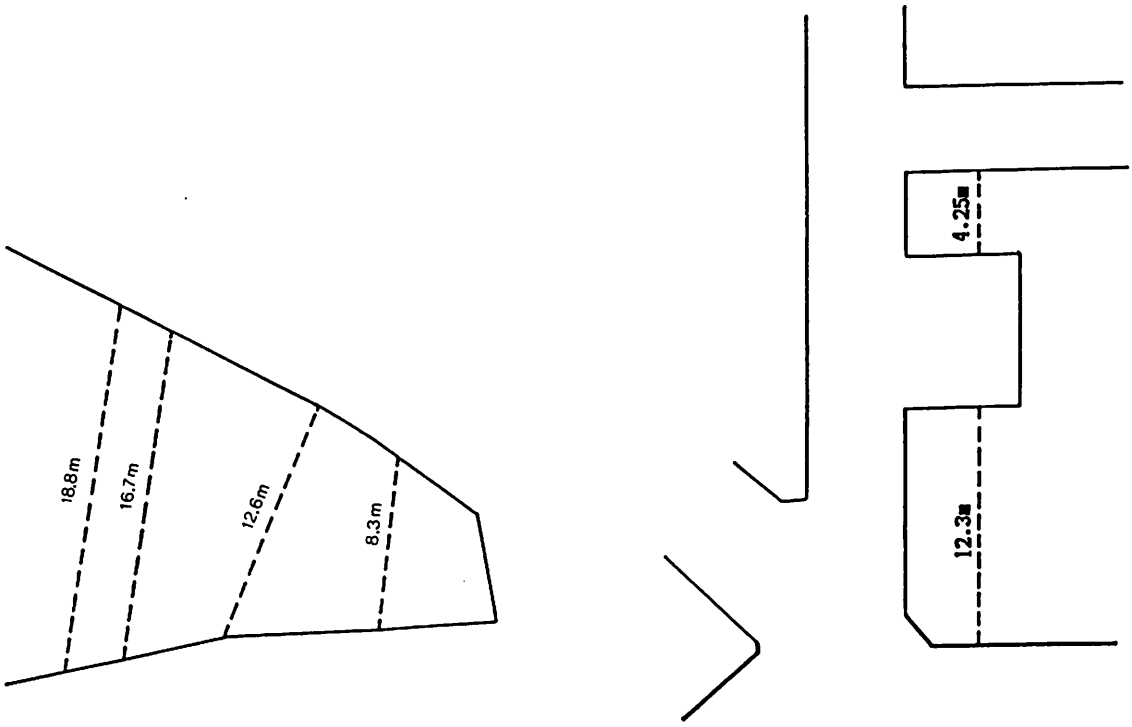


Fig.14 The experimental place at Une Limestone Mine (Transmission method)

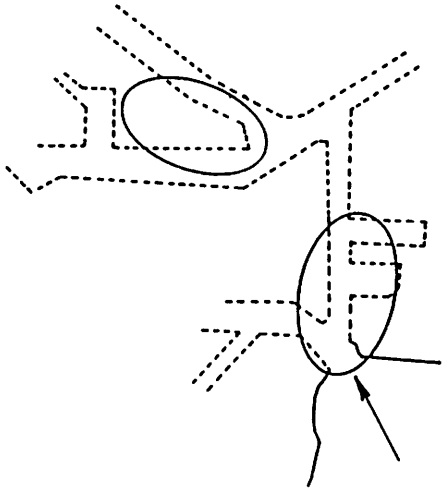


Fig.15 The tunnel of Uto Limestone Mine

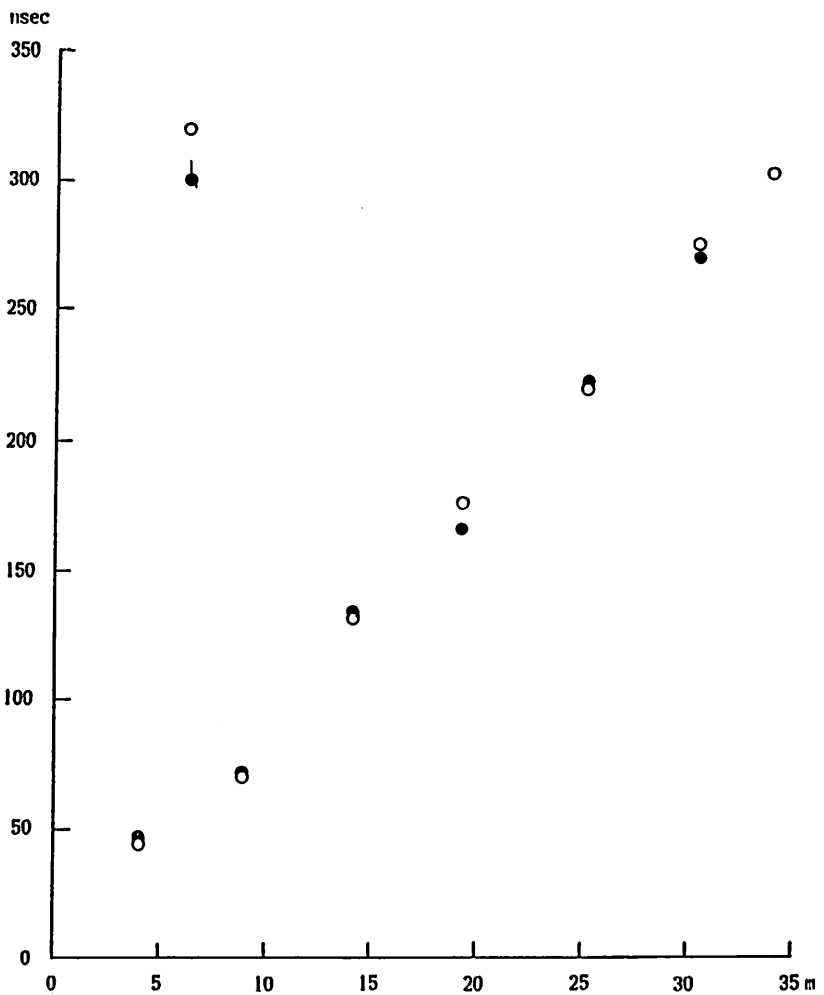


Fig.17 Travel time diagram at Une Limestone Mine

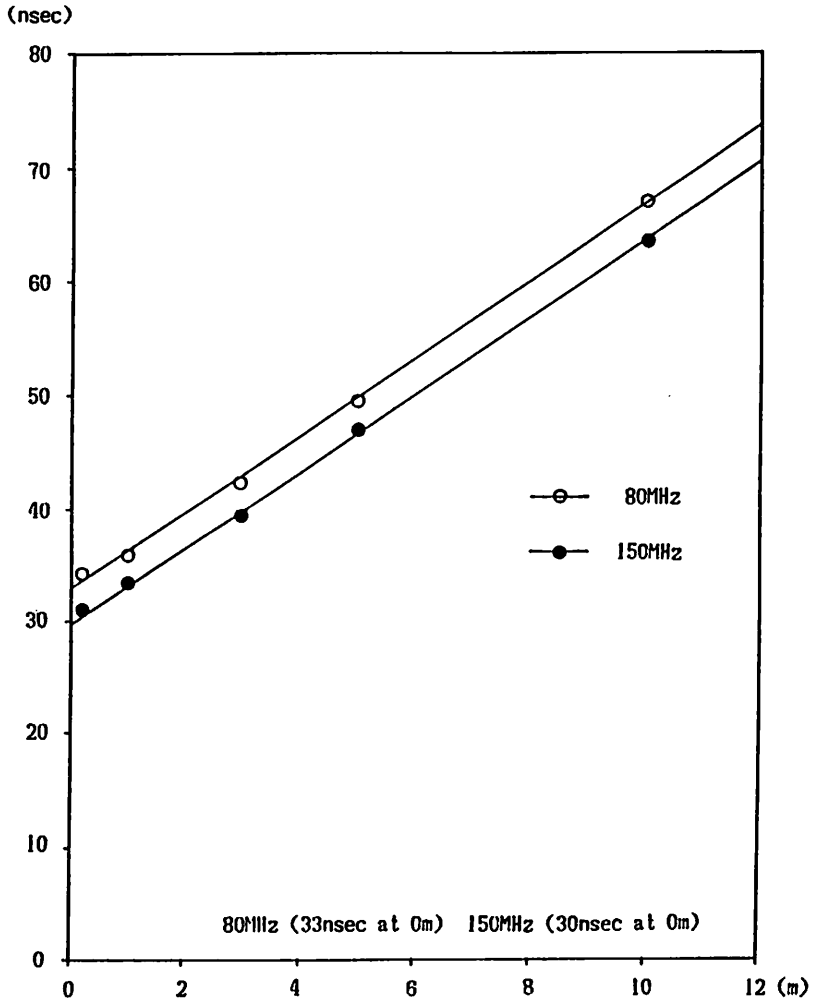


Fig.16 Travel time diagram in the air

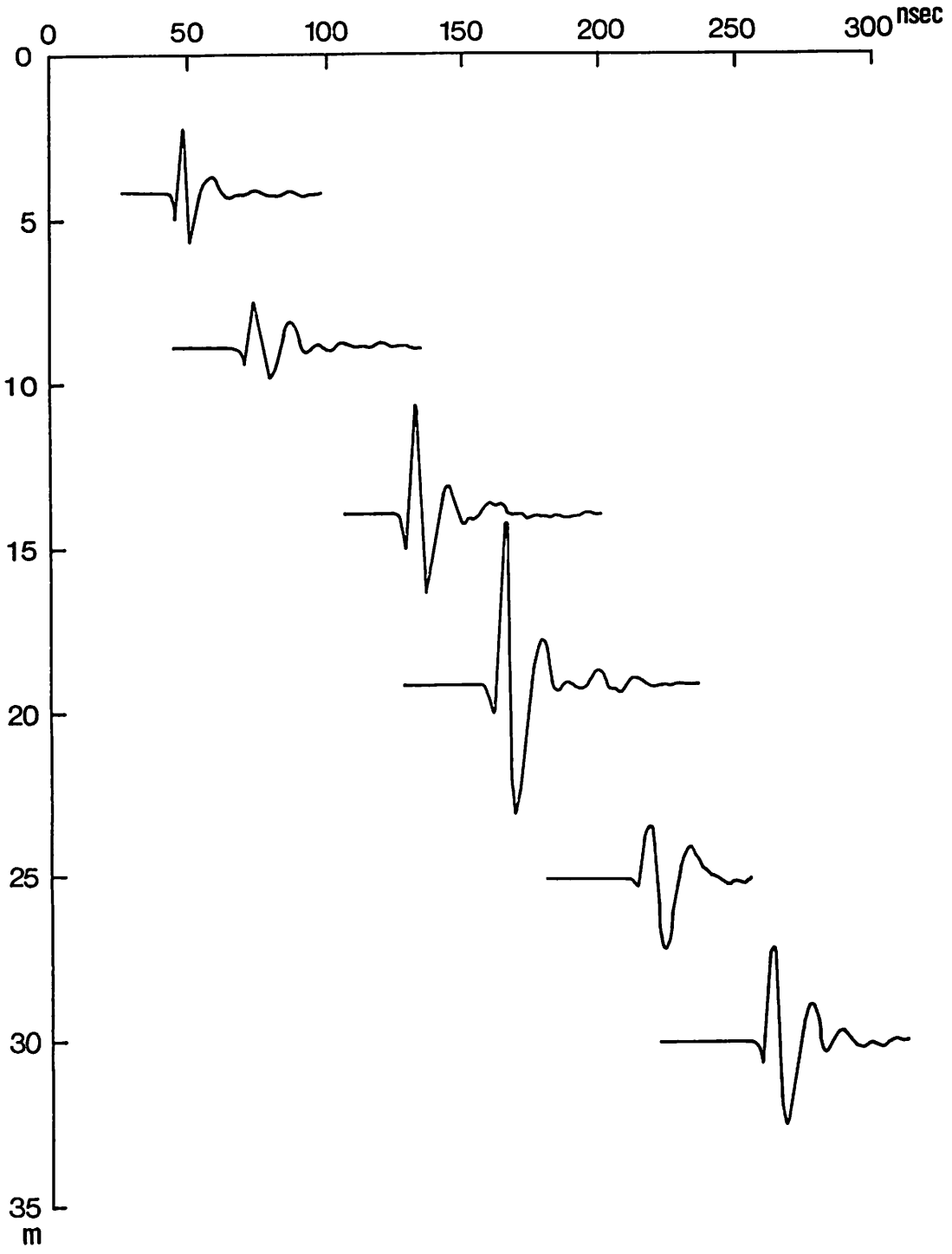


Fig.18 Transmissive experiment at Une Mine (150MHz)

No.	Distance (m)	Travel time (nsec)	Velocity (m/sec) x10^8	Dielectric constant (εr)
1-1	14.0	133.64	8.80	8.15
1-2	19.2	166.48	1.15	6.80
1-3	25.2	221.76	1.14	6.92
1-4	30.2	269.44	1.12	7.17

Table 1 The experimental data at Une Limestone Mine (150MHz)

No.	Distance (m)	Travel time (nsec)	Velocity (m/sec) x10^8	Dielectric constant (εr)
2-1	14.0	139.90	1.07	7.85
2-2	19.2	175.84	1.09	7.57
2-3	25.2	219.30	1.15	6.80
2-4	30.2	274.60	1.10	7.43
2-5	33.8	298.27	1.13	7.04
2-6	33.8	302.26	1.12	7.17

Table 2 The experimental data at Une Limestone Mine (80MHz)

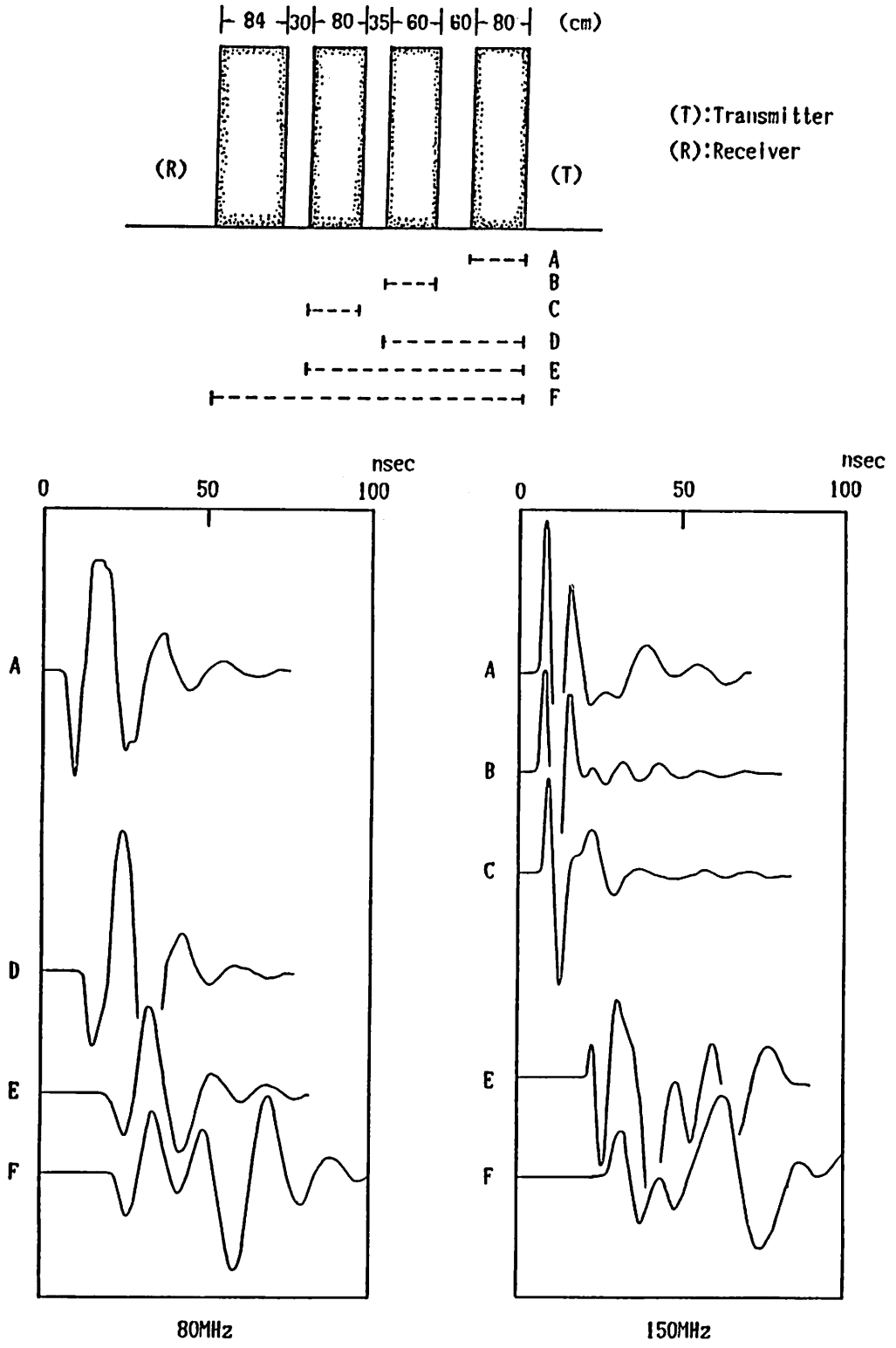


Fig.19 Transmissive experiment of limestone at Khufu Boat

Sample No.	Distance (m)	Travel time (nsec)	Velocity (m/sec) $\times 10^8$	Dielectric constant (ε_r)
B	0.6	5.19	1.16	6.68
C	0.8	6.42	1.25	5.75
E	3.15	21.02	1.05	8.15
F	4.29	25.58	1.19	6.35

Table 3 The experimental data of limestone lid stones from Khufu Boat (150MHz)

Sample No.	Distance (m)	Travel time (nsec)	Velocity (m/sec) $\times 10^8$	Dielectric constant (ε_r)
A	0.8	5.77	1.39	4.65
D	2.0	11.77	1.19	6.35
E	3.15	19.08	1.15	6.80
F	4.29	21.78	1.40	4.59

Table 4 The experimental data of limestone lid stones from Khufu Boat (80MHz)

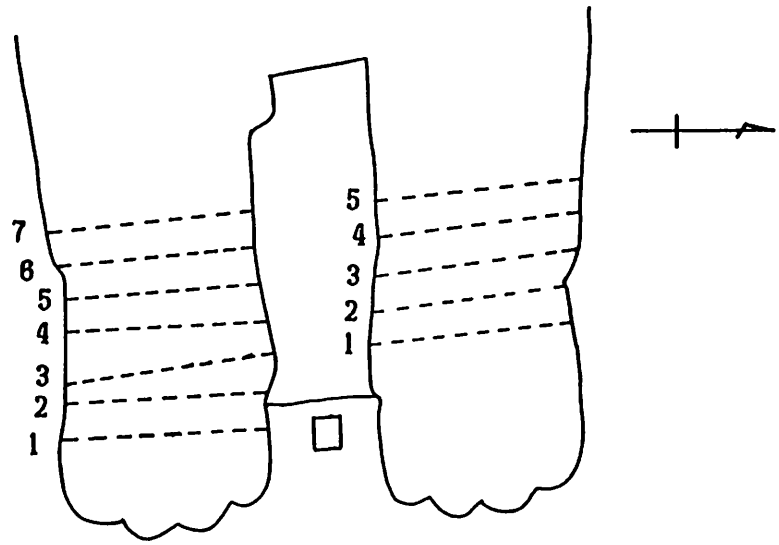


Fig.20 Geometry of propagation through two legs of Great Sphinx

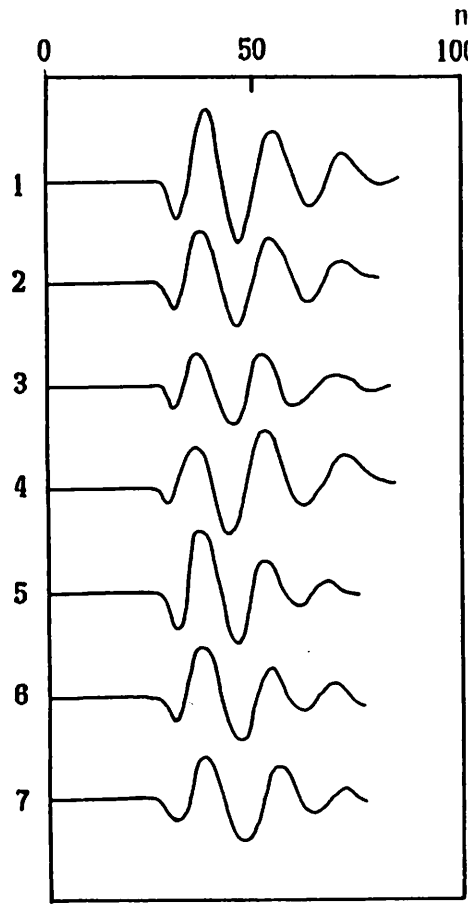


Fig.21 Pulse of propagation at right leg of Great Sphinx

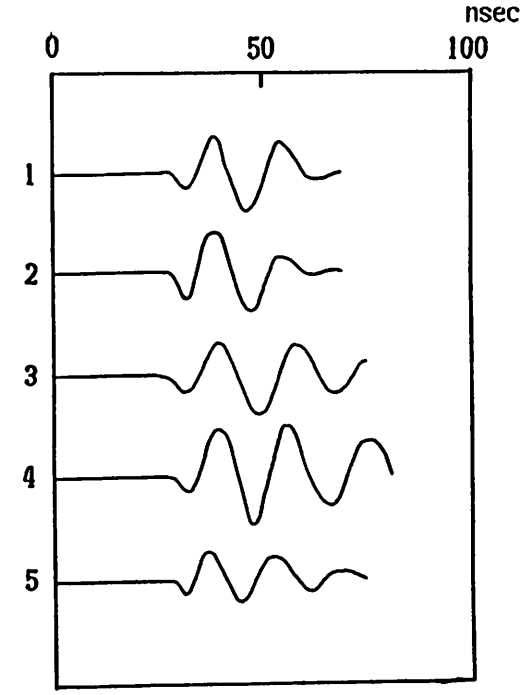


Fig.22 Pulse of propagation at left leg of Great Sphinx

Sample No.	Distance (m)	Travel time (nsec)	Velocity (m/sec) x10^8	Dielectric constant (ε_r)
1	5.40	28.36	1.90	2.49
2	5.20	28.98	1.79	2.81
3	5.15	27.74	1.86	2.60
4	5.15	28.98	1.78	2.84
5	5.20	28.98	1.79	2.81

Table 5 The data of left elbow of Great Sphinx (80MHz)

Sample No.	Distance (m)	Travel time (nsec)	Velocity (m/sec) x10^8	Dielectric constant (ε_r)
1	5.30	27.74	1.91	2.46
2	5.20	26.51	1.96	2.34
3	5.55	27.12	2.05	2.14
4	5.27	26.51	1.99	2.27
5	5.05	26.51	1.90	2.49
6	5.10	25.27	2.02	2.20
7	5.15	25.27	2.04	2.16

Table 6 The data of light elbow of Great Sphinx (80MHz)

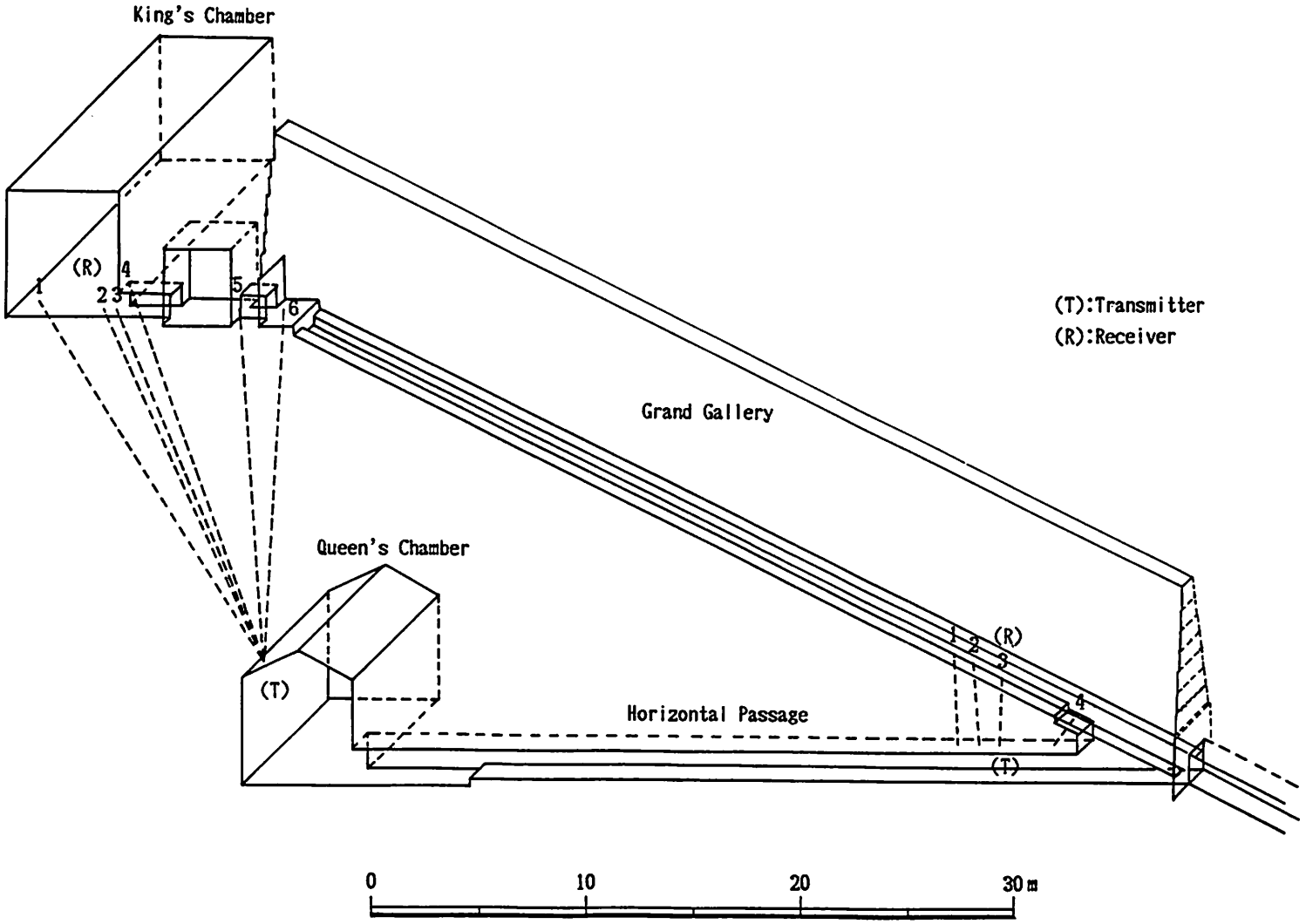


Fig.23 The experiment of transmission method between Horizontal Passage and Grand Gallery

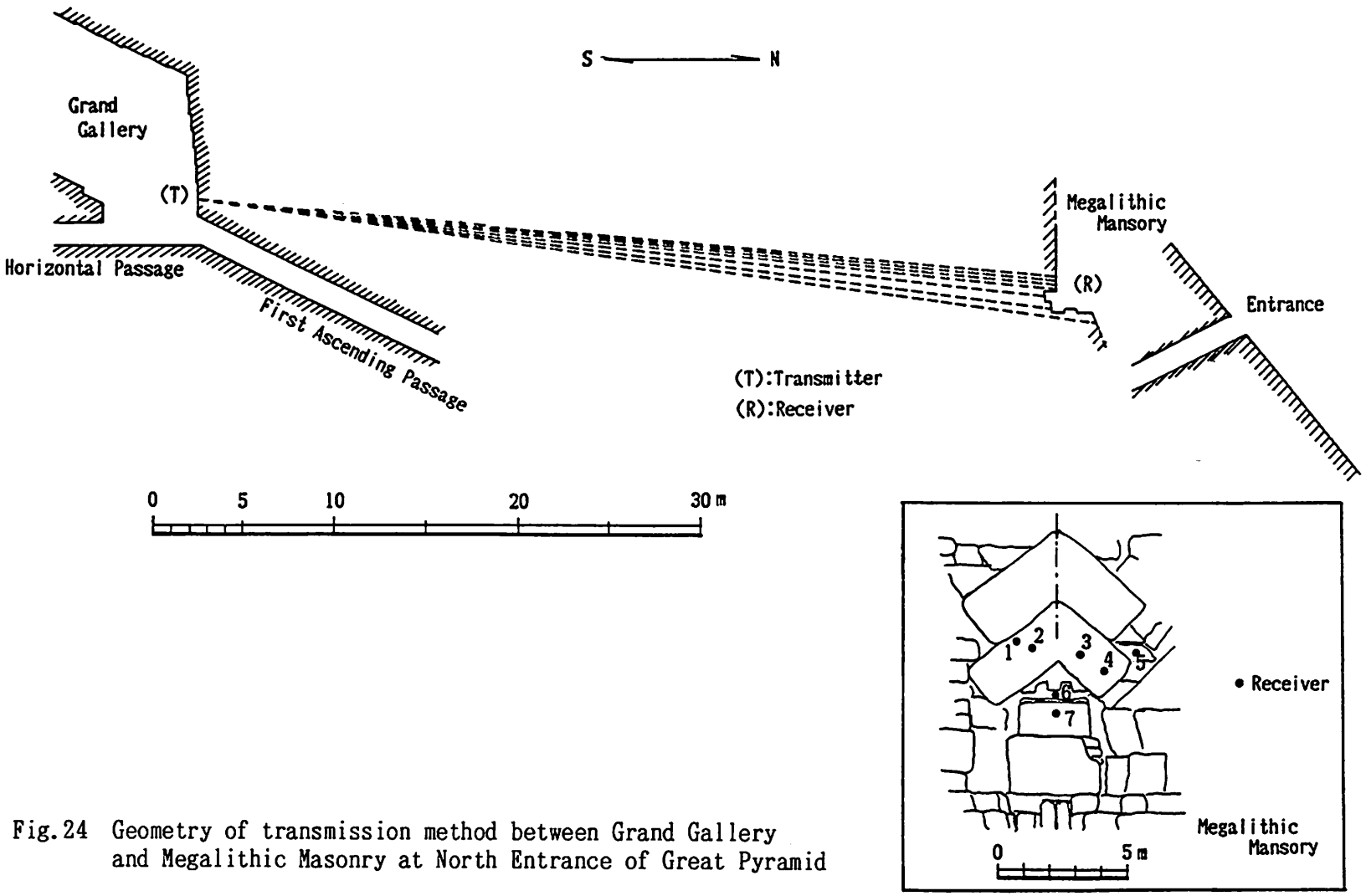


Fig.24 Geometry of transmission method between Grand Gallery and Megalithic Masonry at North Entrance of Great Pyramid

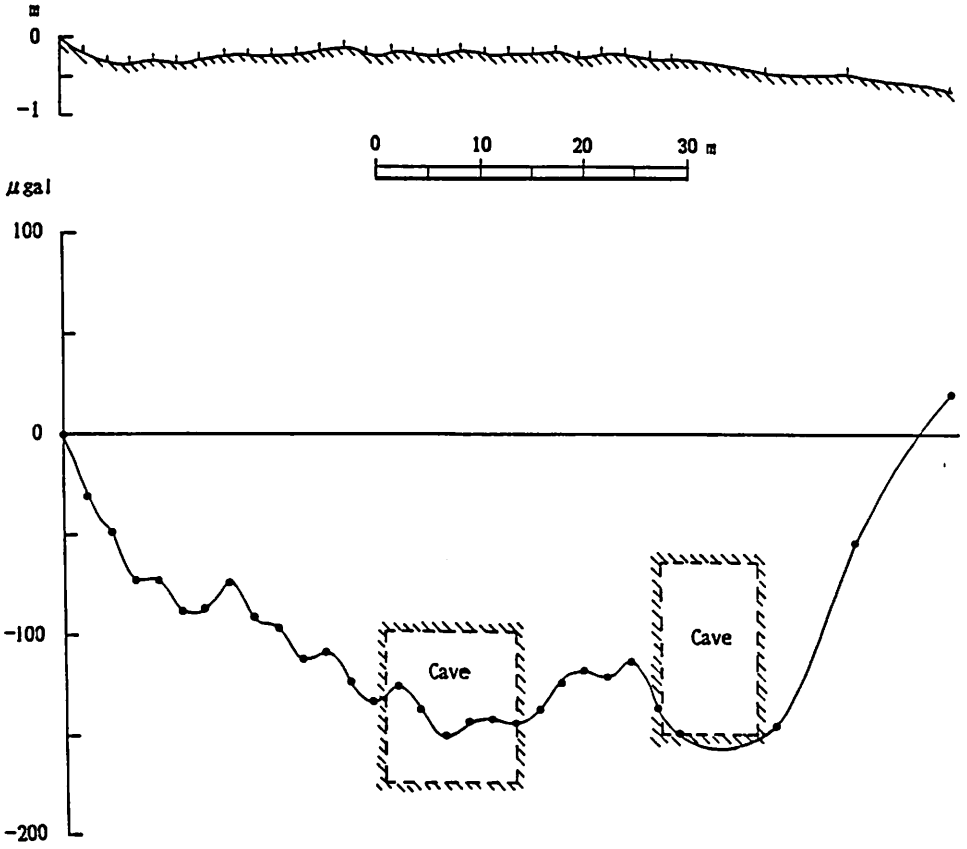


Fig.25 Gravity anomaly at Oya in Japan

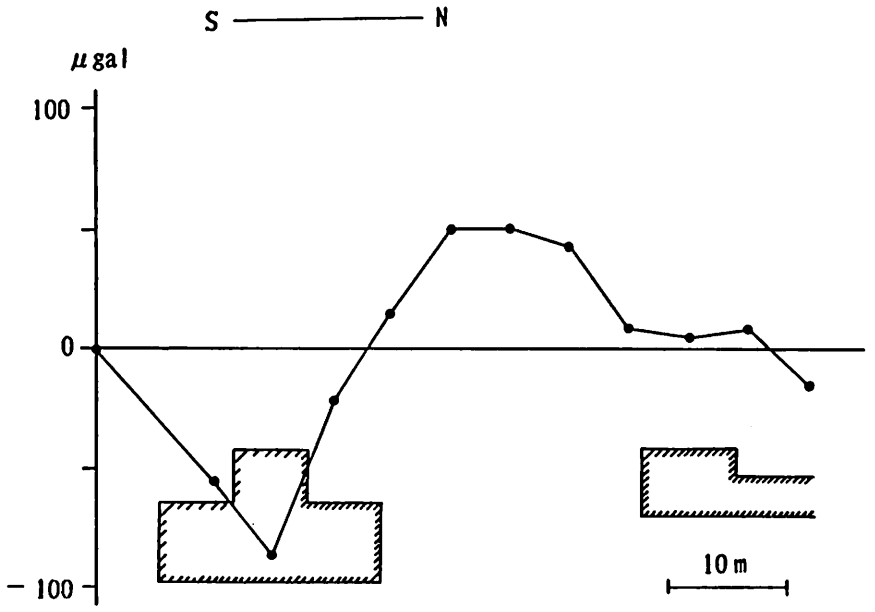


Fig.26 The result of the experiment at Serapeum at Saqqara

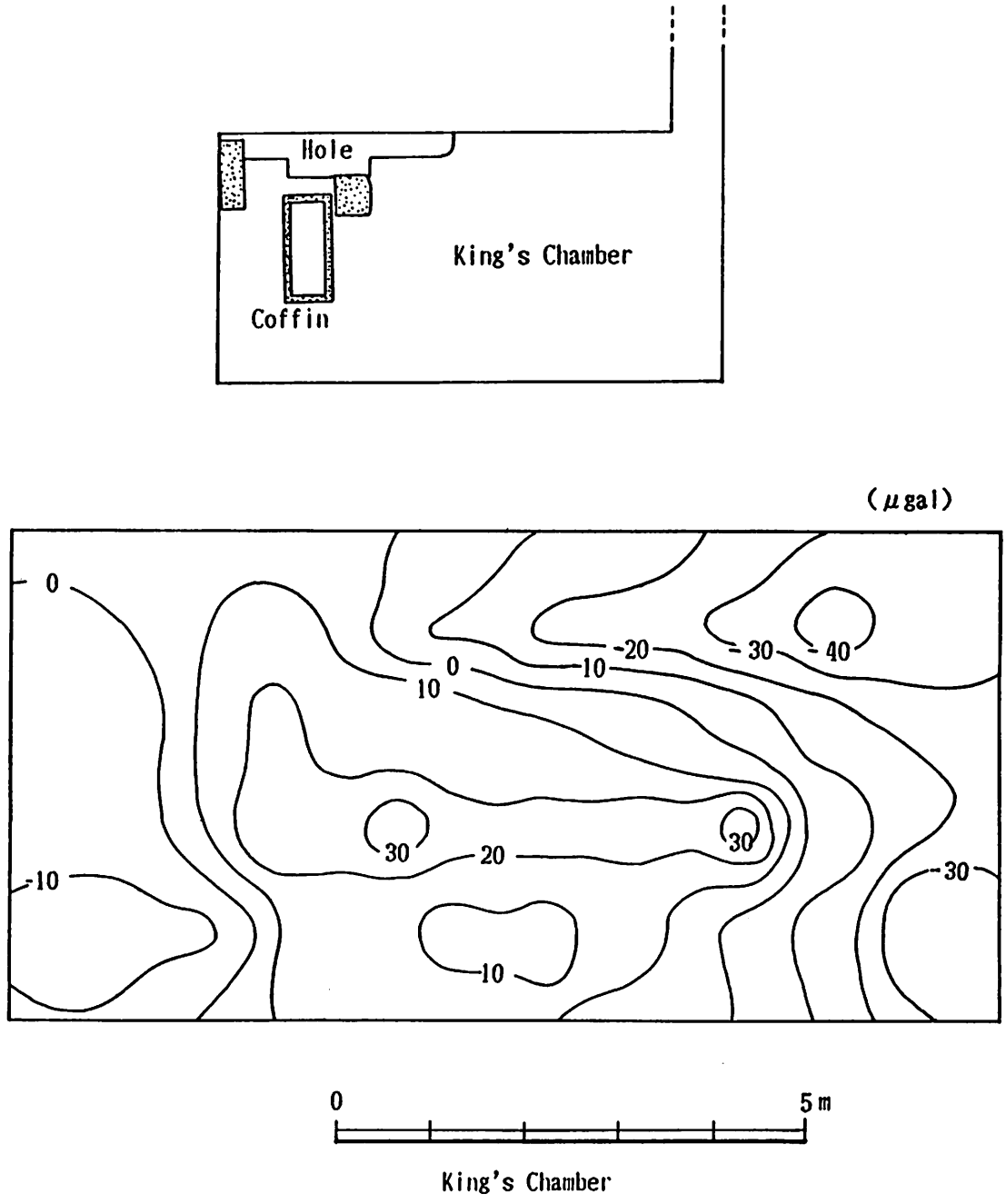
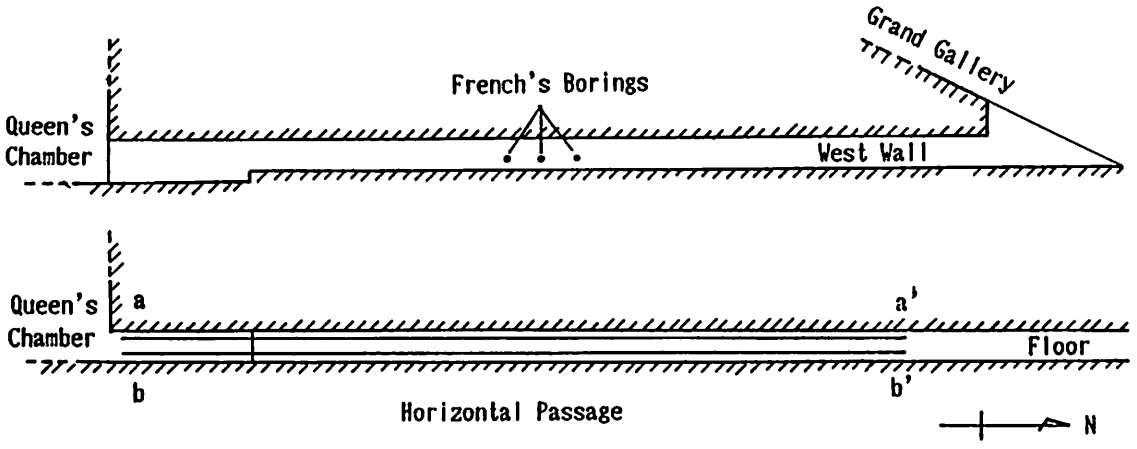


Fig.27 The gravity anomaly map of King's Chamber



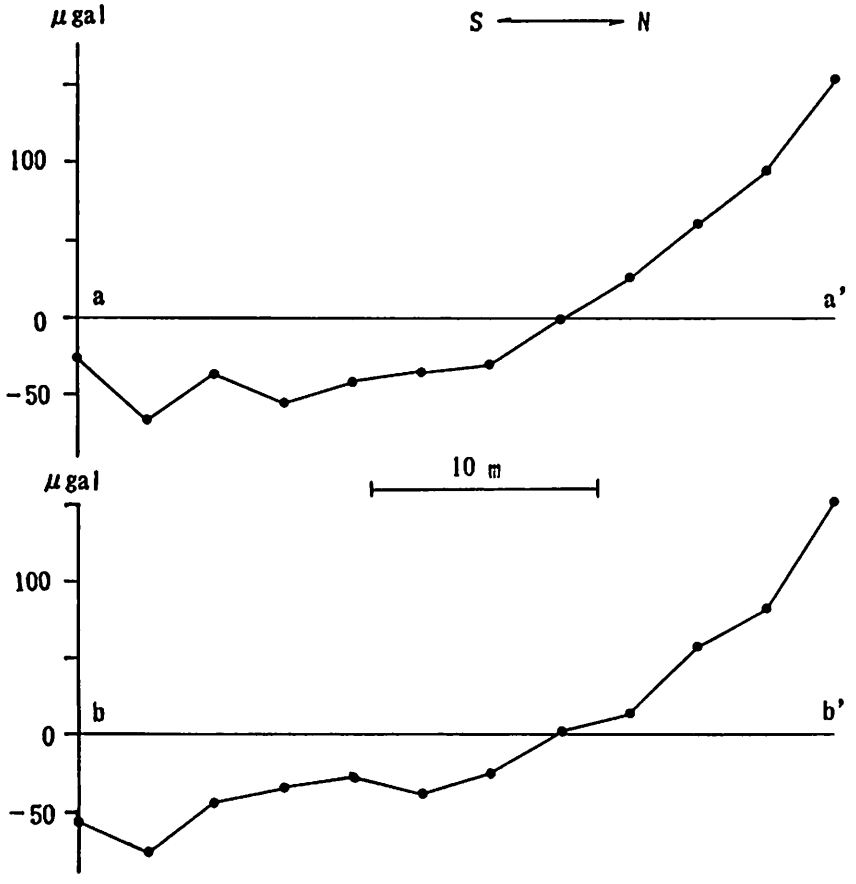


Fig.28 The anomaly profile in Horizontal Passage

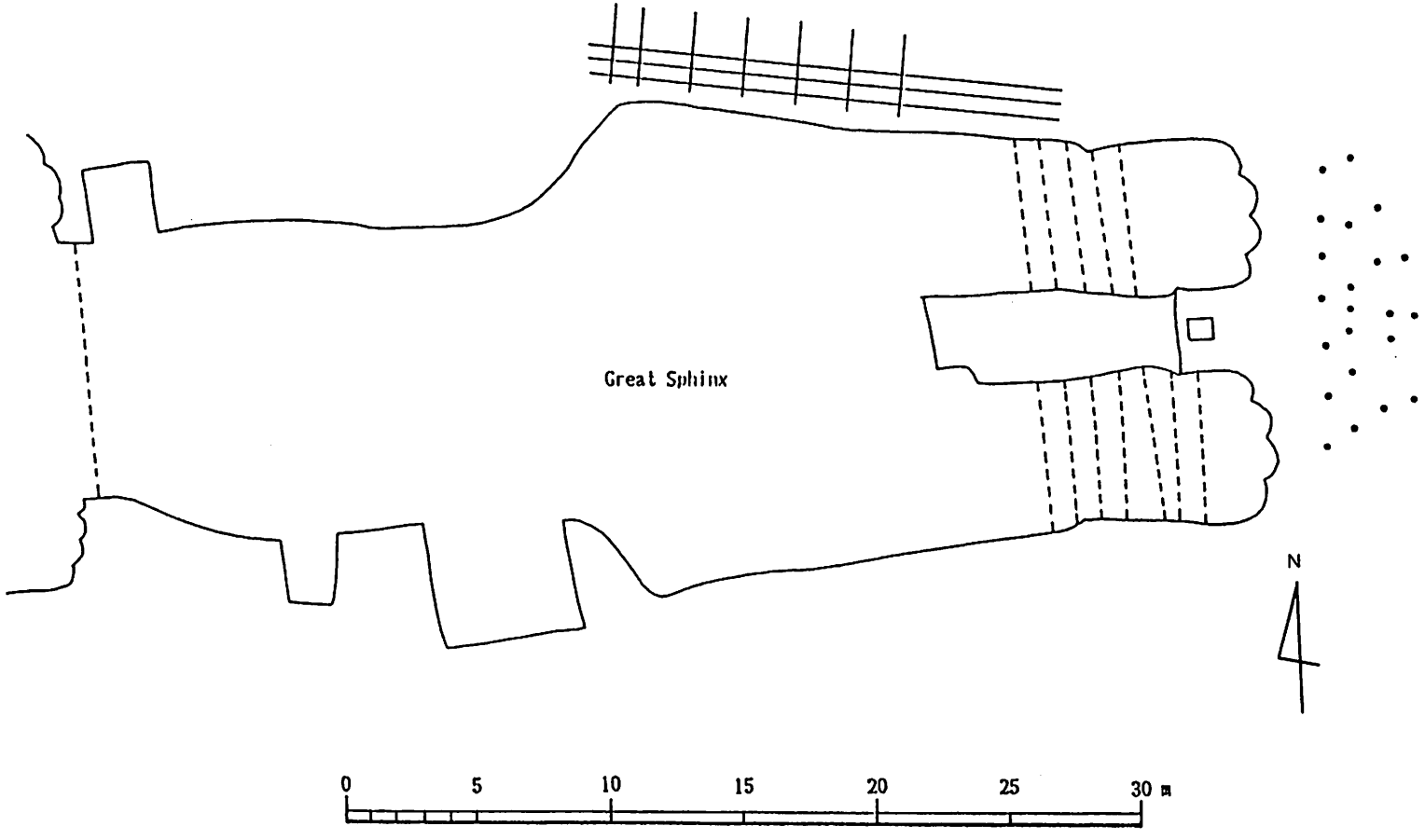


Fig.29 The gravity measurement point at the front of Great Sphinx

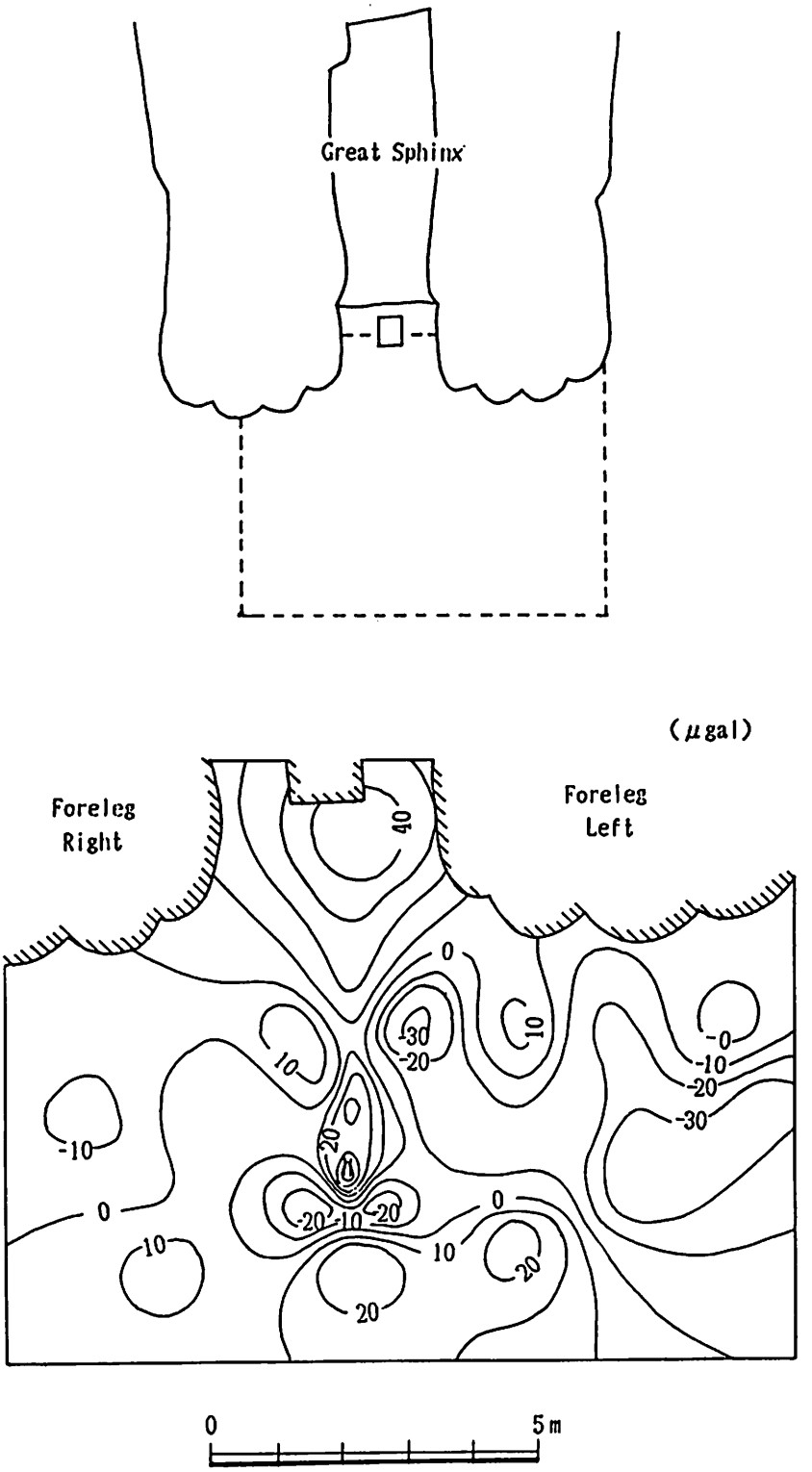
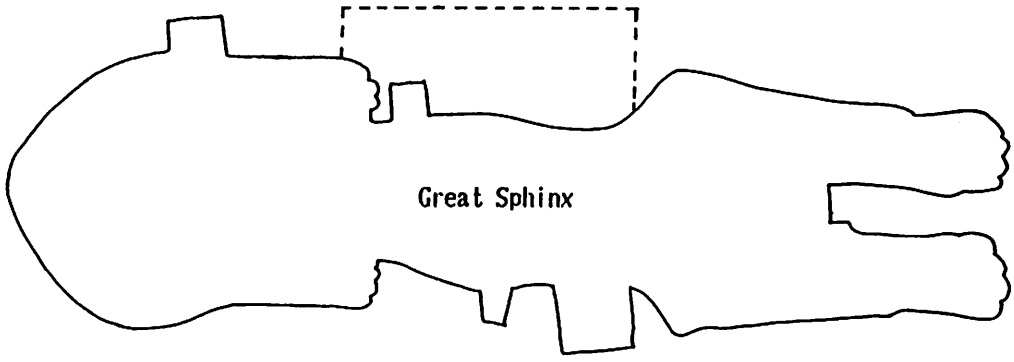


Fig.30 The gravity anomaly map at the front of Great Sphinx



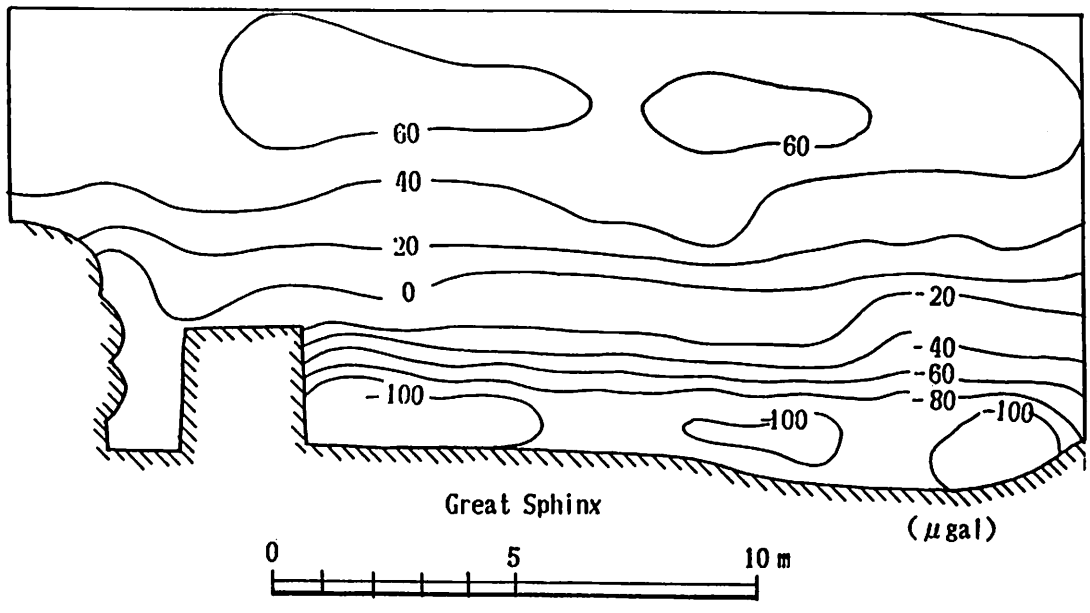
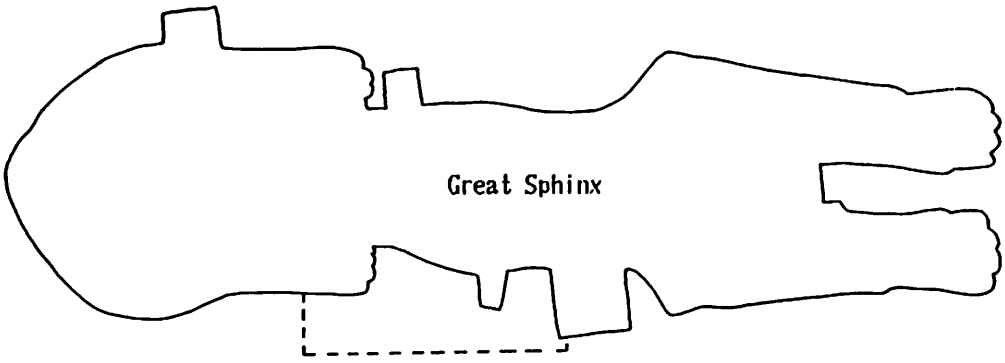


Fig.31 The gravity anomaly map at northern part of Great Sphinx



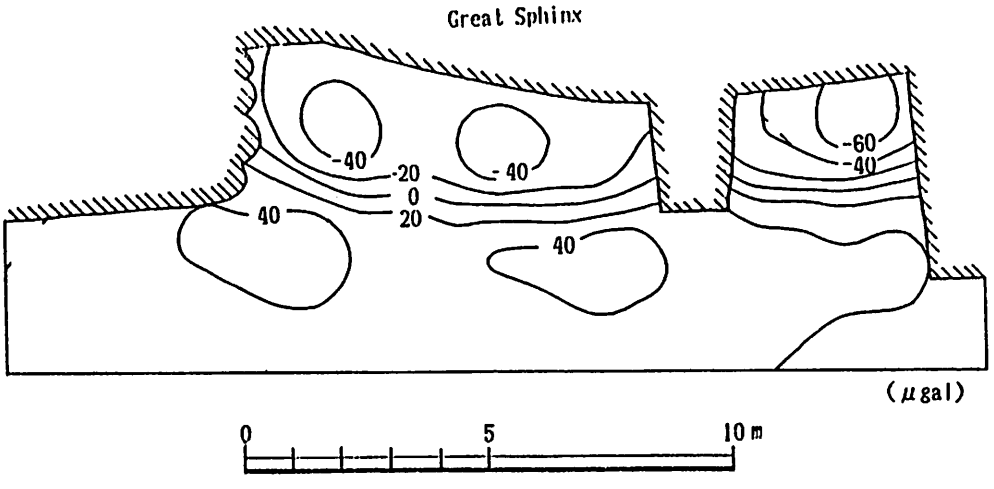


Fig.32 The gravity anomaly map at southern part of Great Sphinx

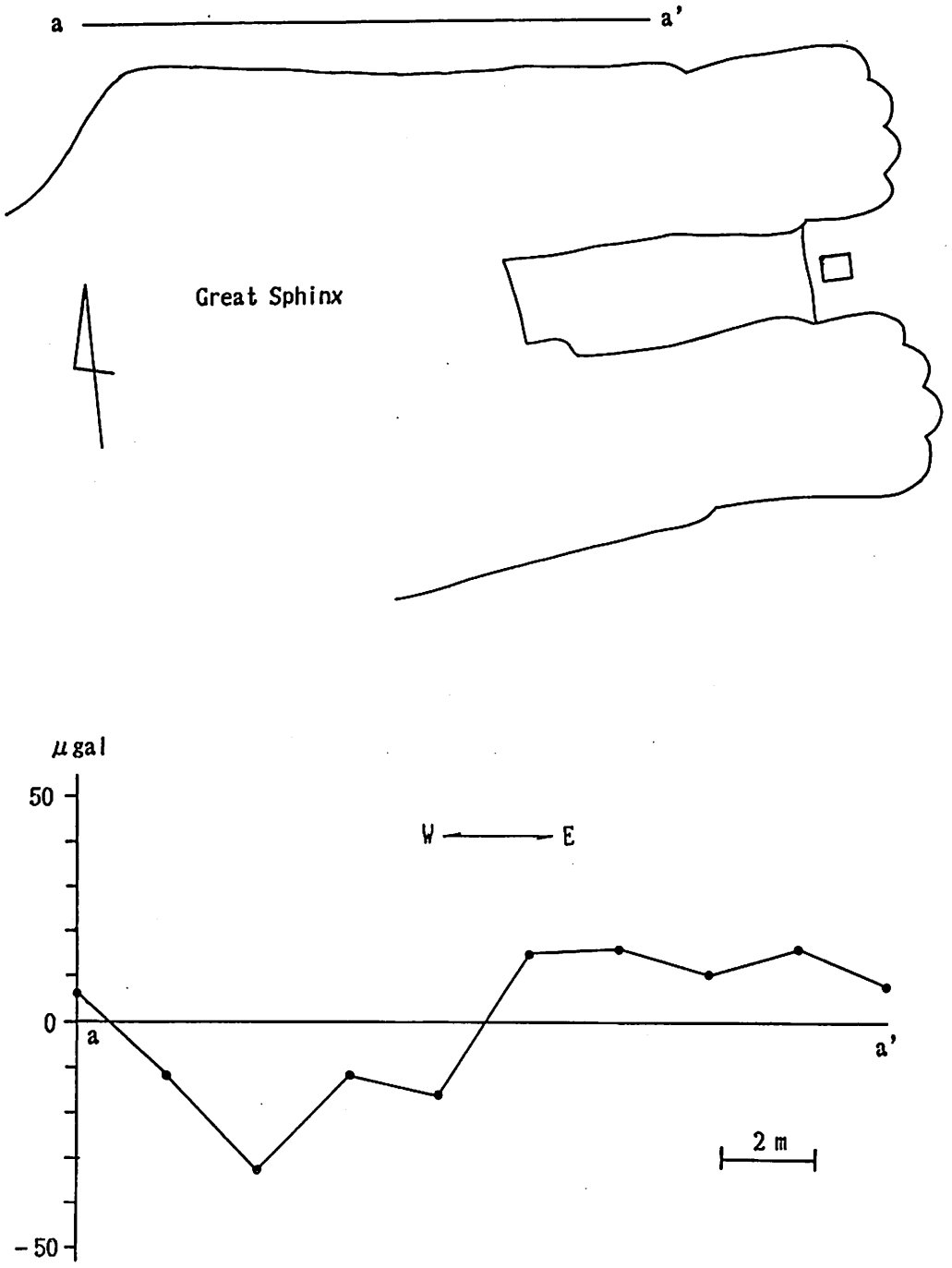


Fig.33 The gravity anomaly profile beside the left leg of Great Sphinx

Ⅲ ARCHAEOLOGICAL INTERPRETATION OF THE RESULTS OF NON-DESTRUCTIVE INVESTIGATION

Sakuji Yoshimura

(1) Non-destructive Investigation at Giza Plateau in the Second Season

As mentioned before, non-destructive investigations using an electromagnetic wave system and a microgravimeter were conducted in Giza Plateau during the second pyramid survey. The purposes of the survey were to reveal "the interior structure of Great Pyramid" and "the structure of Great Sphinx and its periphery". The locations of investigation, the device utilized, the investigation methods, and the frequencies of the electromagnetic waves were as follows:

A) Inside of Great Pyramid

① Floor of King's Chamber (Third Burial Chamber)

Electromagnetic wave system	Reflection method	80 MHz
Microgravimeter	Gravity measurement	

② Floor of Antechamber

Electromagnetic wave system	Reflection method	80 MHz
Microgravimeter	Gravity measurement	

③ Walls of Grand Gallery

Electromagnetic wave system	Reflection method	80 MHz

④ Floor and walls of Queen's Chamber (Second Burial Chamber)

Electromagnetic wave system	Reflection method	400 MHz,80 MHz

Floor of Queen's Chamber

Microgravimeter	Gravity measurement	

⑤ Floor and walls of Horizontal Passage

Electromagnetic wave system	Reflection method	400 MHz, 80 MHz

Floor of Horizontal Passage

Microgravimeter	Gravity measurement	

⑥ Floor and walls of Underground Gallery (First Burial Chamber)

Electromagnetic wave system	Reflection method	80 MHz

⑦ Between Northern Entrance and the northern wall of Grand Gallery

Electromagnetic wave system	Transmission method	80 MHz, 150 MHz

⑧ Between the floor of King's Chamber and the ceiling of Queen's Chamber

Electromagnetic wave system	Transmission method	80 MHz, 150 MHz

⑨ Between the floor of Grand Gallery and the ceiling of Horizontal Passage

Electromagnetic wave system Transmission method 80 MHz, 150 MHz

B) Outside of Great Pyramid

① Ground on the Second Boat Pit of Khufu

Electromagnetic wave system Reflection method 400 MHz, 80 MHz

Ground

Microgravimeter Gravity measurement

② Ground at the south side of Great Pyramid

Electromagnetic wave system Reflection method 400 MHz, 80 MHz

Ground

Microgravimeter Gravity measurement

C) Area around of Great Sphinx

① Ground at the north side of the trunk

Electromagnetic wave system Reflection method 400 MHz, 80 MHz

Ground

Microgravimeter Gravity measurement

② Ground at the north side of the left paw

Electromagnetic wave system Reflection method 400 MHz, 80 MHz

Ground

Microgravimeter Gravity measurement

③ Ground of the front court

Electromagnetic wave system Reflection method 400 MHz, 80 MHz

Ground

Microgravimeter Gravity measurement

④ Ground at the area between the paws

Electromagnetic wave system Reflection method 400 MHz, 80 MHz

⑤ Ground at the south side of the right paw

Microgravimeter Gravity measurement

⑥ Ground at the south side of the trunk

Microgravimeter Gravity measurement

⑦ Ground at the the western terrace

Electromagnetic wave system Reflection method

(2) Interpretation of the Results of Non-destructive Investigations

Data were collected according to the above investigation methods. Except for the case when results are remarkably evident, the meanings of the collected data are not clarified until a computer analysis of such data is completed in the case of the electromagnetic wave investigation and until the above-mentioned corrections are added, in the case of the microgravimeter examination. Especially, computer analysis of the data obtained from the electromagnetic wave examination requires a long time, and the analysis is now under way, except for several investigations.

The corrected data of gravity measurements are described in Chapter II. Therefore, this chapter deals with the presentation and interpretation of the results of electromagnetic wave investigation for which computer analysis has been completed, as well as the data whose results were evident and meanings were self-explanatory to some extent without analysis. The results of gravity measurements using a microgravimeter are also added to the data for interpretation.

A) Inside of Great Pyramid

① King's Chamber (Third Burial Chamber)

The floor and the walls of King's Chamber were investigated using electromagnetic wave system when the first pyramid survey was execued. At that time, however, no unusual reflections were observed. In this survey, the floor was reinvestigated using antennas with a frequency of 80MHz along measuring lines installed on the floor as shown in Fig. 34. The result of the survey was analyzed by a computer and Plate 5 is a color plotter image of the result of analysis. In the area right to the center of the figure, a portion representing the southern part under the floor of the granite sarcophagus is red, which shows a storong reflection. This indicates the existence of a cavity which was not detected in the previous survey. To define the scale of the cavity, it is necessary to make further analysis and clarify the relationship between the cavity and the tunnel whose opening is located on the northern floor of King's Chamber which was excavated by Vyse.

As a result of gravity measurement with a microgravimeter, an area with an anomaly was observed on the southeastern corner of King's Chamber. However, this anomaly was not detected by an electromagnetic wave system.

② Antechamber

During this survey, the floor and the walls of the Antechamber were surveyed by the electromagnetic wave reflection method. The reflected waves showed two cavitys at the lower part of the inside of the western wall. Gravity measurement with a microgravimeter also showed an anomaly. It is necessary to clarify the relationship between these results and the tunnel with an opening in its western wall.

③ Grand Gallery

The walls of Grand Gallery were surveyed using the electromagnetic wave reflection system. Because of unfavorable surface conditions, the electromagnetic wave was disturbed. This made it difficult to read the monitor image at the site. At present, we are waiting for the completion of the computer analysis.

④ Queen's Chamber (Second Burial Chamber)

In this survey, four walls were investigated with the electromagnetic wave reflection method. Special attention was paid to the northern walls on which abnormal reflections were observed in the first survey.

Measuring lines shown in Fig. 36 were installed to survey the eastern, western, southern, and northern walls. The reflection waves indicating a cavity was observed inside the western part of the northern walls, as observed in the first survey.

As shown in Fig. 36, horizontal and vertical measuring lines were installed especially closely on the northern wall. As a result, similar to the first survey, the reflection of the other side of surface of the block detected at 3 m beyond the north wall. The monitored image shows a cavity 3m wide. It has been proven from the reflection test of the known cavity in Great Pyramid that the monitored image is twice as large as the actual dimension. Taking this fact into consideration, the actual width of the cavity on the northern side of the northern walls is judged to be between 1 and 1.5m. This phenomena is assumed to be caused by the separation of the transmitting antenna and the receiving antenna and their horizontal connecting position. When the height was measured by vertically placing the transmitting antenna and receiving one, a reflection suggesting a cavity was observed at less than 1 m from the floor. This is considered to be almost the actual height of the cavity. Therefore, the size of east-west cross section of the cavity is approximately 1.5 m by 1 m, which is almost the same as the size of Horizontal Passage.

⑤ Horizontal Passage

In this survey, the floor and both walls of Horizontal Passage were investigated by the electromagnetic wave reflection system, and the gravity was measured with the microgravimeter. In order to determine the shape of the northern cavity of the northern wall, which was detected on the western part of the northern wall of Queen's Chamber, the investigation of the western wall of Horizontal Passage by an electromagnetic wave reflection method has been regarded as a critical part of the survey in this season.

The electromagnetic wave examination of Horizontal Passage was conducted along with the measuring lines shown in Fig. 37. Plates 1 and 2 show the image displayed on the monitor. Plate 3 is a color plotter output of the result of the investigation, on the western wall, analyzed by a computer. In Plates 1 and 2, below red, orange and yellow from the top, two green lines are shown with a blue line between them. These indicate the boundaries on which waves were strongly reflected and the distances from Horizontal Passage were approximately 4 m and 5 m

respectively. Such a reflection was observed in the range of approximately 30 m toward the north from the north wall of Queen's Chamber. Judging from the fact that two parallel lines of strong reflection were observed with lengths of 30 m, the cavity between the walls is assumed to be a passage rather than a chamber. It is presumed that another passage which is parallel to Horizontal Passage exists beyond its western wall . This newly discovered passage starts from a point only one block's width away from the northern wall of Queen's Chamber. The reflection ends at a point approximately 30 m north of Queen's Chamber. Therefore the passage is thought to come to an end here or to turn west at a right angle. It was not possible to determine which was the case with the present electromagnetic wave investigation. Further investigation of transmission method using improved detection devices will be tried in the future. Succeeding the first survey, the floor of Horizontal Passage was investigated by the eletromagnetic wave reflection method. The frequency used was 80 MHz. In the previous survey, a cavity was detected 1.5 m under the floor. It extended approximately 3m northward from the point approximately 15 m north of Queen's Chamber where French Mission made a boreing reseach. Therefore the results of the survey made by the French Mission using an absolute gravimeter were confirmed. It was confirmed that the cavity extended 2.5 to 3 m downward and that sands were present in it. In this season, our research also revealed that there was no cavity in the north of the northernmost hole which French Mission bored. A cavity was confirmed to exist around the 2nd and the 3rd hole from the north. However, at the area south of the holes, the existence of a cavity was not confirmed. Existence of the sands were reconfirmed by 80 MHz antennas.

In this survey, the eastern wall was also surveyed by the electromagnetic reflection system but no unusual reflection was observed beyond the wall.

The cavity which French Mission discovered is expected to extend westward. In order to confirm this, investigation was made by inclining the antenna at angles of 30°, 45°, and 60°below the western wall. Since it is difficult to draw a conclusion from the monitored image due to strong surface reflection at the connecting point of the wall and the floor, the interpretation of the results cannot be made until a computer analysis is completed.

⑥ Underground Chamber (First Burial Chamber)

In this survey, Underground Chamber was investigated for the first time using the electromagnetic wave reflection method. As shown in Fig. 39, measurng lines were installed on the floor of the western section where the surface condition was relatively favorable and on the southern, northern, and western walls. A reflection which suggests a cavity of approximately 2 m wide and 2 m high was observed approximately 3 m inside the western section of the northern wall. In this direction, there is an intersection of grotto which extends from Grand Gallery and the descending passage. However, it is not reasonable to ascribe the reflection to the intersection. There is a possibility of another cavity. At present, whether this cavity is artificial or natural is unknown.

⑦ Between Northern Entrance and the northern wall of Grand Gallery

The area between Northern Entrance and the northern wall of Grand Gallery was investigated for the first time in this survey using a transmission method. According to a hypothesis of the French Mission, there is a hidden passage at this position which directly leads from Northern Entrance to Grand Gallery. The distance is approximately 50 m. If there were a passage and a hollow space as they speculated, the 80 MHz electromagnetic waves used in this survey had passed through. We set the antennas for the receivers and transmitters near the copestone at Northern Entrance and on the northern wall of Grand Gallery respectively. Investigations was made on 7 points. (Fig. 40) However, no penetration of electromagnetic waves was observed at any point. Although the measurng points we had selected might not be located at both end of the passage speculated by French Mission, the investigations made from the seven measuring points are considered to have covered almost all the areas where the passage was assumed to exist because electromagnetic waves were transmitted spreading at the angle of 30°. Therefore, the results of this survey were rather negative regarding the existence of the passage speculated by the French Mission. However, since this survey was the first investigation using a transmission method, we would like to avoid drawing hasty conclusions. We will survey and confirm this result in the next survey using more improved devices.

⑧ Between the floor of King's Chamber and the ceiling of Queen's Chamber

The area between the floor of King's Chamber and the ceiling of Queen's Chamber was investigated by the electromagnetic wave transmission method. (Fig. 40) The distance is approximately 20 m. Since it was confirmed in Japan that an electromagnetic wave of 80 MHz was capable of penetrating at least 20 m, the wave was expected to pass through the distance. Actually, however, the wave was attenuated and barely passed through, probably because of ionized salt contained in the stones, which was caused by high humidity produced by sightseers' exhalation and underground water, which influenced the stones by a capillary phenomena. As a result, no visible data were obtained.

B) Outside of Great Pyramid

① The second Boat Pit of Khufu

In the first survey, investigation by the electromagnetic wave reflection method was made on the limestone lids which were placed on the pit where the second Khufu's boat was considered to be stored. At that time, a reflection to suggest a cavity was observed under lids with an average thickness of 1.7 m. Judging from the irregular reflection observed at the depth of 3 m or less, the existence of many kinds of materials at th bottom of the space was highly possible. A similar result was obtained in this survey, in which an electromagnetic wave of 80 MHz frequency was used. Then, the boring survey conducted by the American Mission in October the same year revealed accumulation of wooden material for the boat. This proves the accuracy of the

electromagnetic wave survey.

② South side of Great Pyramid

In the first survey, investigation by the electromagnetic wave reflection method was conducted in the area south of Great Pyramid. (Fig. 41) A reflection which suggested a cavity was observed in the western section of the surveyed area. The cavity seemed to represent a pit which was approximately 3 m wide, 2 m long, and 3 to 5 m deep. In this survey, measuring lines were crossd as shown in Fig. 41 and investigation was made using an electromagnetic wave of 80 MHz frequency. The existence of the pit was confirmed.

C) Area around of Great Sphinx

① Area north of the trunk of Great Sphinx

In the first survey, a reflection suggesting a cavity was observed in a reflection method investigation using an electromagnetic wave of 150 MHz. A similar cavity was recognized on the southern part of the body. Consequently, the existence of a tunnel which ran through under the Sphinx body from north to south was speculated. The same place was investigated with an electromagnetic wave of 80 MHz in this survey. The same reflection was observed again. It is believed to confirm the existence of the cavity after conducting the cleaning in the future.

In addition, a strong reflection dividing the front part of the body into eastern and western parts was observed, which suggested the possibility of a gap of limestone under base rock this spot.

② Area north of the left paw of Great Sphinx

In the first survey, an investigation by an electromagnetic wave reflection method was made in this area. A strong reflection which extended approximately 7 m from east to west and approximately 1.5 m from north to south was observed at a depth of about 1.5 m. From this reflection, the existence of something other than limestone was presumed. In this survey, the measuring line was installed as shown in Fig. 42 and an electromagnetic wave of 80 MHz was used. Plate 4 is a color plotted image of the result analyzed by a computer. In the right portion of this figure, a red section can be seen. This is the area where the reflection was especially strong. The result obtained in this survey was, therefore, the same as the previous one.

③ The front court of Great Sphinx

The front court of Great Sphinx consists of a platform where limestone blocks are arranged artificially. In the first sruvey using electromagnetic wave method, a rather strong reflection was observed at a depth of 1.5 m under the front court. The spot is on the extended center line of Great Sphinx and suggested a possibility of a cavity. In this survey, a reflection method was adopted using an electromagnetic wave of 80 MHz. Measuring lines were placed from east to west as shown in Fig. 43. The reflection was not significant as compared with the one obtained in the previous survey. It was found that the existence of the cavity could not be confirmed

without a boring operation.

④ Between the paws of Great Sphinx

In the first survey, the area between the paws of Great Sphinx was investigated by an electromagnetic wave reflection method. At that time, although irregular reflection was intensive and the measurement was not sufficiently accurate, a cavity was assumed to exist 1 or 2 m under the ground and the possibility of the relation with the cavity under the front court was also considered. In this survey, a reflection different from the previous survey was obtained when an electromagnetic wave of 80 MHz was used. Thus, a survey should be conducted again with a different frequency. We are making a computer analysis of the results of this survey, and the difference between the results of this survey and the previous one using electromagnetic wave of 150 MHz.

⑤ Western terrace of Great Sphinx

This area has not been excavated. This is rare around Great Sphinx. In this survey, the underground was surveyed by the electromagnetic wave reflection method from the surface. As shown in Fig. 44, eight measuring lines were installed from east to west and 10 from north to south. The area covered in this way was approximately 50m^2. On the east side, a bed rock was detected near the surface of the earth. On the west side, a bed rock was buried rather deep inside. It is obvious from this result that various remains under the desert. It seems that the walls of Thutmes IV, remainders of walls which Baraize built to prevent the landslide during excavation, and many other constructions are left underground. We will make a excavation in this area to reveal the conditions of underground, while comparing the results of electromagnetic wave investigations and the actual excavations.

(3) Contribution of non-destructive investigation to the history of Giza

As mentioned before, the purpose of the non-destructive investigation in the second survey was to reveal " the interior structure of Great Pyramid " and " the structure of Great Sphinx and its periphery " without destroying the relics. Although we could not draw a definite conclusion to the items we presented as main purposes, we have obtained significant results which may contribute to the above purposes and the objectives of this mission mentioned in Chapter 1. The following are the archaeological significances of these results.

In the surveys made until now, the possibilities of unknown space, such as a new passage in the north of Queen's Chamber, have been revealed by scientific methods. Although the presence of such cavities inside Great Pyramid and its rate of cavity had been discussed, it was difficult to scientifically prove the hypothesis. Therefore, these possibilities were not widely accepted from the scientific and histrical viewpoints. However, it is now possible to estimate the location and scale of these spaces based on scientific methods. From now on, discussions should be held about

Great Pyramid and other pyramids, taking the presence of such unknown cavities into consideration. Then, the conventional theories on the interpretation of the pyramids in Egypt will be corrected. Many religious buildings in ancient Egypt have symmetrical structures. As viewed from Queen's Chamber, the passage which is speculated to continue from the north side of Queen's Chamber in the previous survey and in this survey is supposed to be located symmetrically with respect to the existing passage from Queen's Chamber. Such a structure may be interpreted based on the symbolism of Great Pyramid, which is later discussed in the consideration of architectural history.

The first and the second surveys revealed that heretofore unknown cavities exist around Great Sphinx, and that the structures are more complicated than was conventionally thought. Since Great Sphinx was built by excavating a bed rock, it is difficult to determine the reign of the specific King in which it was built. By making further investigations on the spot where the storong reflection was observed, and on the unknown peripheral spaces, a possibility of finding a clue for the determination of the age will be developed. It was also clarified in the surveys that an unexcavated remains existed on the south side of Great Sphinx through the investigations made on the western terrace of this area. The excavation of this area will also give a hint in determining the age.

Since non-destructive investigations made by our mission are so-called remote investigations without actual excavation, it may be difficult to draw a decisive conclusion. The conclusion will be formed in due course by archaeological excavations.

However, we believe that the data collected from such non-destructive investigations, which avoid unnecessary destruction of relics, will reveal more about numerous relics of the ancient Egypt including the Pyramids of Giza.

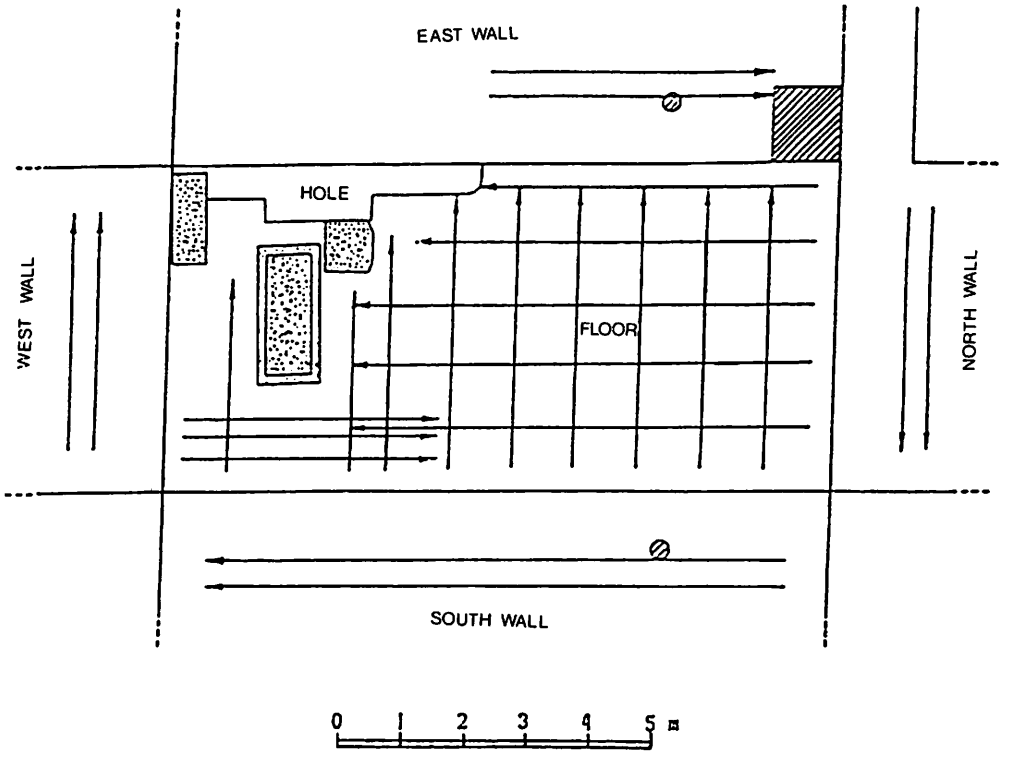


Fig.34 Measurement lines in King's Chamber

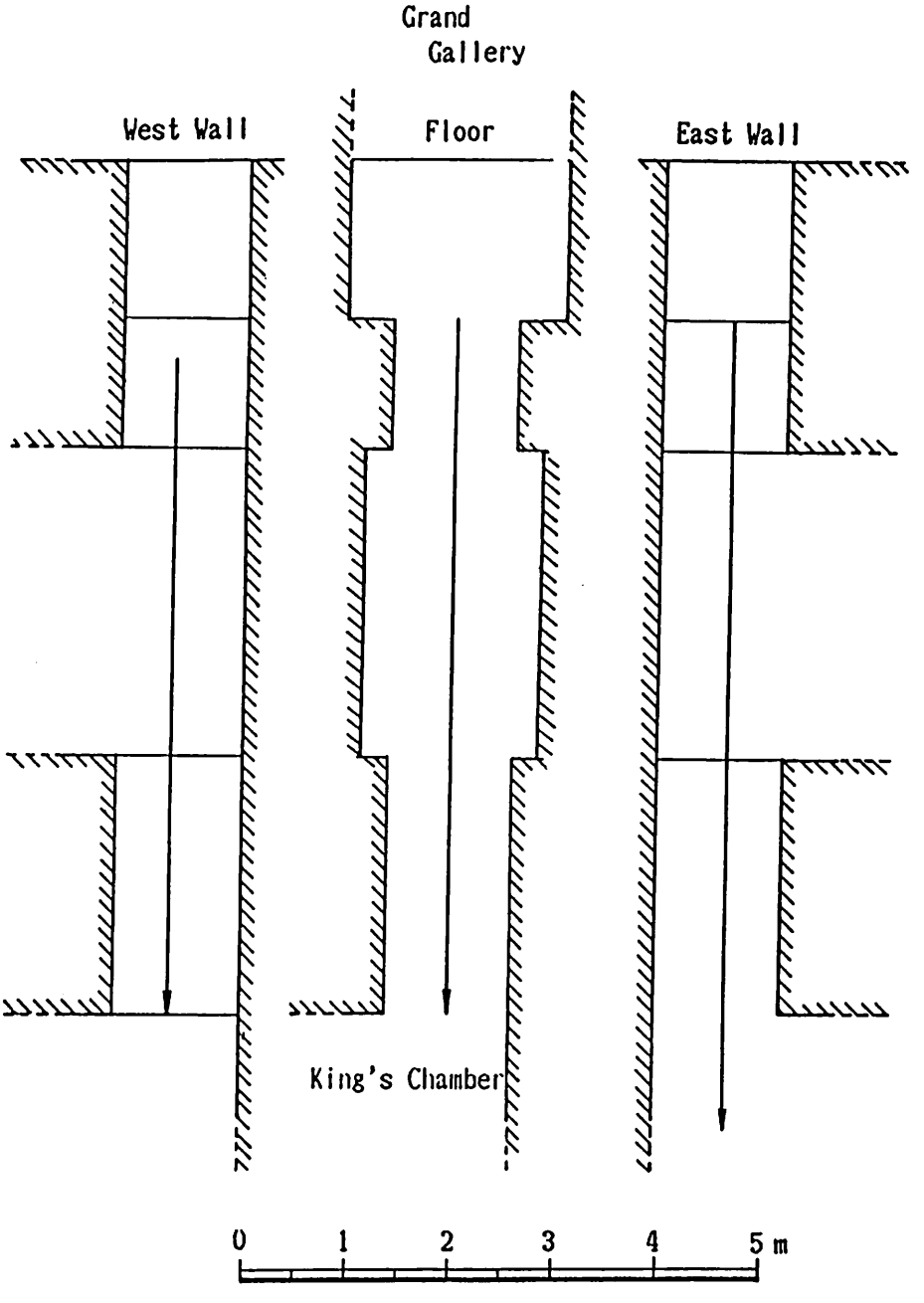


Fig.35 Measurement lines in Antechamber

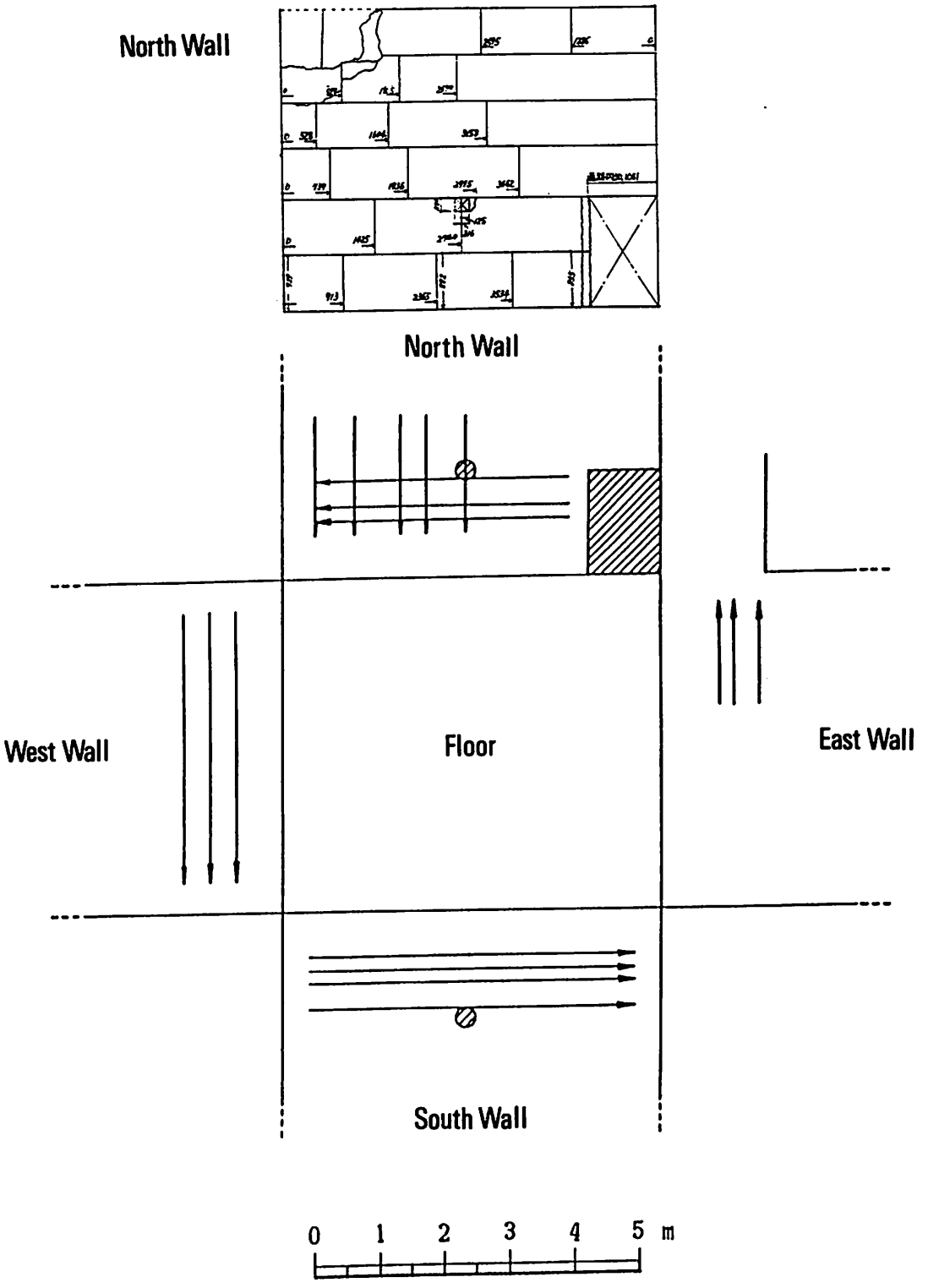


Fig.36 Measurement lines in Queen's Chamber

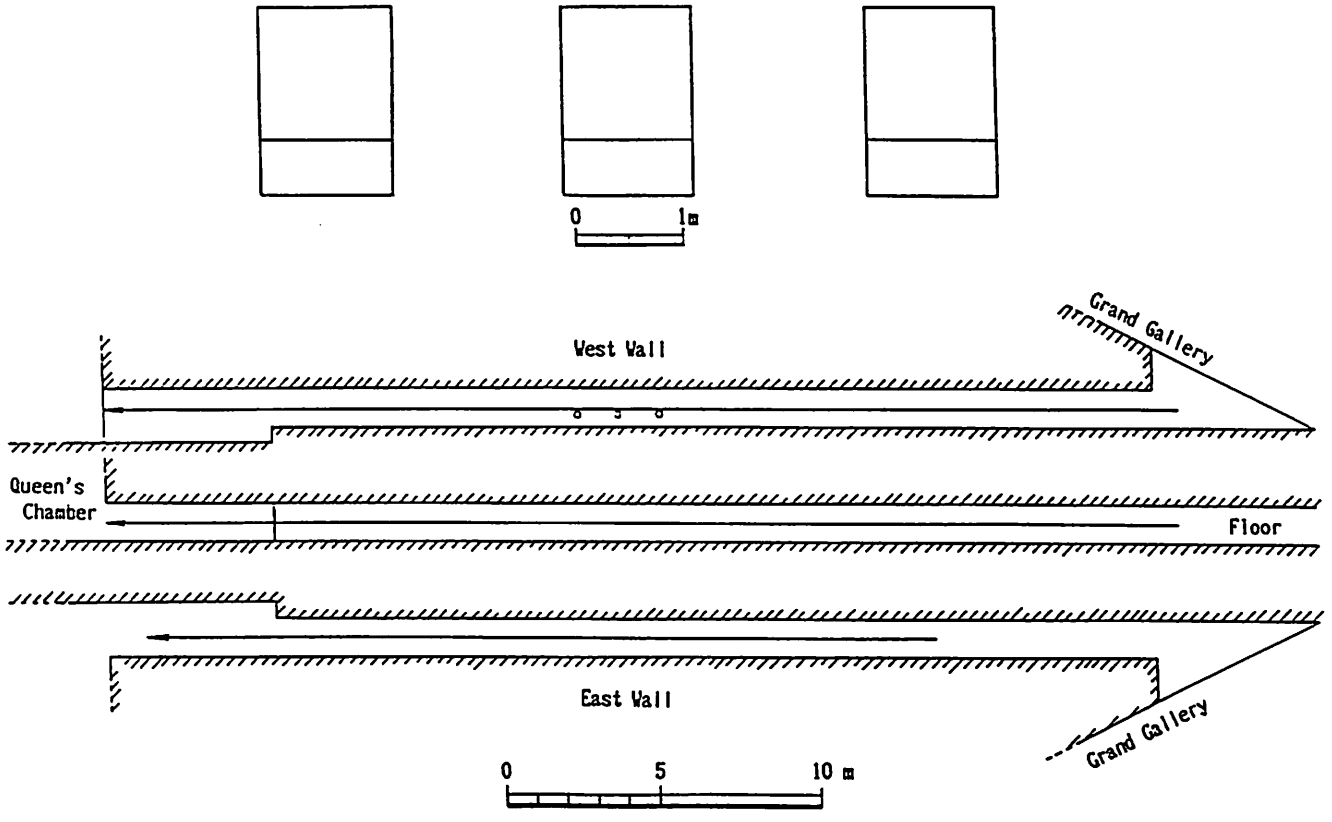


Fig.37 Measurement lines in Horizontal Passage

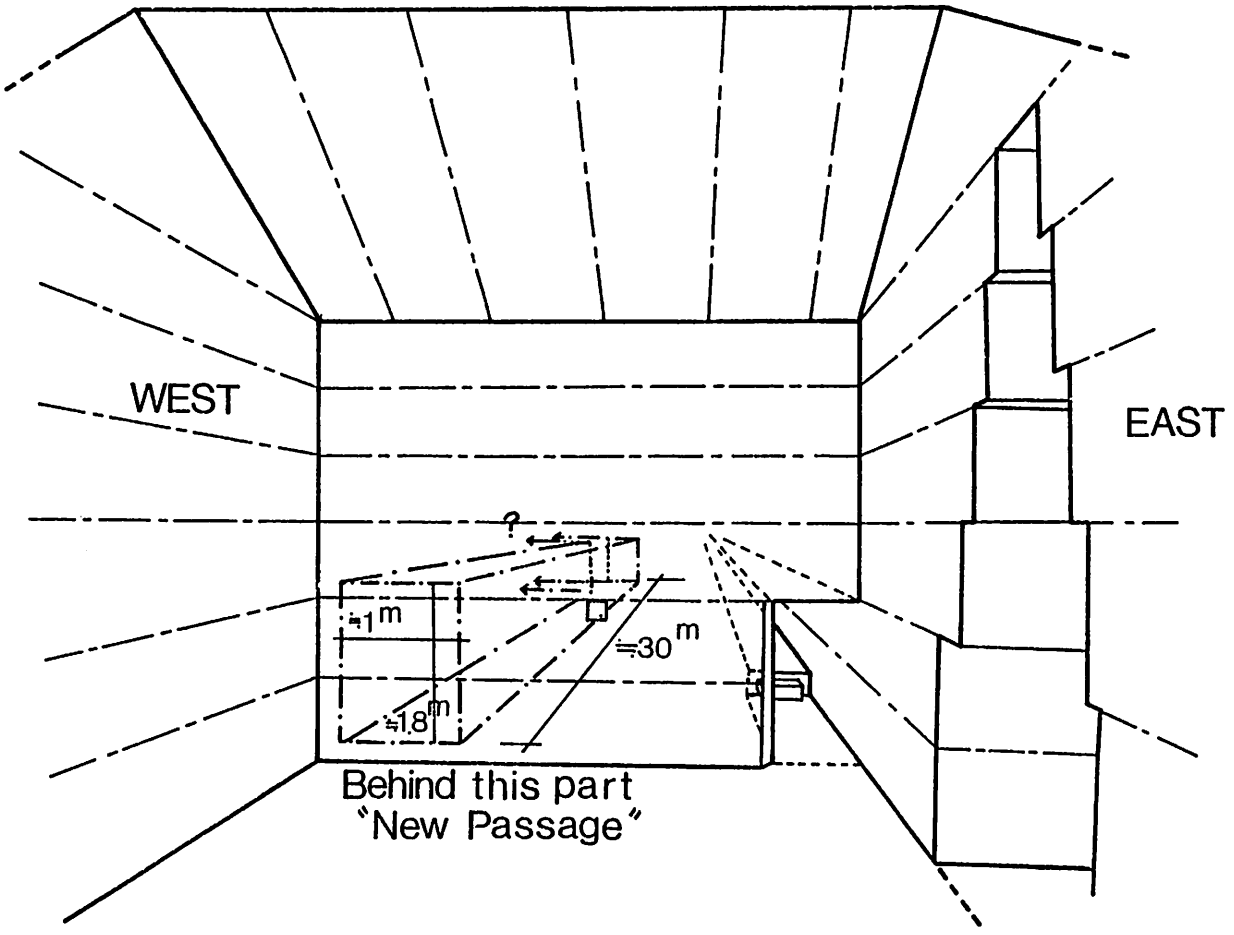


Fig.38 North wall of Queen's Chamber

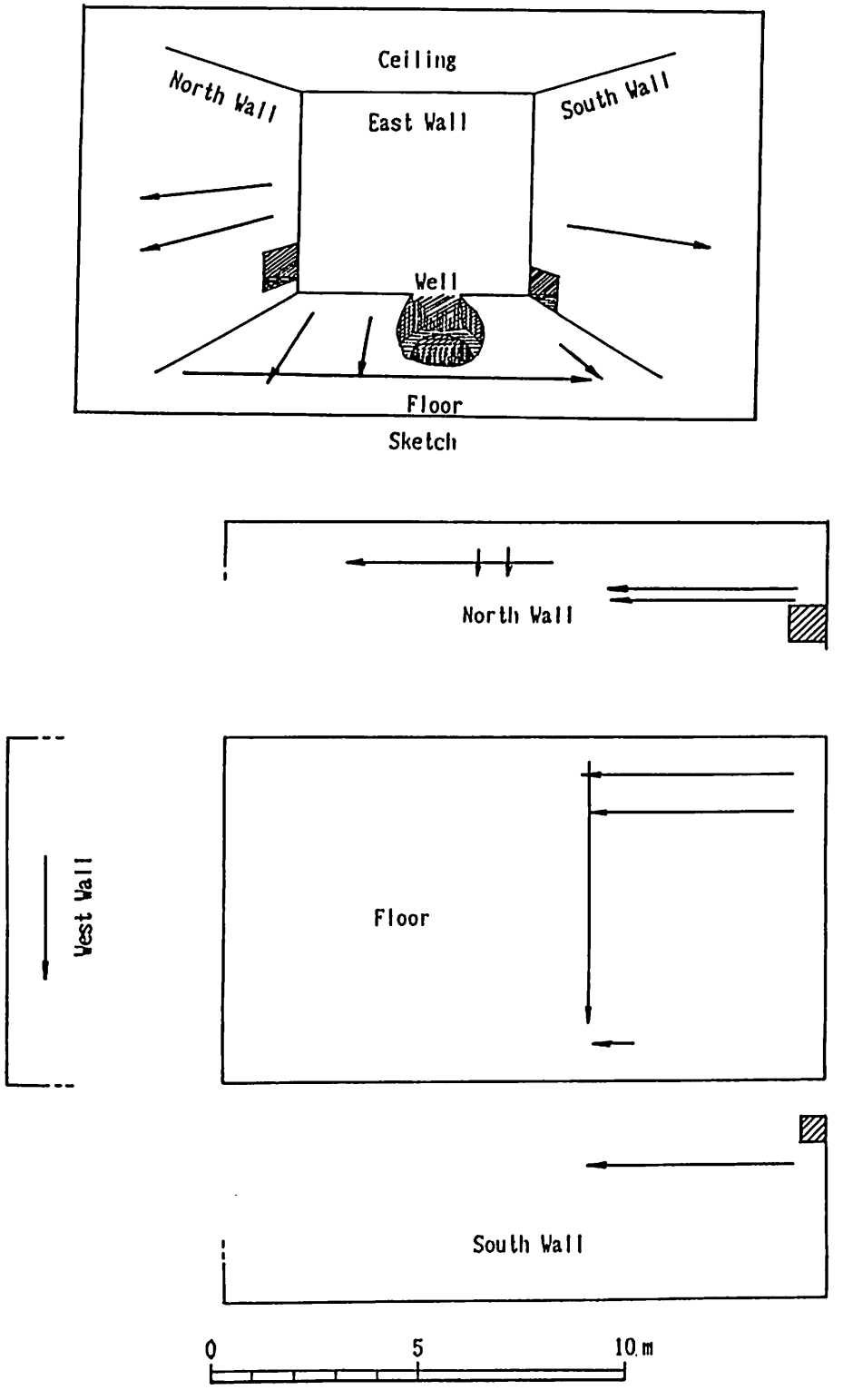


Fig.39 Measurement lines in Underground Chamber

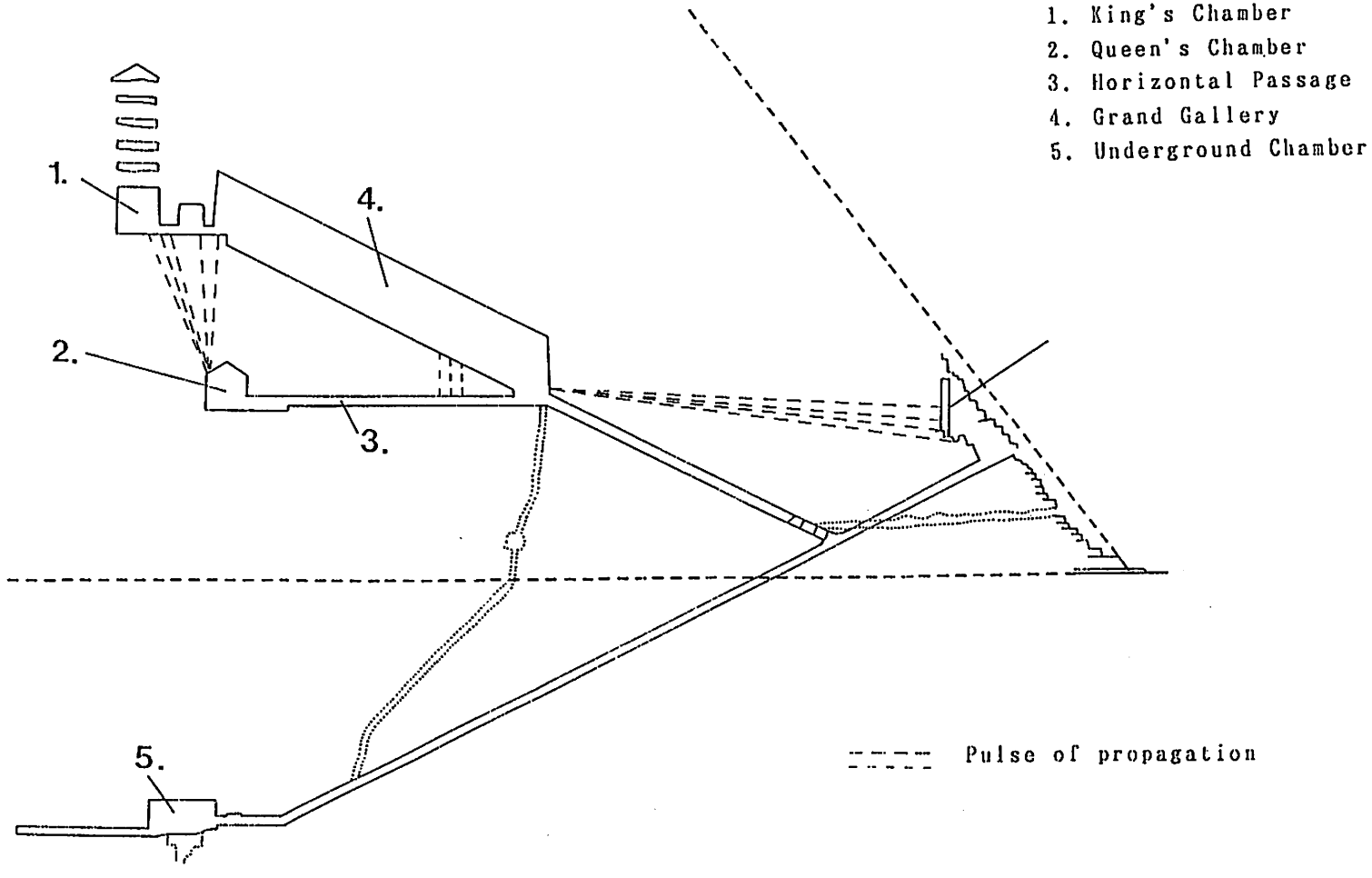


Fig.40 Geometry of the transmission method at Great Pyramid

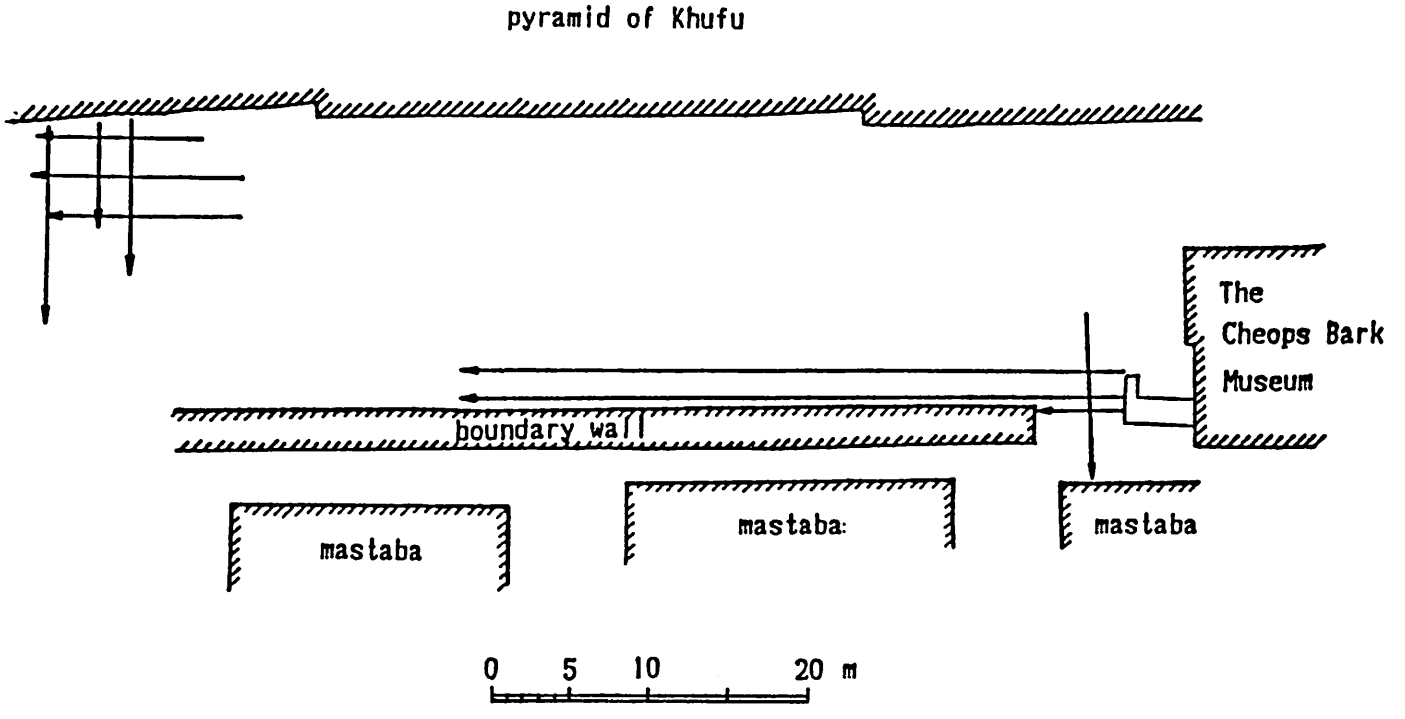


Fig.41 Measurement lines on the south side of Great Pyramid

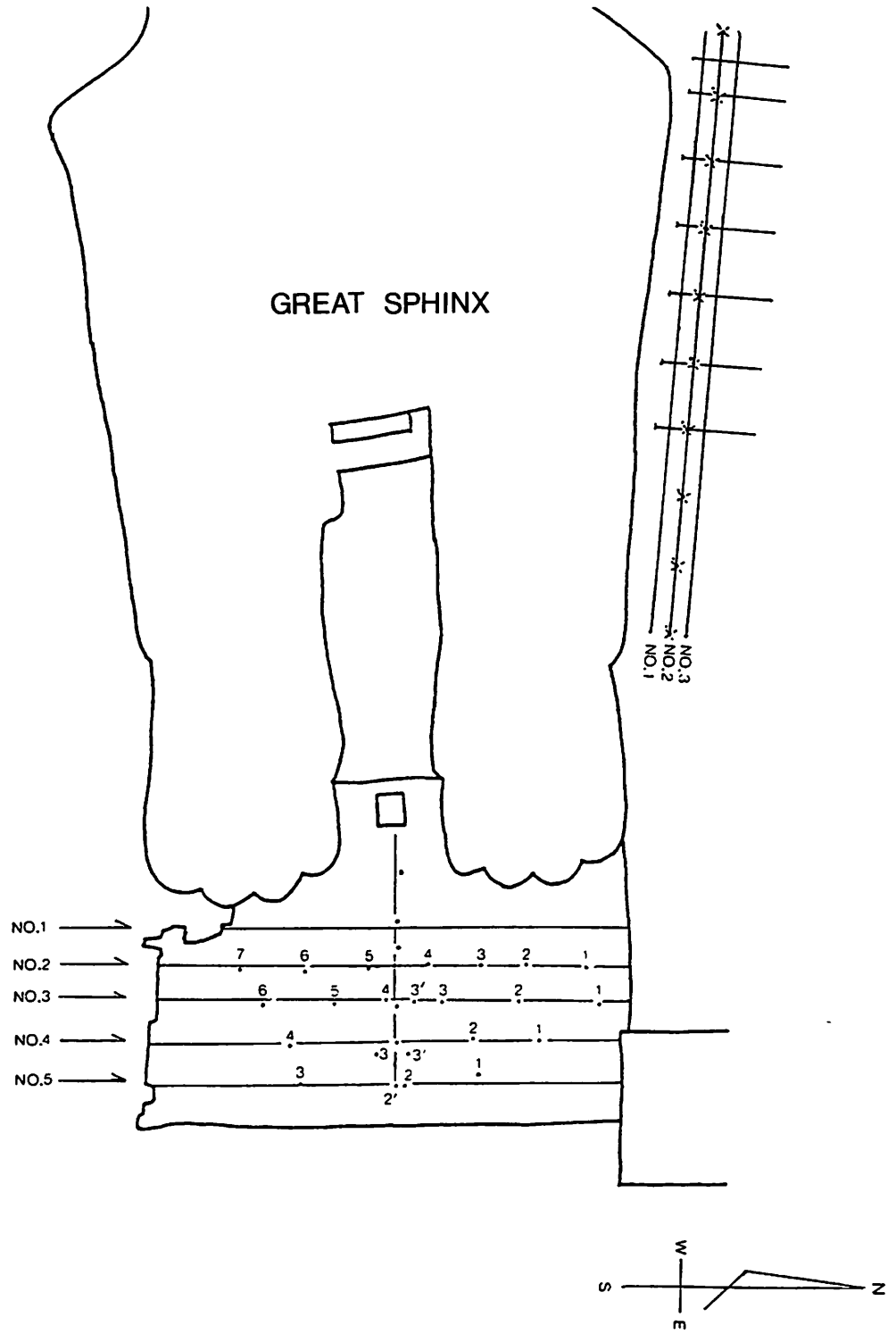


Fig.42 Measurement lines around Great Sphinx

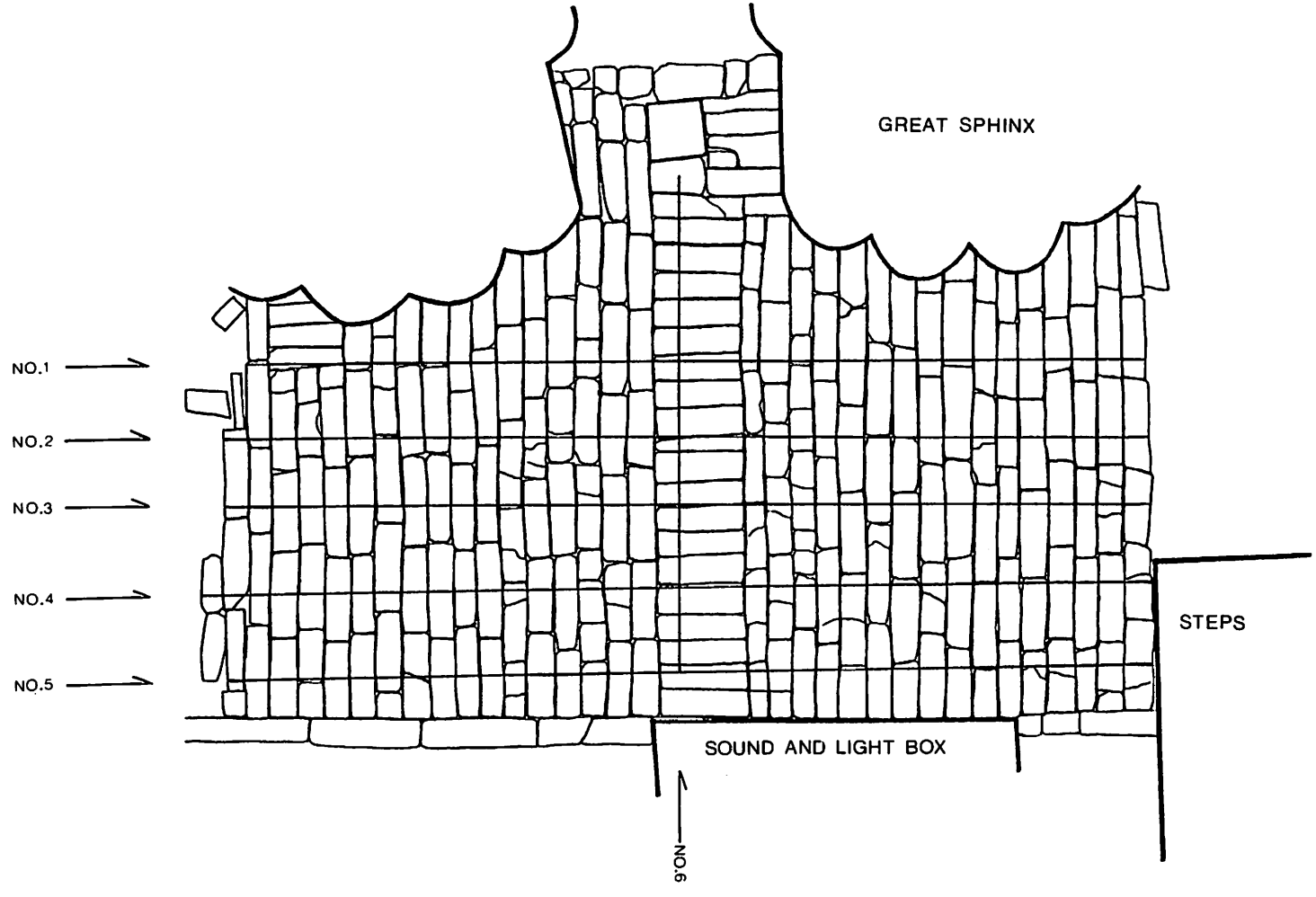


Fig.43 Measurement lines at Front Court of Great Sphinx

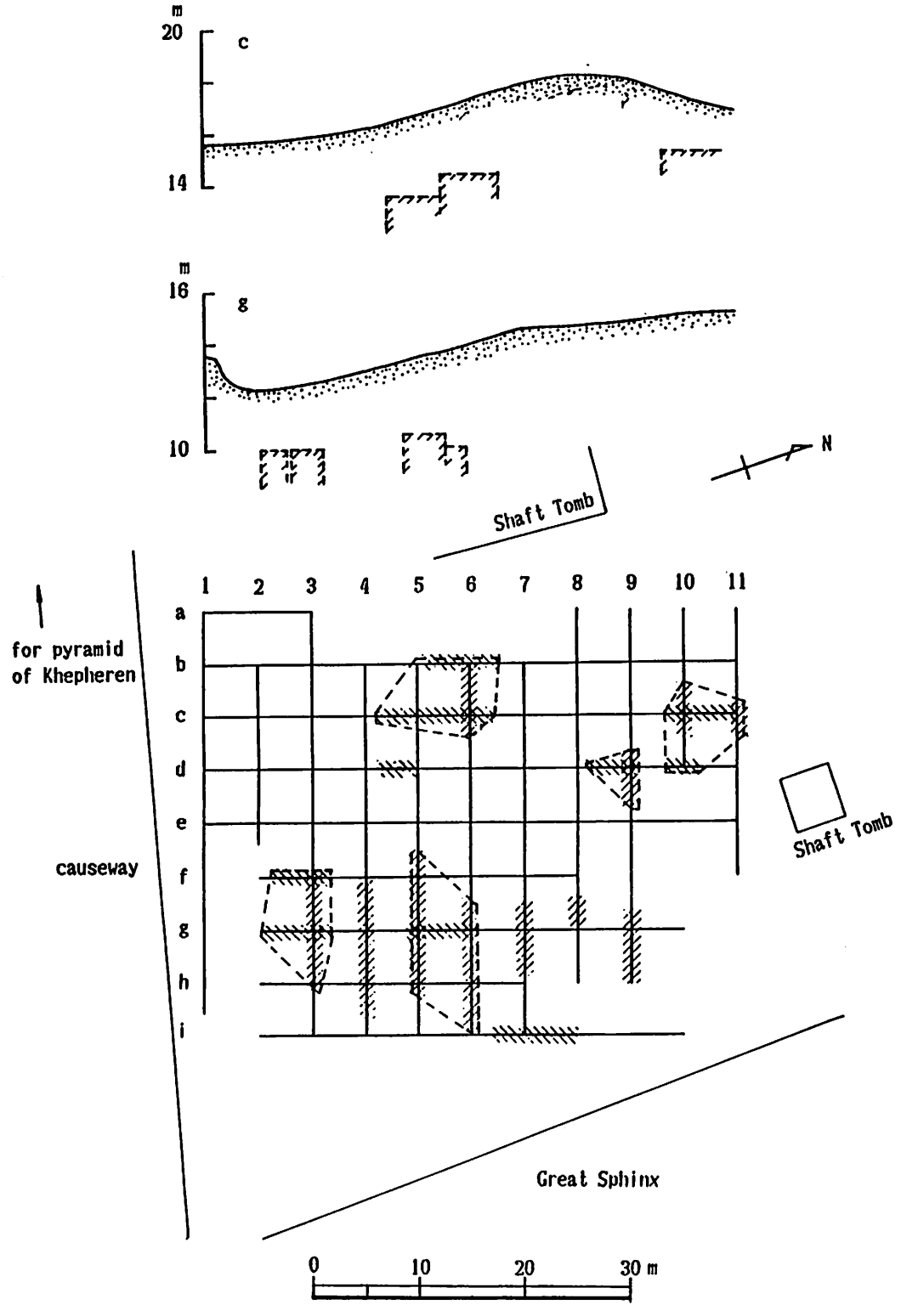


Fig.44 The map of underground abnormal places at the western terrace of Great Sphinx

Ⅳ INVESTIGATION FROM THE VIEW POINT OF ARCHITECTURAL HISTORY IN THE SECOND SEASON

Takeshi Nakagawa
Kazuaki Seki
Shinichi Nishimoto

(1) Introduction

In order to make architectural research on the structure of the Pyramid of Khufu and its purpose, it is indispensable to have reliable and highly precise drawings. If researches are not made based on such precise drawings, the researches will be meaningless. Many measurements have been made on Great Pyramid since the beginning of the 19th century. However, the numerical values obtained have not been effectively utilized to clarify the structure of the Pyramid. Therefore, our objective was set to obtain fundamental data to make architectural researches of Great Pyramid by taking actual measurements of the details inside the pyramid.

As references, we used measurement drawings from "L'architettura delle piramidi menfite, 4" 1965 by Maragiolio, V. and Rinaldi, C.A. which is considered to be the most reliable drawing published. Another target was to prepare more accurate drawings than theirs. Highly precise measurement could be achieved because a light wave meter was used to measure the dimensions of the pyramid.

(2) Outline of the Measurements

In this survey, actual measurements were taken on the following parts in Great Pyramid.

① Confirmation of the length of one side of the pyramid
② Measurement of the position of Northern Entrance which is shifted eastward from the center line of the pyramid
③ Actual measurement of King's Chamber (excluding so-called Chamber of Relieved Gravity)
④ Actual measurement of Antechamber
⑤ Actual measurement of Queen's Chamber
⑥ Actual measurement of Horizontal Passage which leads to Queen's Chamber
⑦ Actual measurement of Underground Chamber
⑧ Actual measurement of the vicinity of Northern Entrance

For King's Chamber, Antechamber, Queen's Chamber, and Horizontal Passage which leads to Queen's Chamber, top views, plane views of the ceiling and developments of each side were

prepared. In order to upgrade the quality of the drawings as a material, joints of stones and observed cracks were entered.

For the vicinity of Northern Entrance, top view and eastwest side views were prepared. A large-scale map of the copestone was prepared separately. Measurement of walls in Underground Chamber were not conducted at this time. The overall length, height, and width of Grand Chamber were measured. However, stone joints and ceilings were not measured. A large-size scaffold is required to measure the ceilings and upper part of the walls. Therefore, the measurement will be made next time.

(3) Measurement of the Position of Northern Entrance which is Shifted Eastward from the Center Line of Great Pyramid.

The eastward deviation of Northern Entrance from the center line of the pyramid was precisely measured and calculated using a light wave meter. It was found out that the eastward deviation was about 7 m 28 cm from the center line, which was made by connecting the center of the northern base and the apex of Great Pyramid.

Compared to the measurement drawings by Maragiolio and Rinaldi, we were able to fill up omissions and correct misunderstandings on several details through this measurement.

(4) Architectural Considerations
—The Complex Organization of Interior Room—

In the history of Pyramid, the Khufu's construction of interior spaces is especially unique, but not isolated. As well as the largest scale and the most skillful building, it should be regarded the Khufu is the peak of the complex organization of interior rooms.

The interior complex of Khufu's is more clear articulated than the Bent Pyramid and the Red Pyramid at Dahshur in the meaning of the three chambers construction. And that of Khafra and of Menkaura are more reduced and simplified than the pyramid of Khufu, for symbolic meaning in details. Therefore, the meaning of the Khufu's interior complex can be said to have generality through the True Pyramid. Then we must take big care of three granite stones stuffed at the crossway, ascending corridor and descending corridor. There is no space between stuffed stones and wall, so they were stuffed when ascending corridor was constructed, not fallen as an usual theory. Therefore, they should be given such a symbolic meaning. According to this stuffed stones, the Pyramid of Khufu was able to arrange the interior complex articulately.

The True Pyramid is not only the huge tomb of the pharaoh, but also a symbol of King's authority itself. On the other hand, the traditional meaning have been continued that the Pyramid was the tomb of the pharaoh. The Khufu shaked off thus tradition at first and then become to be

able to develop drastically on the interior compelx. The meaning of unknown hollow space and the particular sand should be considered under this thinking.

So, Queen's Chamber should be corresponded to this world or King's Palace, and King's Chamber and the upper structure to the world beyond on Heaven, and Grand Gallery to Ceremony Space are connecting them. The Pyramid made the remarkable progress of symbolic power when he could gain the invisible interior complex including both spaces known and unknown.

(5) Conclusion

Our architectural investigation proved that the following should be included in the comprehensive research.

Preparation of objective and precise measurement drawings is a basic means of research. Topics of the research which are listed in our plan are as follows.

① Details of the interior space of the pyramid. Especially, analysis of the system and the dimensions of surface masonry.

② Analysis of the design method. Restoration of design dimensions and scale, and relative relations.

③ Restorative consideration for each part of the pyramid and interpretation of functions.

④ Determining the positions of the unknown inner spaces.

⑤ To consider Pyramid-Building Theories, a comprehensive and comparative study including precise and detailed measuring at the interior complex on the history of pyramids.

⑥ A model experiment of the whole superstructure of Great Pyramid by the light-elasticity method.

⑦ Re-investigation of the Pyramids of Giza from the view point of necropolis planning.

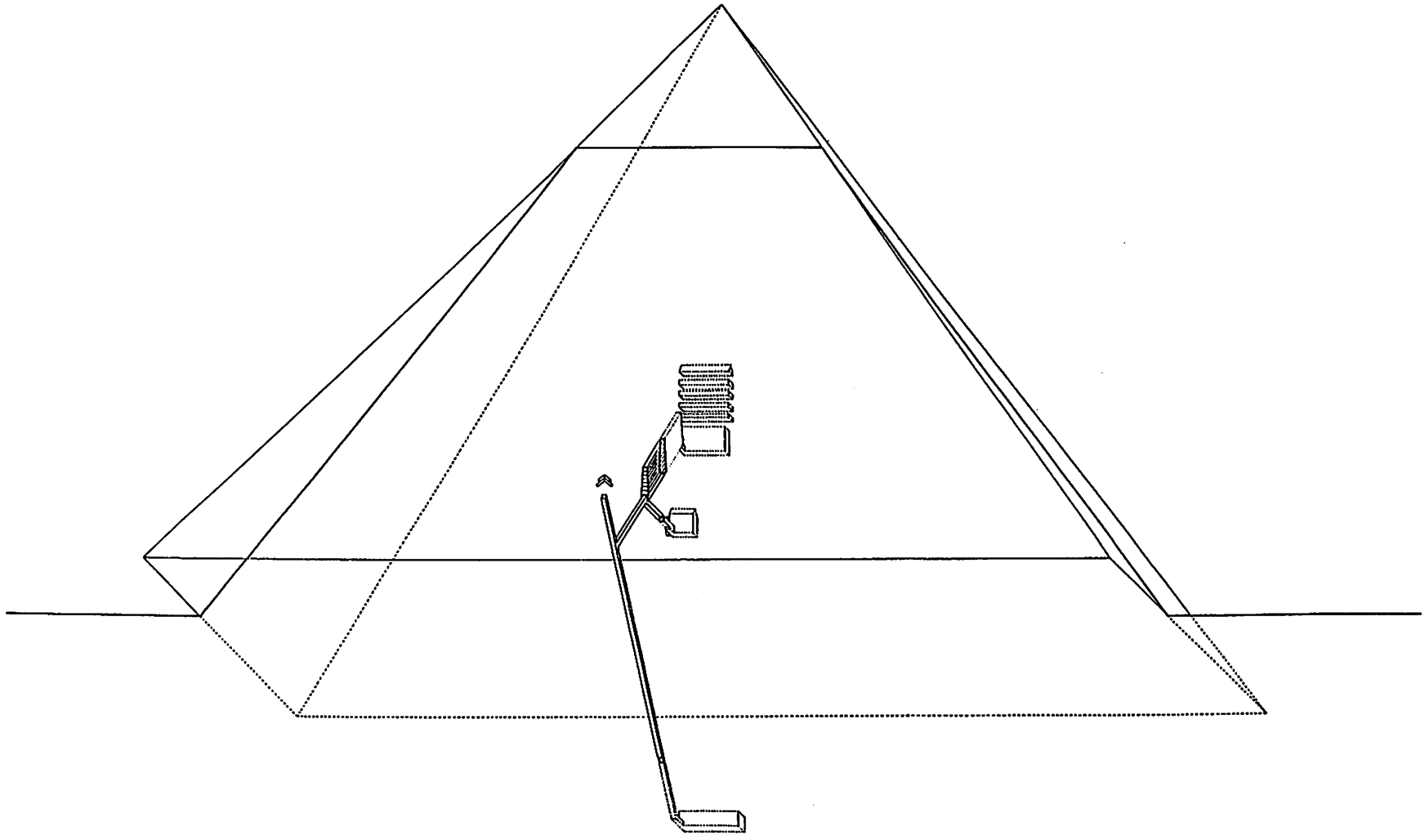


Fig. 45. Section-perspective of Great Pyramid

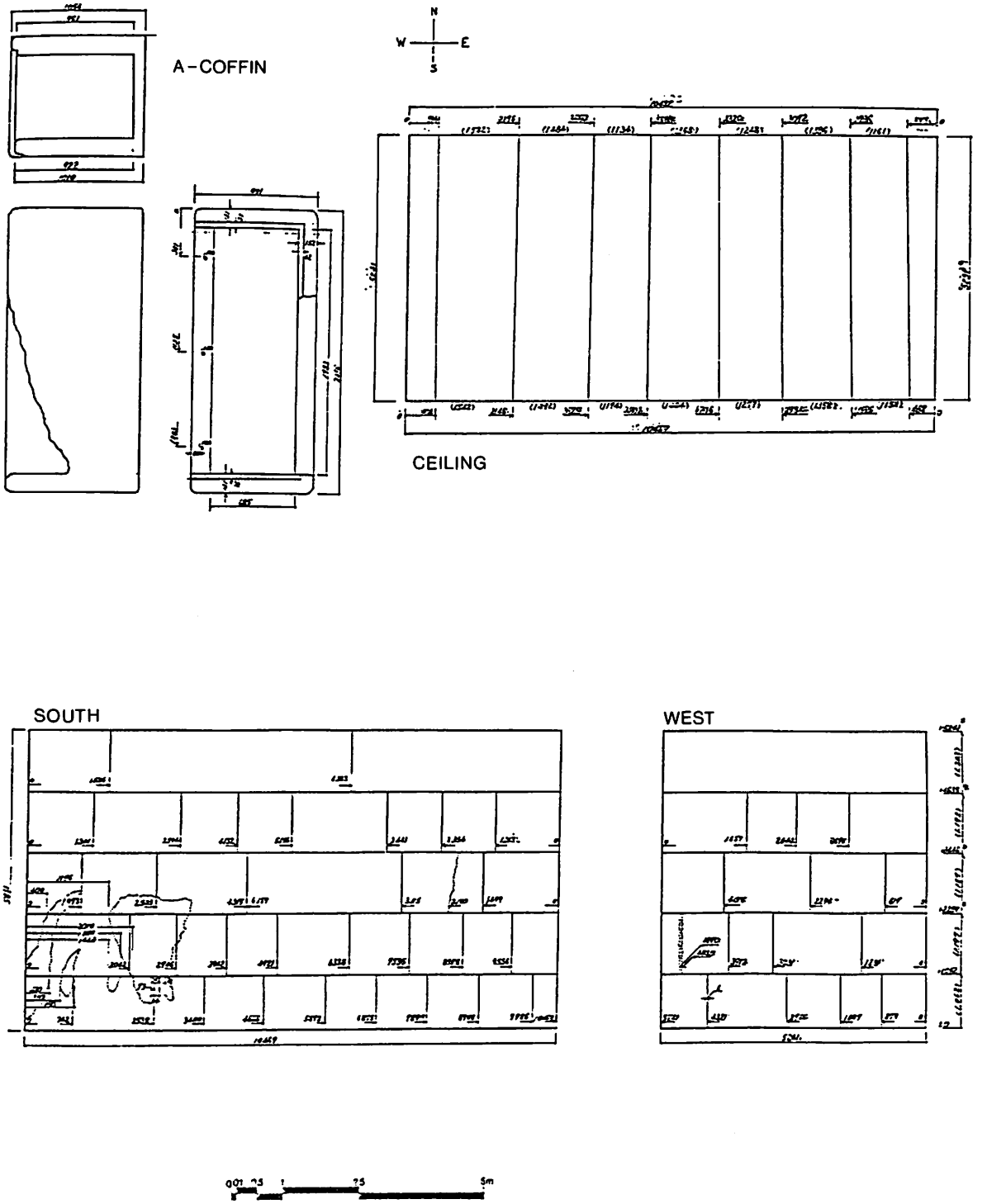
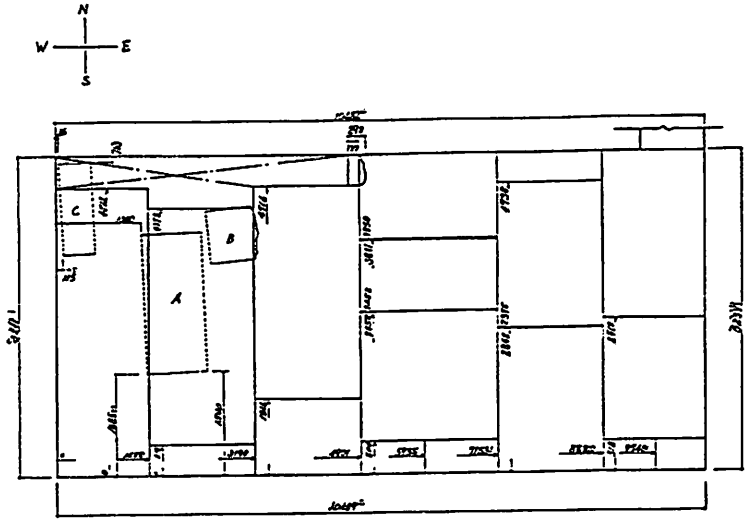


Fig. 46. Development of King's Chamber



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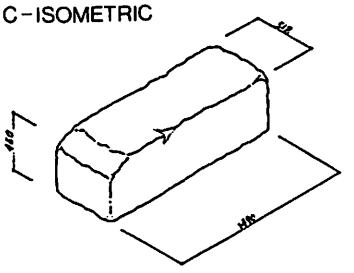

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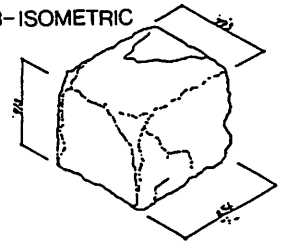

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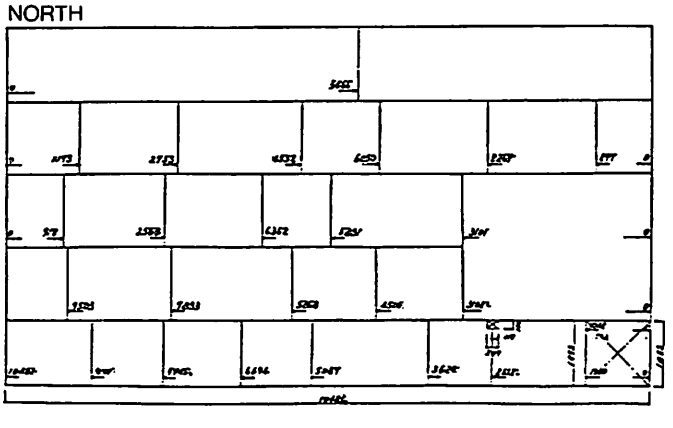

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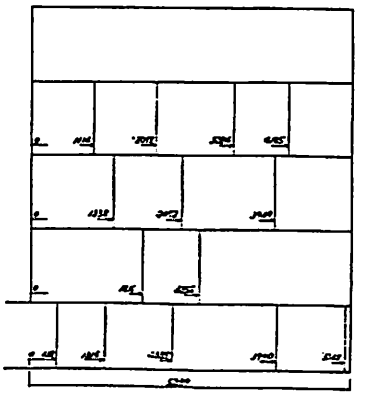

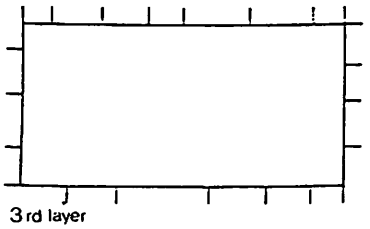

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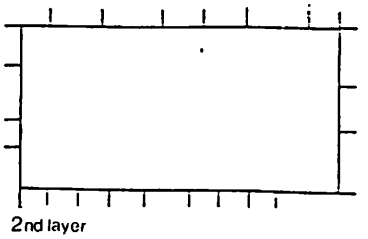

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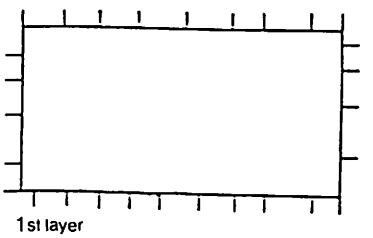

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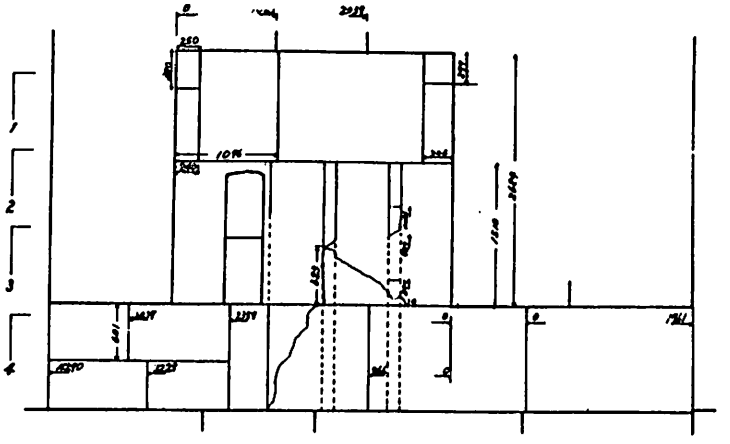

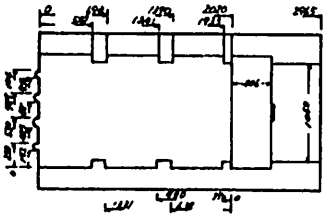

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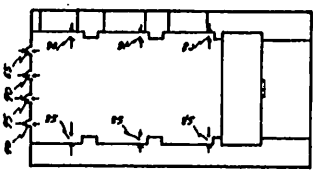

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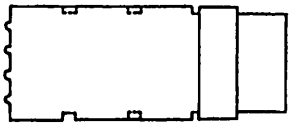

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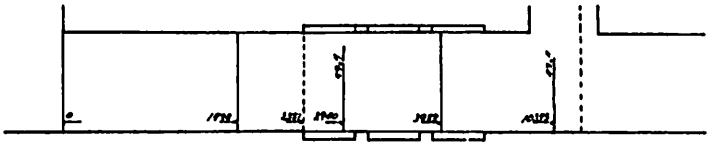

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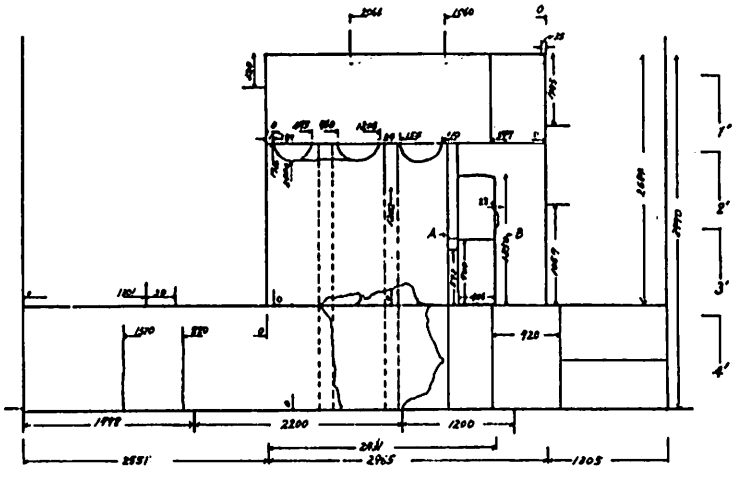
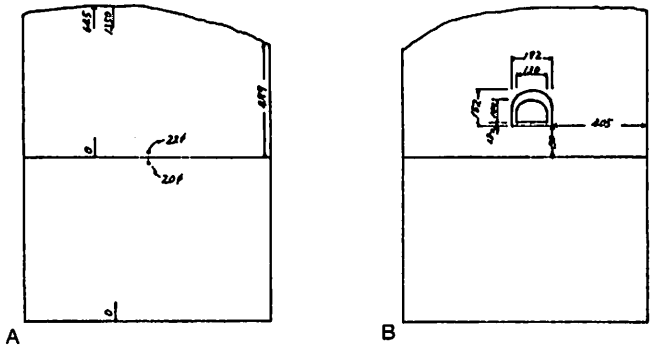
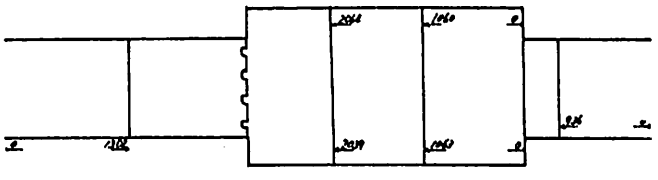
Fig. 47. Development of Antechamber







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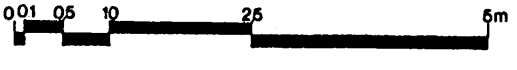


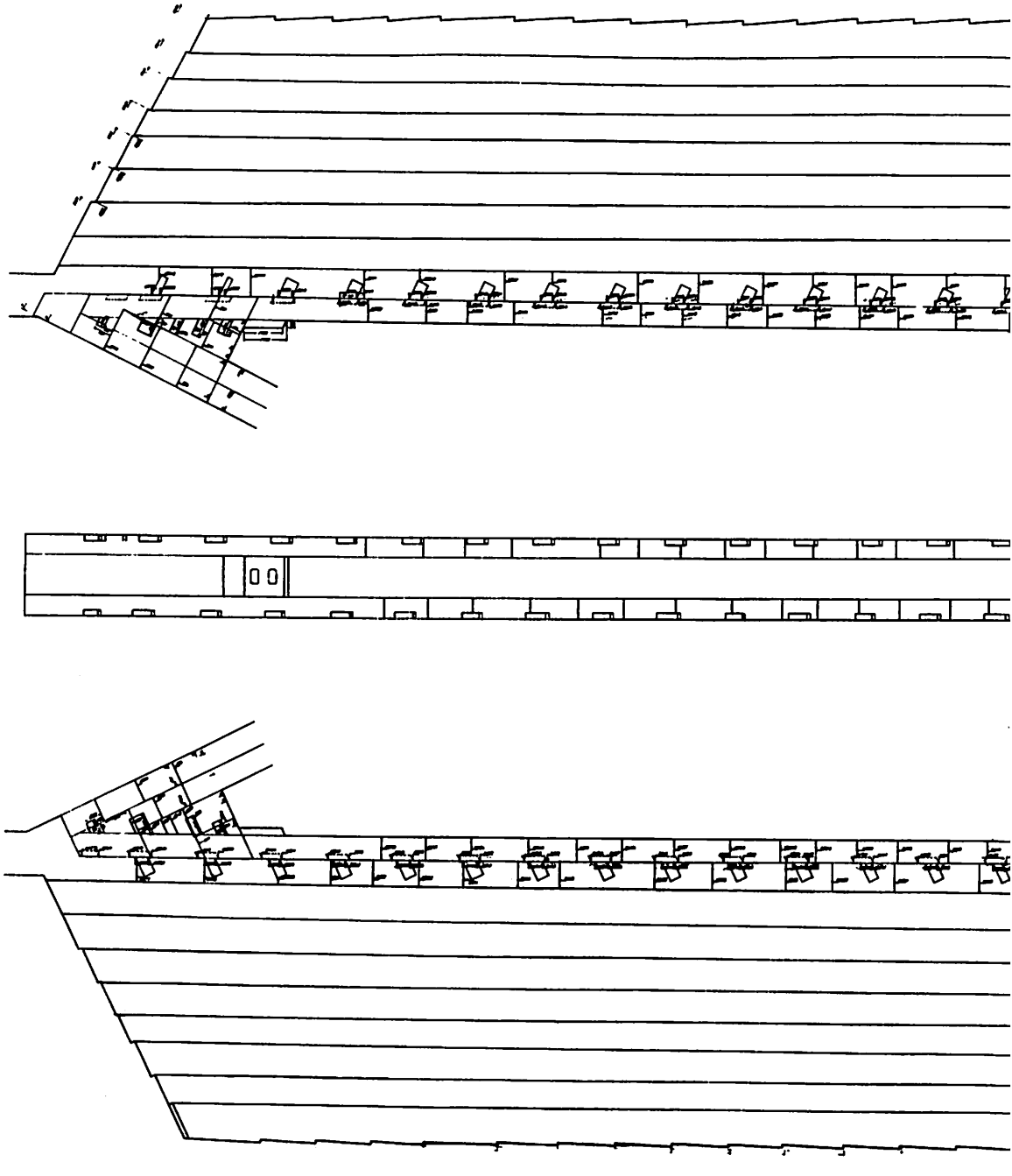
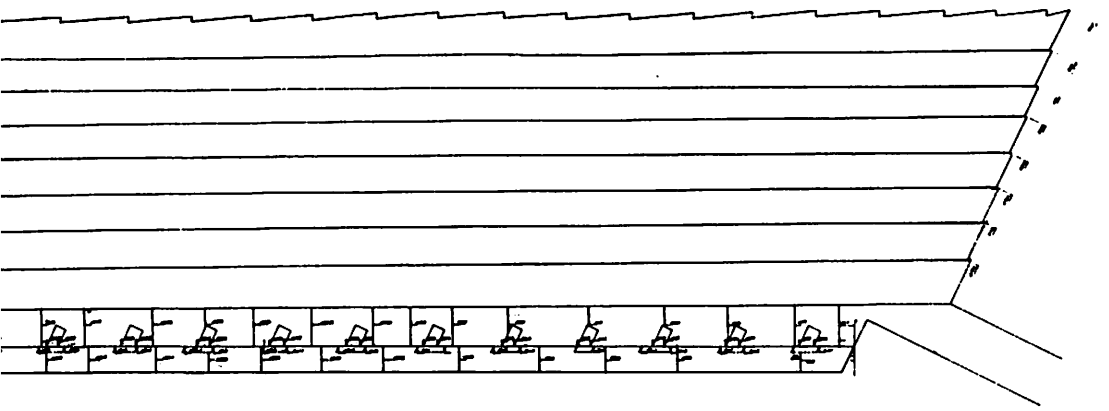
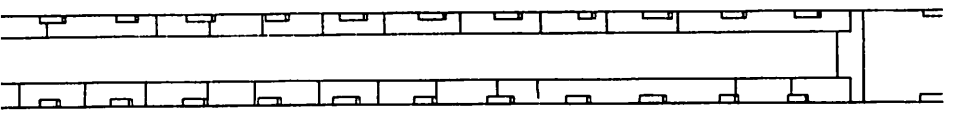
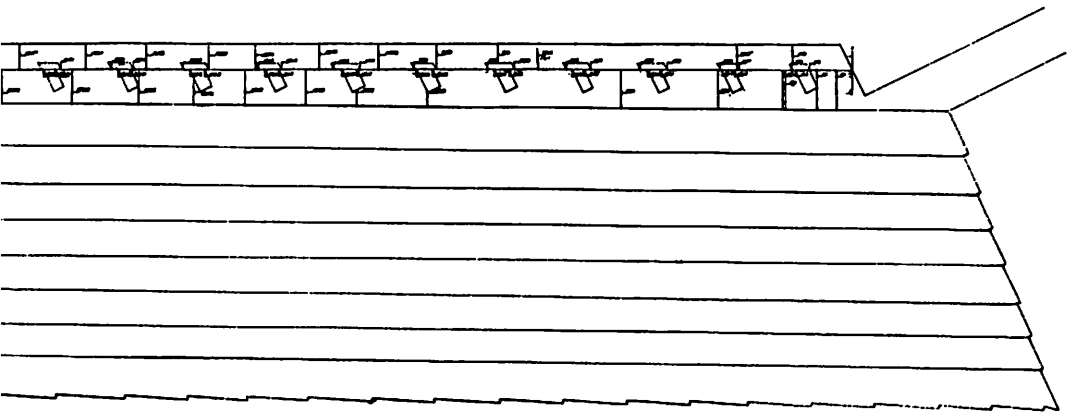
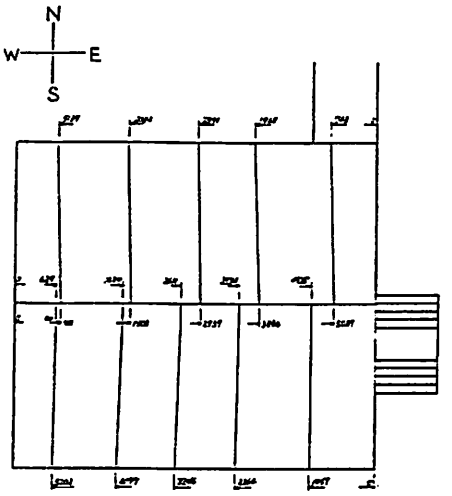


Fig. 48. Development of Grand Gallery









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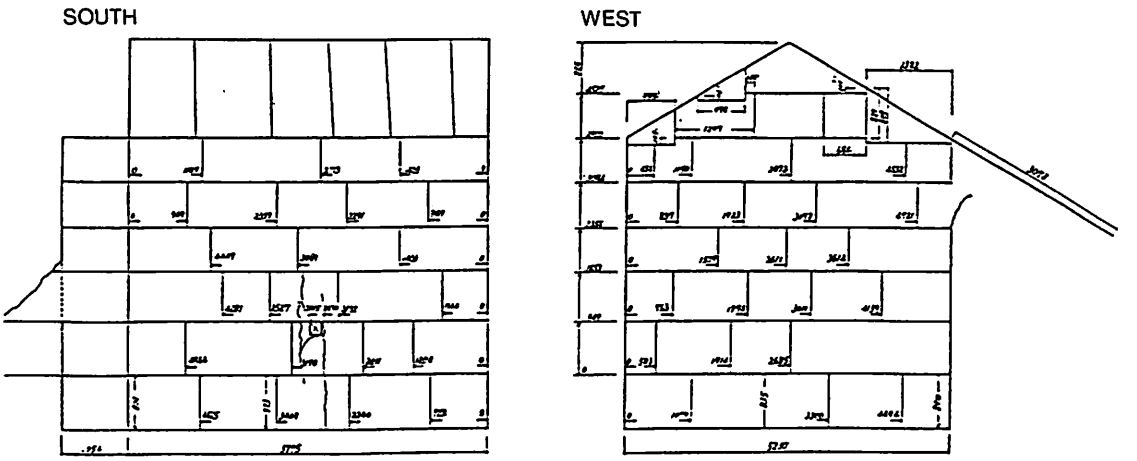
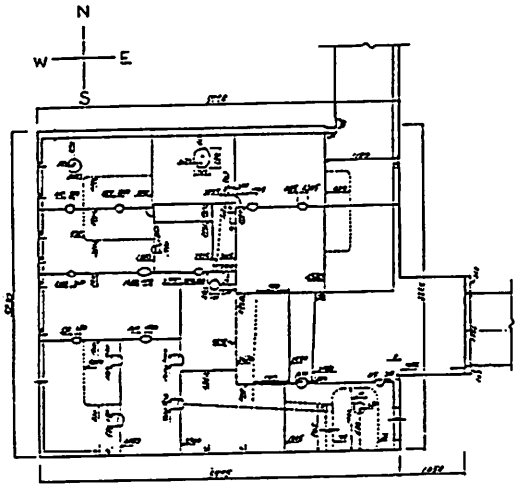
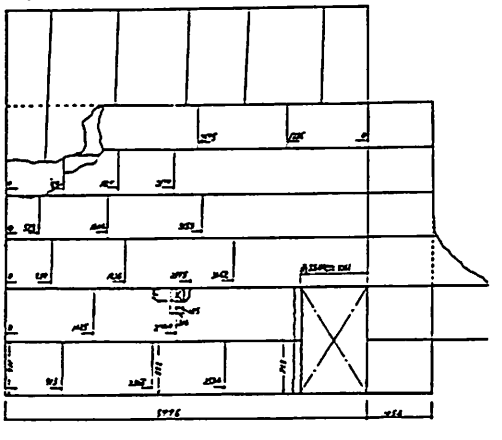


Fig. 49. Development of Queen's Chamber



PLAN

NORTH



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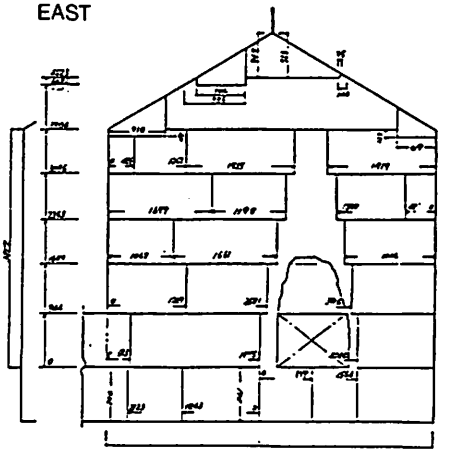
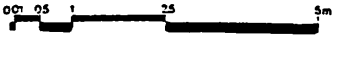




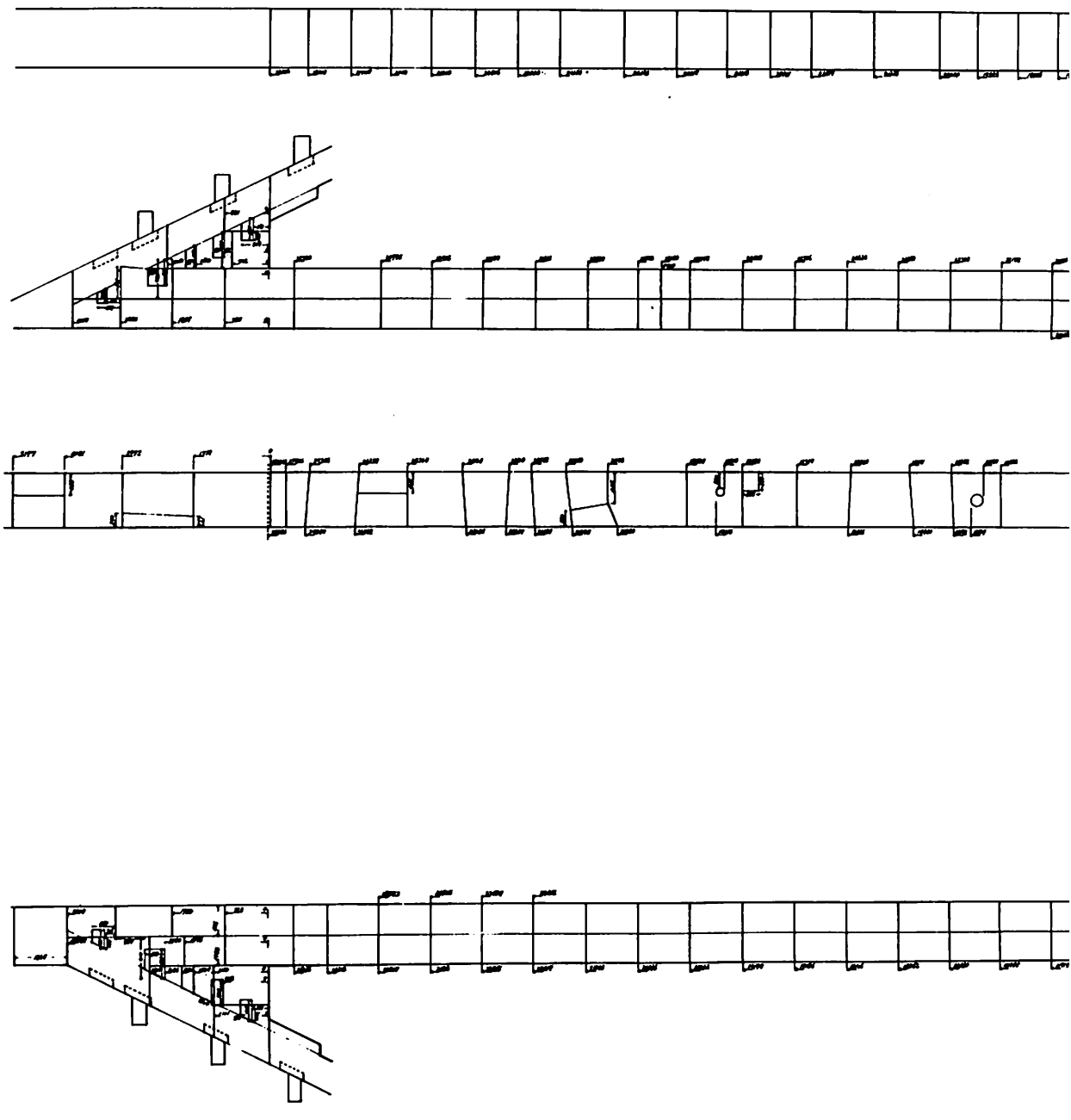
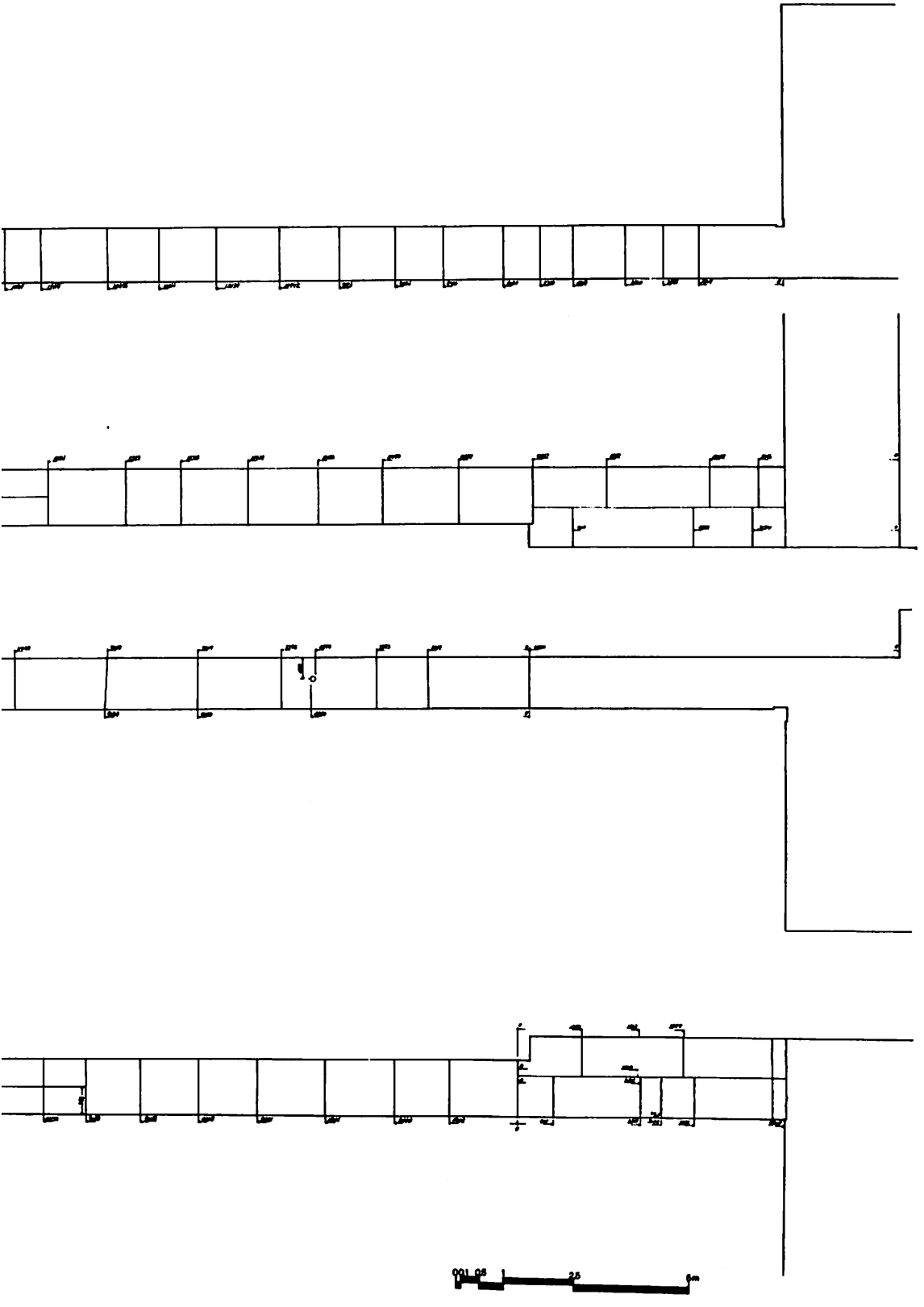


Fig. 50. Development of Horizontal Passage



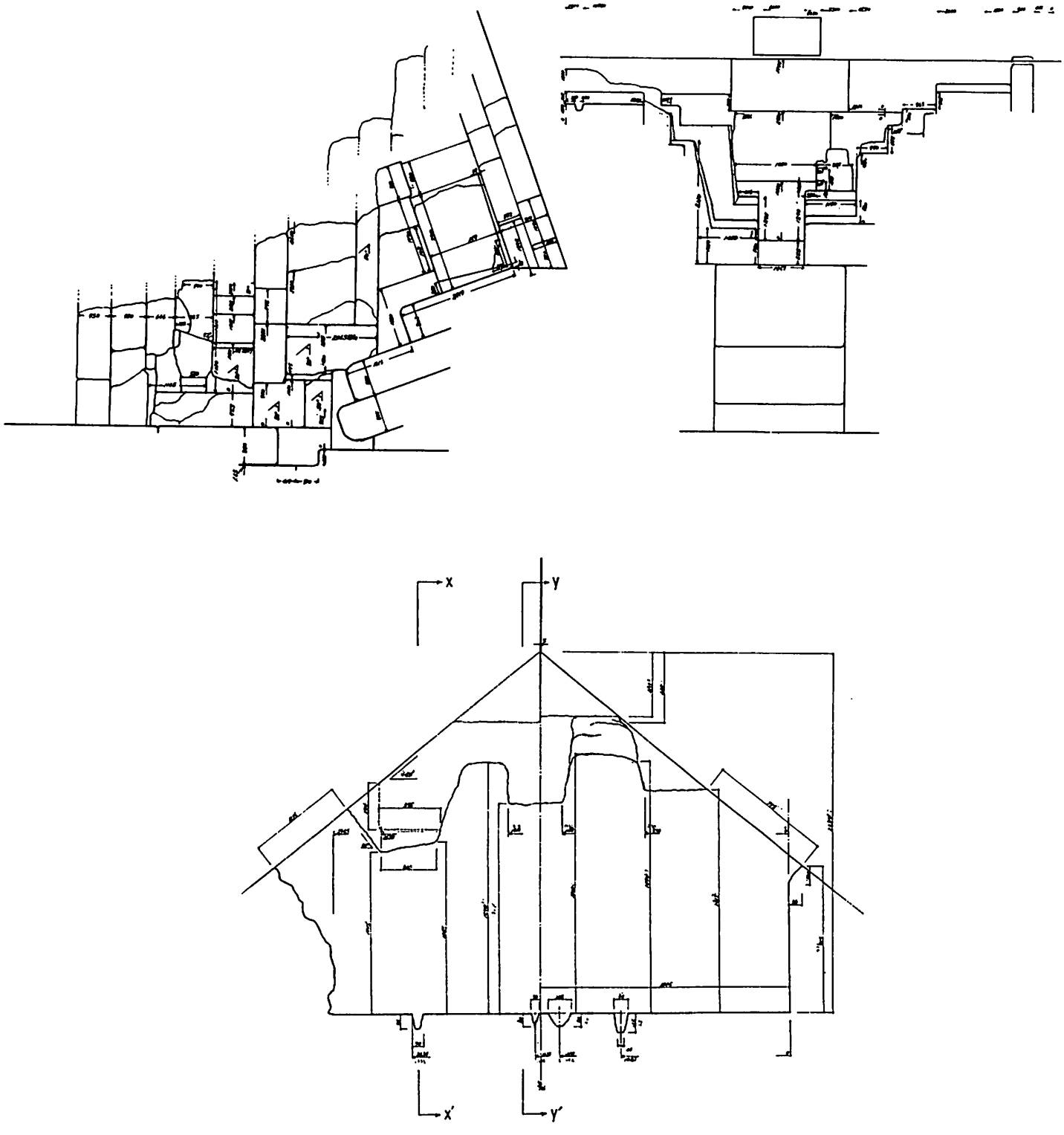
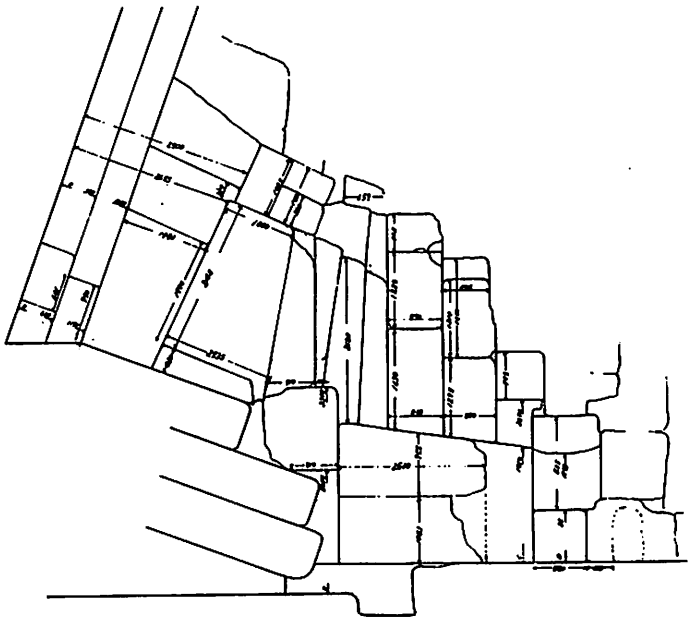
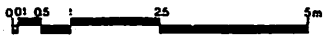


Fig. 51. Development and section of Northern Entrance

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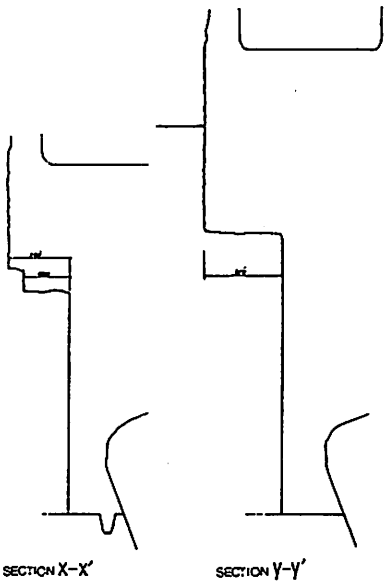
SECTION X-X'
SECTION Y-Y'

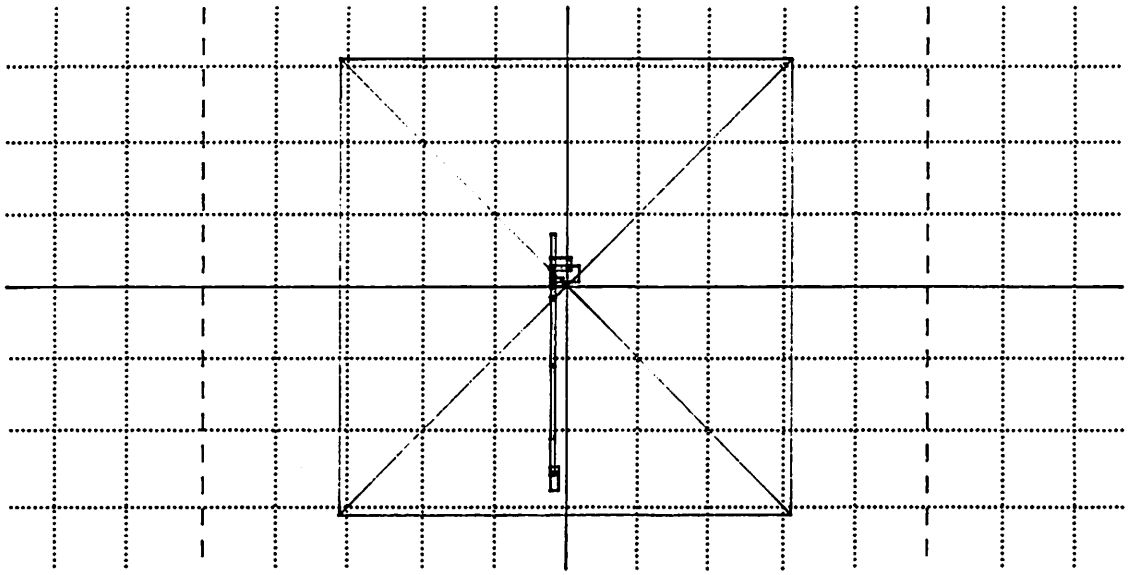

Fig. 52. Plan of Great Pyramid drawn by computer graphic system

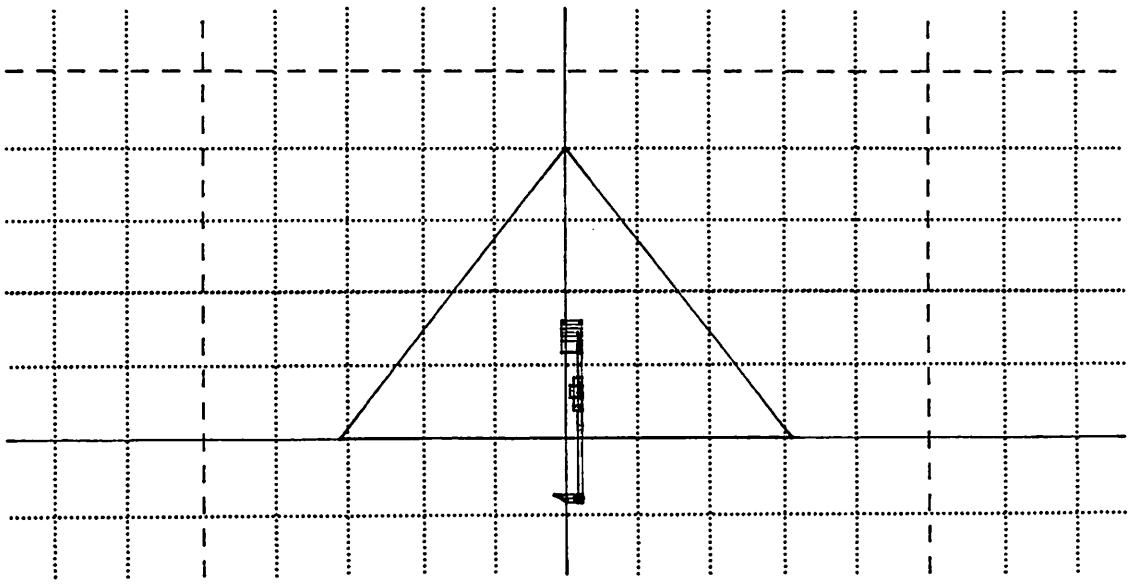

Fig. 53. Axonometric perspective of Great Pyramid from N drawn by computer graphic system

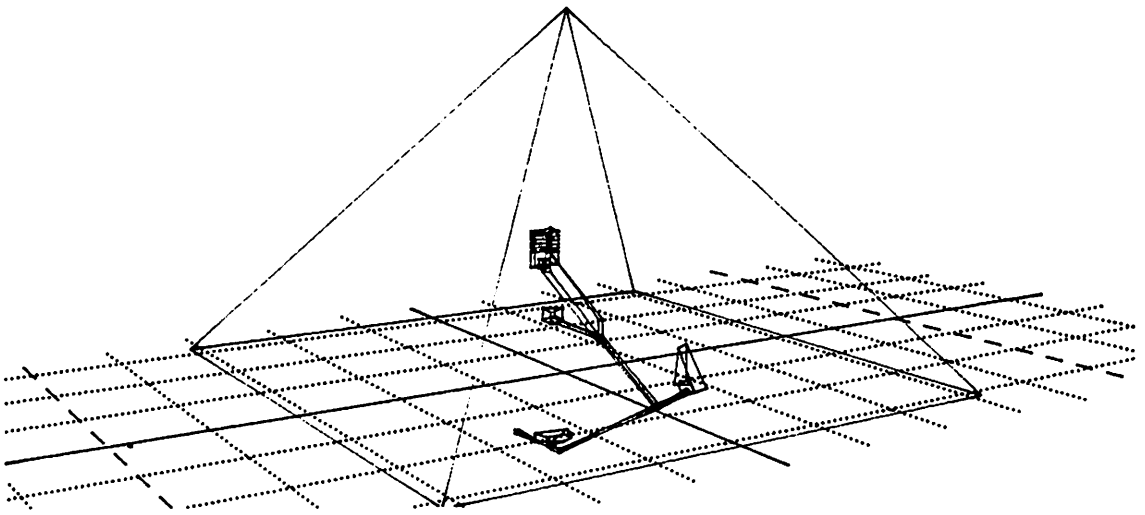

Fig. 54. Bird's-eye view of Great Pyramid from ENE drawn by computer graphic system

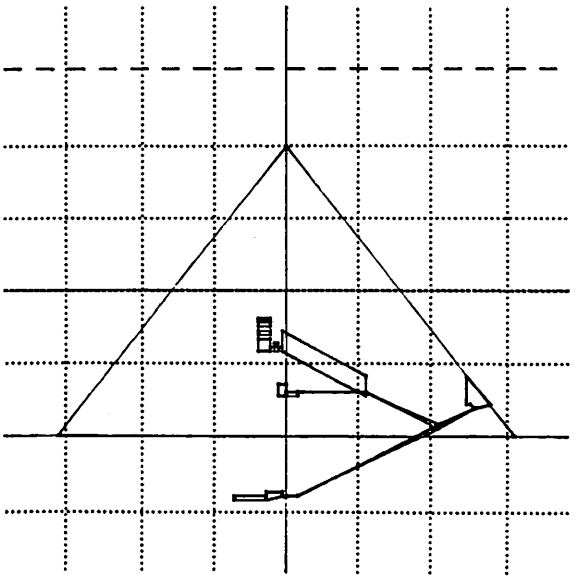

Fig. 55. Axonometric perspective of Great Pyramid from E drawn by computer graphic system

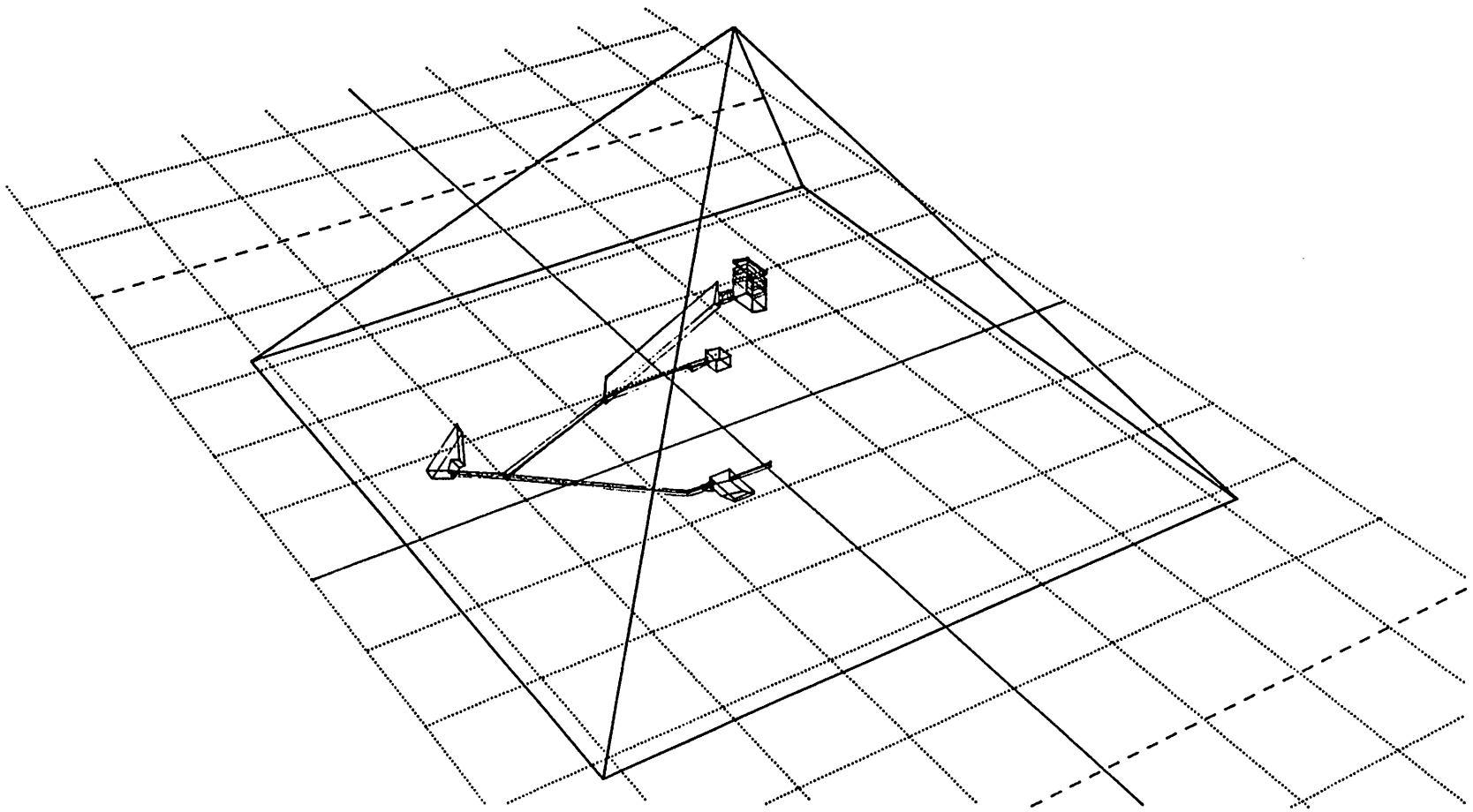

Fig. 56. Bird's-eye view of Great Pyramid from WNW drawn by computer graphic system

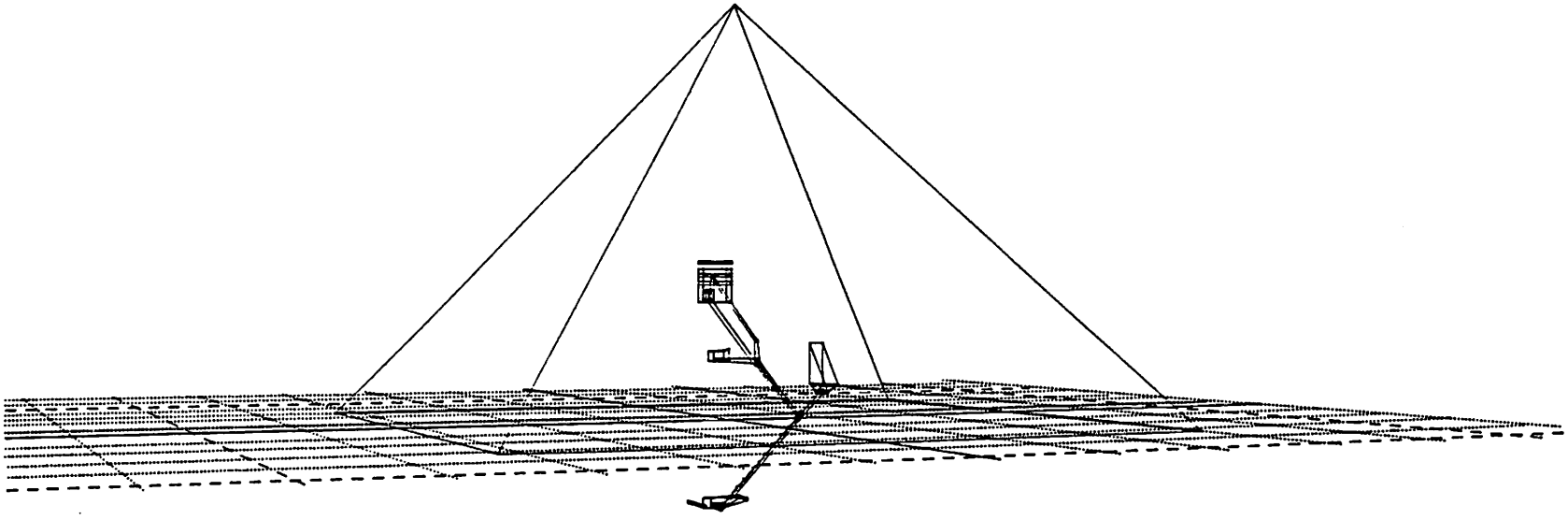

Fig. 57. Bird's-eye view of Great Pyramid from NE drawn by computer graphic system

V PHYSICAL PROPERTY AND MICROSCOPIC OBSERVATION OF THE SAND INSIDE OF GREAT PYRAMID

Shoji Tonouchi

It is necessary to research the physical property of executing of physical prospect. The X-ray analysis and microscopic observation of the sand, limestone and granite. The recrystalization of the coral and shell are often observed. In general, violent recrystalization is seen by microscopic observation. The limestone from pyramid at Giza contained mostly calsite partly are observed plunktonic and benthic foraminifera, quartz and plagioclase. From the result this is muddy limestone, and it seems that this causes the attenuation of electromagnetic waves.

It is considered that the rock name of this pinkish granite is granodiorite, contained minerals are quarts, biotite, hornblend, plagioclase, magnetite and K-feldspar. This rock belongs to usual granodiorite except of the alminum rich. According the result of the experiment, the relative dielectric constant shows the value of 5 as other granite of the world. But attenuation rate is small value of about 2.3.

We gained the following important fact that the sand inside Great Pyramid from French mission's survey is quite diffierent from that from Giza Plateau and Saqqara district. (Pl. 6) However, the sand is now on the process of mineral analysis. The sand found inside of Great Pyramid by French mission is composed mostly with quartz and poorly plagioclase. It composed quartz more than 99% and is generally called quartz sand. The size of the grains is large which is from 100 to 400 micron. The sand collected from the south of Pyramid contains minerals of mostly calsite, quartz, and plagioclase. (Pl. 9) As the characteristic of that is the size of the sand is mostly small less than from 10 to 100 micron and every grain is angular, namely, autochthonous. It shows that the sand was formed at the same place. The sand from the east side of Sphinx and from the desert behind Pyramid are almost the same as it from the south of Pyramid (Pl. 8 and 9). The sand sampled from Saqqara is also the same, and there is an obvious different from the sand from inside of the Pyramid.

The sand from inside of Great Pyramid has the lines created by wind on the surface of the quartz grain. It is important why this particular sand exists inside the Pyramid. It is considered that the sand was used on the construction or the maintenance of Pyramid. I think that this fact means a lot, the key of construction of Pyramid. The questions is that whether this kind of sand exists in other part of the world? From the literatures, I found it distributes at a few places in the world. There are some places in Japan, also and it is called "weeping sand" because it make sound by wind blowing and or by stepping with feet. It is considered that the reason to make sound is that the sand rubs each other, and also is called "music sand" in other part of the world.

The music sand is composed almost 100% of quartz and is relatively large grain size. It is difficult to separate those from igneous rock even with modern technique so that, it is out of consideration for Anciant Egyptian to have such technique or to carry it from literature and found the music sand at Abswella near Tur in Sinai Peninsula. This survey of this place was conducted, because a Bedwin said that the sand make sound. The feature is the same as the sand from inside the Pyramid, and it is considered that granite at Mt. Sinai weathered and transported to the sea, in consequence the quartz separates other minerals accordance with density and size. After sea bottom rises and distribute in sediment. Furthermore, the sediment is weathered and quartz sand is formed.

From now, we intend to do mineral analysis to judge whether the sand from Great Pyramid has the same characteristic as the music sand. Furthermore, it is necessary for us to investigate the Aswan district which granite distribute. I think this fact is important in the study on the construction of Pyramid.

Ⅵ Conclusion

Sakuji Yoshimura

We, the Waseda University Pyramid Investigation Mission, is intended to make clear "Necropolis Project at the Giza Plateau." At the beginning the investigation of the first survey is concentrated on "clarification of the purpose of building Great Pyramid." Since Herodotus, many people thought that "the pyramids were tombs of kings," and thus inherent treasure should be left in Great Pyramid as well as other pyramids, and thus there should be unknown chambers storing the inherent treasure in addition to the chambers that had already been found. On the other hand, there is a belief that Great Pyramid was excavated for piracy before the invasion of Al Mamun in the ninth century and that the inherent treasure was already stolen. These beliefs stem from the belief that Great Pyramid is the tomb of king as well as the tombs in the King's Valley in the New Kingdom.

Our theory set aside such a belief, and starts from what is the purpose for building Great Pyramid. This does not mean a bold project to reevaluate pyramids all over Egypt, but a project used to proceed to the next step by clarifying Great Pyramid with the most complicated internal structure. Of course, it is needless to say that comparison with other pyramids is essential in the observation.

There are many mysteries about Great Pyramid from ancient times. They may be areas that cannot yet be explained, rather than mysteries. There is a tendency for them to be overlooked by experts as discoveries by amateurs. However, even the experts originally know nothing. They utilize the accumulation of the thoughts of amateurs in the history. Thus, we have first tackled such unexplained areas as our start. Among them, there are many facts that have been conventionally discussed, such as the fact that the true Northern Entrance deviate to the east by a little less than 8 meters from the center line of the base, that the stone hiding the entrance is abnormally small, and why Underground Chamber is uncompleted. The reason of these fact were not fully explained, but the discussion was terminated in the middle. Thus, we have started our investigation by accurately remeasuring the internal spaces that have been found until now, and entering the data in a three-dimensional reconstruction system of computer for study from various aspects. It was conducted with the cooperation of experts in various fields including those of the history of architecture, the architectural structure, and the rock mechanics. At the same time, we have developed the technology which enables us to investigate the inside of Great Pyramid. Various experiments have revealed that the electromagnetic wave investigation appears to be best suitable method. Thus, we conducted the first survey in January, 1987 at Giza Plateau. Then, we improved insufficient areas such as the capability of the machines. The

second survey was conducted in September, 1987. This is the report of that survey. We concluded that the current level of the reflection method might be acceptable, and that we should place the emphasis on the transmission method for transmitting the entire Great Pyramid. We developed and improved the equipment for it, and completed it in the end of March, this year.

The reason why we place the emphasis on the transmission of the inside of Great Pyramid lies in the fact that we think that there should be many chambers and passages in addition to those found until now. Its origin is that the true Northern Entrance deviates by a litle less than 8 meters to the east from the center line. A big impact was caused by the discovery of a large space beyond the wall at the western end of the north wall of the so-called Queen's Chamber, that was found in the first survey.

We had hope for the future when, in this survey, we found that the cavity is a passage similar to Horizontal Passage and extending parallel to it, and discontinues at a point near the intersection of Horizontal Passage with Grand Gallery. This is because we can anticipate that the passage bends to the west, which means there is a very high possibility of the existence of a chamber or a passage on the west. In other words, it means that a chamber or a passage similar to those we now know exists on the west side. To identify it, we have to develop an electromagnetic wave system that can penetrate at least 100 m. Because it appears to take much time, as the next step for the time being, we think that we should first explore in an area within 30 m, by using the tomograph method, such problems as whether or not there is a chamber or a passage between the entrance and Grand Gallery, similarly whether or not there is a chamber or a passage between the so-called King's Chamber and the so-called Queen's Chamber, and at the same time how the area between both chambers and Underground Chamber appears. This is because these problems will clarify the structures between the existing spaces in Great Pyramid.

In addition to the clarification of the internal structure of Great Pyramid, the existence of Great Sphinx is also important for us. All of the researchers, including Petrie, who conducted excavation and investigation at the Giza plateau, were interested in the origin of the building of Great Sphinx, and discussed it. However, the discussion continues to the present day without any definite conclusion.

We set aside the conventional approach that Great Sphinx is attached to the Pyramid of King Khafre, and intend to consider of the period of construction. It might be possible that the existence of Great Sphinx let to the building of Great Pyramid and that the first structure built on the Giza plateau was Great Sphinx and its temple,. We wish to make it clear by studying the observation in history of architecture, that is, the plan for the buildings now existing on the Giza plateau, by accurately measuring their axes of orientation, and the distance between them, the directions and the angles of them, and by analyzing them with a computer. We believe that it is very important in considering the cultural background, in which the religion for the Sun God, Ra was rapidly increased in the Fourth dynasty. In addition, as for Great Sphinx, we believe that it will be important to

investigate the possible risk of decaying of the head of the sphinx, because there is a possibility that the underground water rises under the bed rock on which Great Sphinx is constructed, and to investigate whether the metallic reaction under the bed rock near the left forepaw found in the first and the second surveys is a natural object or an artificial one. Furthermore, it is necessary to investigate the underground around the causeway connecting the Pyramid of King Kafura and the opposite temple with an electromagnetic wave system to understand the natural and the artificial environments of the Giza Plateau when Great Pyramid was constructed. If we cannot determine the underground structure by any means but conventional excavation, the time and the labor for it will be enormous, and we should conduct the investigation as the one with the highest priority. However, the underground radar that we have developed is effective, because it reduces resources in every aspects. The survey will be conducted by utilizing a sand buggy for a wide area. We will conduct the survey in the near future. If we further develop this technique, it will become possible to investigate the entire Giza Plateau by loading the survey unit on a helicopter.

The above are the meaning, the method and its development of the survey that we are conducting on the Giza plateau. Our motto is "not to destroy vestiges," "to think through matters from the beginning that were theorized in the past," and thus "to utilize the high technological equipment in reducing time, labor and expenses." We should further add that we do not intend to conduct the survey just for entertainment, neglecting the essence of the civilization of ancient Egypt, with its history of 5,000 years, but are endeavoring every day to attain an integrated survey with the scientists of the world at the top level of each specific field.