Conservation of the Wall Paintings in the Royal Tomb of Amenophis III

- First and Second Phases Report -

Under the auspices of UNESCO / Japan Trust Fund

Joint Project of
Supreme Council of Antiquities, Ministry of Culture
Arab Republic of Egypt
and
Institute of Egyptology, Waseda University

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FRONTCOVER:
Wall Painting in the Royal Tomb of Amenophis III after Conservation
The Image of Amenophis III with Gods and Goddesses
Room E South Wall

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MESSAGE FROM THE SUPREME COUNCIL OF ANTIQUITIES

Zahi HAWASS

Secretary General, Supreme Council of Antiquities,

Ministry of Culture, Arab Republic of Egypt

First of all, I would like to express my heartfelt thanks to Mr. Koïchiro Matsuura for his personal encouragement in opening for the first time the Japanese Fund to the Arab region, specifically to Egypt. Under the aegis of this fund, the Japanese Government put USD 694,100 in trust to carry out the conservation of the tomb of Amenophis III (KV 22). The conservation work done thus far in this tomb would not have been possible without this generous financial contribution and the management of UNESCO.

I wish to offer thanks also for the quality of the work done within the framework of this project, which I have seen for myself. This project has been widely praised by the international scientific community. Notice has been taken especially of the exemplary way in which the project has succeeded in meeting its original schedule, making the Amenophis III Project an international model.

Nevertheless, I would like to draw attention particularly to the necessity of continuing the conservation work in this tomb. The following issues still need attention:

◆ The structure of the tomb still needs to be stabilized. One of the pillars and a retaining wall are both displaying huge cracks; these must be restored, or the tomb will remain in serious danger. This is currently being studied in more depth by Japanese experts.

◆ In order to complete the conservation project planned for the entire tomb, the next priority is the conservation and display of the red granite sarcophagus lid.

◆ Completion of the residual portions, consolidation of all the detached portions of the vault, and consolidation of the unfinished room should also be carried out.

◆ Furthermore, there needs to be a total reworking of all the treated wall surfaces in order to ensure a homogeneous presentation.

◆ It is also important to plan and install appropriate facilities to protect the site after the conservation work has been completed.

◆ Additional work needed includes a ventilation system; illumination with cold lamps; a wooden floor; and study of methods to protect the tomb against flash floods and other external hazards.

For the reasons described above and on behalf of the Egyptian authorities, I would be very grateful if the UNESCO/Japan Trust Fund could support my request for the financing of the next phase for this project. This would fund additional seasons carried out by the same international, multidisciplinary team managed by UNESCO, still in cooperation with the Institute of Egyptology, Waseda University and the Supreme Council of Antiquities, Ministry of Culture, Arab Republic of Egypt.

Finally, I would like to offer our most sincere thanks to the quality of UNESCO staff members, and particularly the Program Specialist in charge of this project, Ms. Mounira Baccar, for the continuous support she has given to the international team of experts and for her constant assistance, without which this conservation work would not have been possible.

MESSAGE FROM UNESCO

Conservation of the wall paintings in the Royal Tomb of Amenophis III

(536EGY4070)

Mounira BACCAR

Program specialist, Division of Cultural Heritage,

United Nations Educational, Scientific and Cultural Organization

UNESCO seeks, through international co-operation, to orient new generations towards peace, intercultural understanding, democracy, tolerance, human rights and security in the world. In this respect, Amenophis III's reign characterizes many of these values, because he consolidated alliances, encouraged diplomatic contacts, peace, prosperity and a high degree of human artistic expression.

In order to carry out the conservation of the Royal Tomb and, particularly thanks to the encouragement shown by the Director-General of UNESCO, Mr. Koïchiro Matsuura, the Japanese Government put at the disposal of UNESCO a Fund-In-Trust, amounting to USD 694,100. This was the first time that Japan had provided financial assistance for a project in the Arab region. The initial idea behind this Fund was to assist the Egyptian Authorities in their endeavours to preserve their cultural heritage by providing them with the technical knowledge necessary in order that they could continue with this task without international support. For this reason, it is vital that the beneficiary country be totally committed to the task-in-hand if the project is to succeed.

The Royal Tomb of Amenophis III is one of the largest and most important tombs in the Western Valley of the Kings and in 1979, the necropolis and area were registered as a World Heritage Site. This splendid cultural heritage has been given a new lease of life through the conservation work conducted under the aegis of UNESCO.

These elaborate paintings, depicting kings and gods together with intricate hieroglyphic texts, are rated as the most exquisite works among the royal tombs of the Eighteenth Dynasty. Since its discovery in 1799, the walls and paintings have cracked and the Tomb threatens to collapse at any moment. The Egyptian Authorities and the Waseda University have stressed that restoration work of the tomb should begin as soon as possible in order to prevent further deterioration of the bedrock and the plaster layer supporting the paintings. Substantial efforts have already been made to restore and enhance this monument.

After a feasibility study was carried out in 2001, a scientific team from the Waseda University, together with other international consultants, designated by UNESCO, started conservation work on the Tomb in 2002. The preliminary cleaning of the walls and the consolidation of the plaster and pigment layers have already been carried out. Furthermore, the team trained Egyptian personnel in the conservation work of the wall paintings. Several scientific surveys of the site were also undertaken, including an analysis of the rock in the Tomb, in order to assess the short and long term treatment required to shore up the walls whilst taking into account the results of the structural and civil engineering surveys which had been previously undertaken. Environmental studies of the temperature, humidity, gas and salt in the air were also carried out in order to ascertain better conditions of conservation.

This publication indicates the progress achieved so far and highlights the action undertaken to preserve the polychrome wall paintings of Amenophis III's Tomb.

I would like to extend my thanks and appreciation to all those who have contributed to the work carried out to date and to the preparation of this publication.

I. PREFACE

Sakuji YOSHIMURA

Professor, School of Human Sciences, Waseda University

This enterprise is the first project that the Institute of Egyptology at Waseda University (Tokyo, Japan) has conducted jointly with the United Nations Educational, Scientific and Cultural Organization (UNESCO).

The results achieved during these five months were very productive. Dr. Zahi Hawass, Secretary General of the Supreme Council of Antiquities (SCA) in Egypt's Ministry of Culture, visited the site and praised our efforts very highly. In fact, Waseda University has been conducting excavations in Egypt for 35 years, but we cannot recall one time in which the SCA was so pleased with our work. This just shows how valuable it was to conduct this project with UNESCO.

We encountered some serious difficulties due to a delay in starting the project and a delay in the forwarding of the needed funds. However, once the project was actually started, our work progressed rather smoothly. There were some very valuable results and the guidance and cooperation between the conservators went very well.

There are, of course, many areas that we need to reexamine and many improvements could be made to the project. We have given these items careful study and we were able to exchange opinions with UNESCO, represented by our project manager Ms. Mounira Baccar, at the meetings held in Luxor on April 29 and 30, 2003 and March 6, 2004.

We are confident that these experiences will be adequately reflected in the future phases of such projects. Furthermore, under the guidance of Italian conservators some excellent techniques are being passed to the Egyptian and Japanese conservators. We believe that this has been an important aim for UNESCO. In this aspect, we feel that the success of the project is being seen on more than just one level.

The report presented here is the result of the enormous cooperation by each responsible expert that shares time out of their busy schedule to assist us in the project. Experts from various fields also shared with us their skills and expert eyes in conducting this study. Thanks to their efforts, we were able to achieve some results that we had never seen before. We hope that this report will be read carefully. Finally, we thank UNESCO and the SCA very much.

II. ACKNOWLEDGEMENT

We would like to express our thanks to the Permanent Committee of the Supreme Council of Antiquities (SCA) for granting permission to carry out this work, in particular to Dr. Zahi Hawass, Secretary General of the SCA, Mr. Sabri Abd al-Aziz, Director of the Egyptian Antiquities Sector of the SCA, Mr. Magdi al-Ghandour, Director of Foreign and Egyptian missions affairs, Dr. Ahmad Shwaib, Director of the Department of the Conservation of the SCA, and to all the members of the Committee. We are also grateful to Dr. Samia al-Mallah, Director of foreign relations of the SCA especially for UNESCO affairs. In Luxor, our debt of gratitude to all the member of the SCA is immense, in particular to Dr. Holeil Ghaly, General Director of Central Administration of Upper Egypt and Oasis Antiquities, to Mr. Mohammad Aasem, Director of Antiquities in Luxor, to Mr. Ali Asfar, Director of the Antiquities on the West bank of Luxor (Qurna), to Mr. Ibrahim Soliman, Former Chief Inspector of the Valley of the Kings. During these two seasons we had two inspectors each time to our mission: Mr. Mahmoud Zaki Mousa and Ms. Hekamat al-Arabi Mahmoud for the first phase, Mr. Bahaa Abdel Gabar and Ms. Malvet Meakail for the second phase. We appreciate their cooperation and help throughout the seasons.

We also would like to express our gratitude to the Division of Cultural Heritage of UNESCO, in particular to Mr. Mounir Bouchenaki, Director of the Division, Mr. Gadi Mgomezulu and Mr. Laurent Lévi-Strauss, Deputy Director of the Division for facilitating our project. Thanks are due to Ms. Mounira Baccar, Program Specialist for the Arab countries of the Cultural Heritage Division of UNESCO for her unfailing support. We are grateful to the Japanese permanent delegation to UNESCO from Japan's Ministry of Foreign Affairs for their kind assistance.

We would like to thank foreign missions working in Luxor for their help and encouragement, in particular Dr. Raymond Johnson and his staff at Chicago House. Finally, we wish to thank Ms. Heather Reeves for checking our English manuscript.

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IV. THE SCIENTIFIC REPORT

Part 1 THE FIRST PHASE

1. Introduction

Sakuji YOSHIMURA[1] and Nozomu KAWAI[2]

1) Professor, School of Human Sciences, Waseda University
2) Research Fellow, Institute of Egyptology, Waseda University
UNESCO Counterpart of the Project

The Institute of Egyptology at Waseda University initiated its comprehensive investigation of the royal tomb of Amenophis III in the Western Valley of the Kings since 1989 under the direction of Prof. Dr. Sakuji Yoshimura and Ass. Prof. Jiro Kondo. The work has included mapping, excavation, documentation, epigraphic work, and electromagnetic survey. Fifteen seasons of work have been carried out from 1989 to 2000.

The royal tomb of Amenophis III is decorated with elaborate paintings of very high quality. Painted walls exist in room E (shaft chamber), room I (antechamber), and room J (burial chamber) (Fig.1). These chambers are decorated with the images of king and gods, and intricate hieroglyphic texts. The tomb paintings of Amenophis III are regarded as some of the most exquisite works of the royal tomb paintings in the Eighteenth Dynasty Egypt. The quality of these paintings, however, has been compromised by their precarious condition. Since their formal discovery by Napoleon's expedition in 1799, the wall paintings have never been taken care of or conserved. During the clearance of the tomb by our mission, the following undesirable conditions were observed.

First, the wall paintings are badly stained by bat guano and microorganisms throughout the tomb. Second, the surface of the painted plaster has been detaching from the bedrock, which causes the corruption of the painted plaster. Third, cracks on the walls and pillars have caused severe damage. Fourth, some artificial damage was done to the wall paintings in the past. We realized that the wall paintings of the royal tomb of Amenophis III are in a seriously perilous state. Indeed, the further deterioration of these wall paintings would be an incalculable cultural loss for all humanity. Thanks to the UNESCO/Japan Trust Fund, the proposal to save this precious cultural heritage was approved in December 2000. In the following year, we conducted a feasibility study for conservation in the tomb in order to make some trial cleaning and consolidation tests, as well as to plan the program for the entire project. Trial cleaning and consolidation tests were conducted by Dr. Giorgio Capriotti, the chief conservator of the project. It should be mentioned that he has great expertise, having been a member of the conservation team of the wall paintings in the tomb of Nefertari. Having realized the possibility of conserving all the wall paintings in the tomb of Amenophis III, we started our preliminary campaign in March and April of 2002. In that preliminary campaign, we made actual conservation interventions, including a condition survey to diagnose the current condition of the wall paintings, partial trial cleanings, and emergency consolidations. We also carried out X-ray florescence analysis, microscopic observations, and a photographic campaign of the wall paintings.

The first long-term campaign was started in January 2003. Initially we conducted the preparation for conservation work. During the last mission, from March to April of 2002, it was suggested that cleaning the entire tomb and setting up anti-dust sheets were mandatory to protect the wall painting against dust and to produce a better environment for the conservation works. Cleanings were carried out across the tomb floors and anti-dust sheets were put in the areas where our conservators were working. We also had a wooden staircase installed to make going up and down easier (Fig.2). Excavation was conducted in room E (shaft chamber) which is 7.6 m deep from the floor. We found piles of blocks on its floor. After having cleaned the floor, we set up scaffoldings that were approximately 7.6 m high. Finally, the wooden floor was installed so that we could work in this room without difficulty (Fig.4).

A ventilation system was installed for the conservation work in the tomb at the beginning of our campaign. The distance from room J to the entrance of the tomb is approximately 85 m, and room J is located about 20 m lower than the floor level at the entrance of the tomb. The conservation projects require dangerous solvents, including acetone, ammonia, thinner, and ethanol. In order to provide better air conditions for the conservators, we installed two long duct pipes 20 cm in diameter to extract those gasses from the inside of the tomb. The motors on the outside are 3 horse power and are powered by a generator (Fig.3). We also installed 10 wind fans inside the tomb to send in fresh air from outside. During the presence of our environmental advisors, Ms. Harue Igarashi and Mr. Tsugunori Muramatsu, the ventilation system was revised. They suggested that it would be preferable to install another duct to send the fresh air from the outside in order to decrease the density of the solvent gases inside the tomb. They measured gas in the air inside the tomb and warned that we should be careful when mixing different solvents, which causes a high proportion of harmful gases. They also installed a thermometer data-logger inside and outside the tomb, as well as an oxygen measure to prevent a shortage oxygen inside the tomb. It was proposed that more wind fans should be installed to circulate the fresh air inside the tomb. They also suggested another ventilation pipe would be needed to send the fresh air from the outside, but it required more electric power. There are now about ten conservators working in room J, and when all are using a *cleaning solution* which contains ammonia, acetone, and ethanol, for cleaning the wall, the density of the solvent gases will be high. This is not a desirable environment. It is hoped that a better solution will be considered for conservators for the next campaign.

A photographic campaign was conducted by Mr. Tsuyoshi Sasaoka in order to record the condition of the walls before conservation. We also photographed several different diagnostic damages on the wall paintings. The photographer was instructed to take picture of each wall to ultimately make one even picture. The photos were taken horizontally to prevent the photograph from having an uneven perspective on top and down, right and left. The rooms he photographed were rooms E, I, J, and Je. While taking the photos, a Kodak Color Separation Guide was used in order to reproduce the correct colors in printing, and a meter staff was used as a scale.

The conservation work was started under the direction of Dr. Capriotti. Dr. Capriotti and Ms. Caterina Tocci had worked in the main decorated part of the wall of room I. Room I is decorated with exquisite wall paintings on its three walls, east, west, and north. The best preserved walls are the north wall and west wall; the east wall is mostly collapsed. These walls are stained by guano and bacteria, and some portion of the plaster was already collapsed, with the remaining part suffering from detachment. So far, the conservation of room I is almost finished except for the small sample areas showing its state before conservation (Figs.5-10).

Both Japanese and Egyptian conservators have been working in room J, where six pillars are located. The walls of this room are decorated with the *Book of Amduat*, and they need to be cleaned and consolidated. The six pillars are painted with the images of the king and deities. They face the problem of the detachment and fragmentation of the painted plaster caused by small cracks.

Two Japanese assistant conservators, Mr. Kunihiro Seto and Ms. Akiko Nishisaka, started working on the faces of pillar 1 and 3 of room J. Subsequently, they moved to work on the south wall of the same room and were joined by Dr. Eriko Nakau beginning in April. Initially four Egyptian conservators, Mr. Ahmed Ali, Mr. Abdel Nasr, Mr. Mohammad Salama, and Mr. Mohammad Mahmoud, were divided into two teams; one for pillar 2 and the other for pillar 4. Later, Mr. Mohammad Mahmoud was assigned to work on the frieze decoration of the wall in room I. Then two conservators, Mr. Mohammad Assas and Mr. Ahmad Shwaib, joined the team and started working on the north wall of room J. Two trainees, Mr. Sayed Ataya and Mr. Mustafa Osman, also joined us, and they have been working on the rock surfaces of the pillar. The conservation of the faces of the pillars has been completed about 80% (Figs.11, 12). The conservation of the north and south walls in room J was undertaken until the end of the campaign (Figs.13-16). Towards the end of the campaign, Dr. Capriotti made two trial cleaning interventions on the walls of room E, where conservation will be undertaken in the coming campaign (Figs.17, 18). The detail of the intervention will be explained by our chief conservator, Dr. Capriotti, in his independent report. The matter of training should also be discussed during this meeting.

The results of conservation work on the wall paintings include a clearer appearance as well as increased stability. The conservation work has contributed not only to the preservation of the monument, but also to Egyptology. For example, we are now able to see the details of the decorated pattern of the dresses of the king and gods and intricate hieroglyphic texts. The result gives a better understanding of the wisdom and technique of the people of Ancient Egypt.

Biological attack is one of the main causes of the deterioration of the wall paintings of the tomb of Amenophis III. In order to understand the biological activities in the tomb and to prevent more deterioration in the future, Dr. Hideo Arai, our biologist, carried out a biological investigation of the tomb. In the course of his work, Dr. Arai found a beetle, silverfish, microorganisms or bacteria and guano. Airborne microorganisms at the center of room J were measured before and after conservation work. Three kinds of agar strips were applied to measure general bacteria and fungi and xerophilic fungi.

X-ray diffraction and florescence analyses were carried out by Prof. Dr. M. Uda and Mr. M. Tamada at various points in the tomb in order to determine the materials, which were used as pigments and support for the wall paintings. Microscopic observations of pigments were also conducted in the course of analysis. From these analyses, the principal colors used throughout the tomb were suggested. Red ocher is composed of hematite (Iron oxide mixed with varying quantities of clay and chalk). Thin red or pink is composed of realgar. Yellow ocher is composed of gethite and shiny yellow is orpiment (arsenic trisulphide). Blue is Egyptian blue (a synthetic pigment obtained from the fusion of silica, calcium carbonate, sodium carbonate, and copper) and green is from the same material as blue but with a different oxidation. White is made of huntite and black is made of carbon and manganese. It is notable that the applications of rare pigments such as realgar and orpiment for particular motifs of the paintings such as the sun-disks or skin of the goddess were suggested by the analysis. However, it was realized that the conservators should be careful when treating such pigments during the intervention because these pigments contain arsenic, which is toxic for humans.

In order to understand the material of pigments in detail, it would be preferable to conduct microscopic analysis of pigments and binding media in a laboratory of the SCA, since sampling is currently prohibited.

The deterioration of the tomb and its wall paintings has also resulted from the geological environment of the tomb. The investigation of the stability of the tomb from a rock engineering point of view was conducted by Prof. Dr. Masanori Hamada, Prof. Dr. Ömer Aydan, and Prof. Dr. Hisataka Tano. It was suggested that the wall between room J and room Jd is of great concern and has a great impact on the overall stability of room J and its adjacent rooms Ja, Jc, Jd, and Je. Therefore, the repair and reinforcement of the wall between rooms J and Jd must be carried out first. Then repair works can be initiated on pillars in rooms J and Je. Actual intervention is expected to be conducted in the future campaign.

The result of the work in the first campaign was appreciated by Egyptian authorities and foreign missions working in the same area. It is hoped that more progress will be made in the next campaign. We are very grateful to UNESCO's headquarters in Paris for their understanding and unfailing encouragement which facilitated the project and its success.

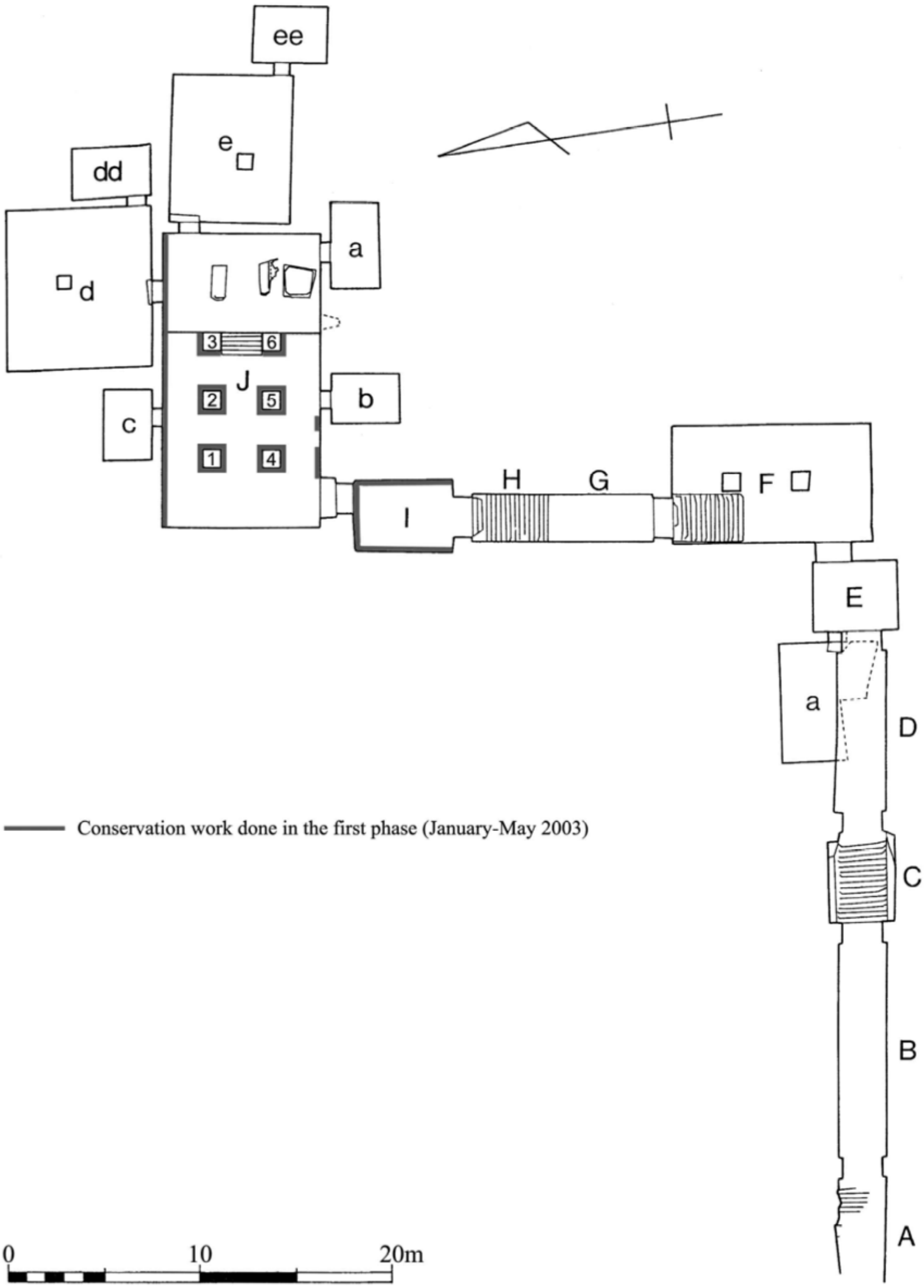

Fig.1 The plan of the royal tomb of Amenophis III (KV 22)

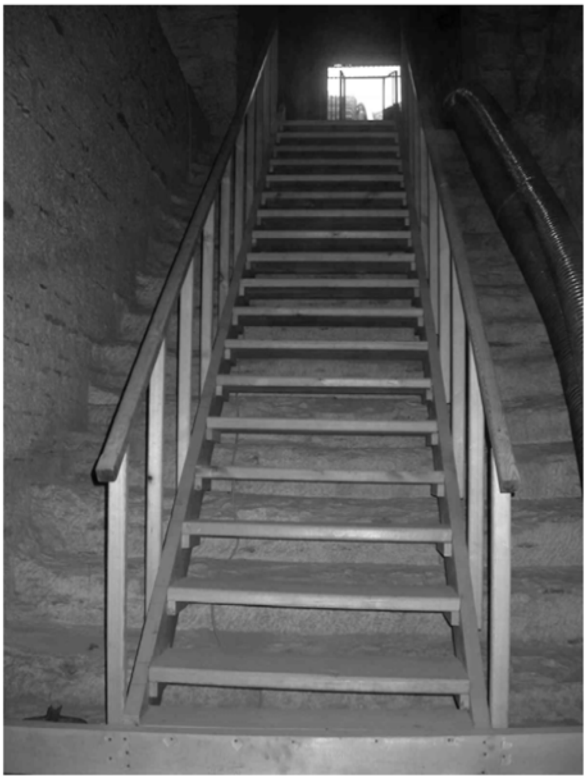

Fig.2 Newly installed wooden staircase

Fig.3 Ventilation motors outside the tomb

Fig.4 Room E (shaft chamber) after preparing the floor for conservation work

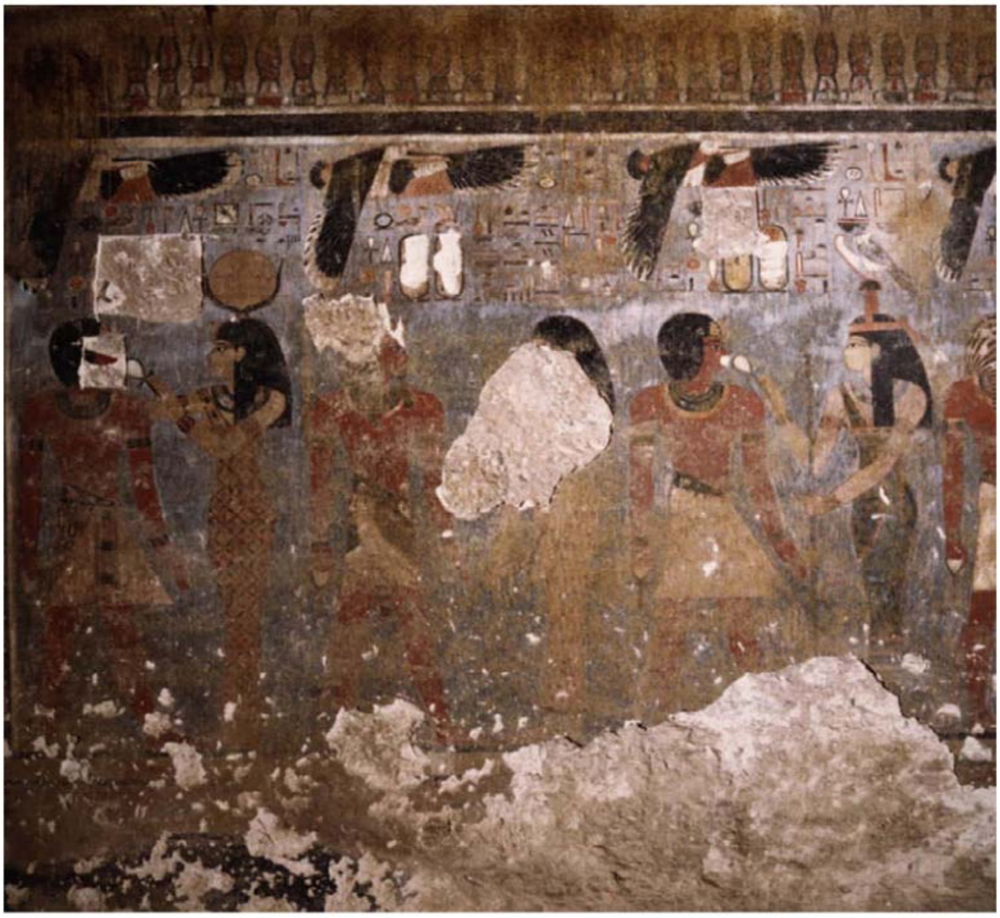

Fig.5 Room I west wall southern part before conservation

Fig.6 Room I west wall southern part after conservation

Fig.7 Room I west wall northern part before conservation

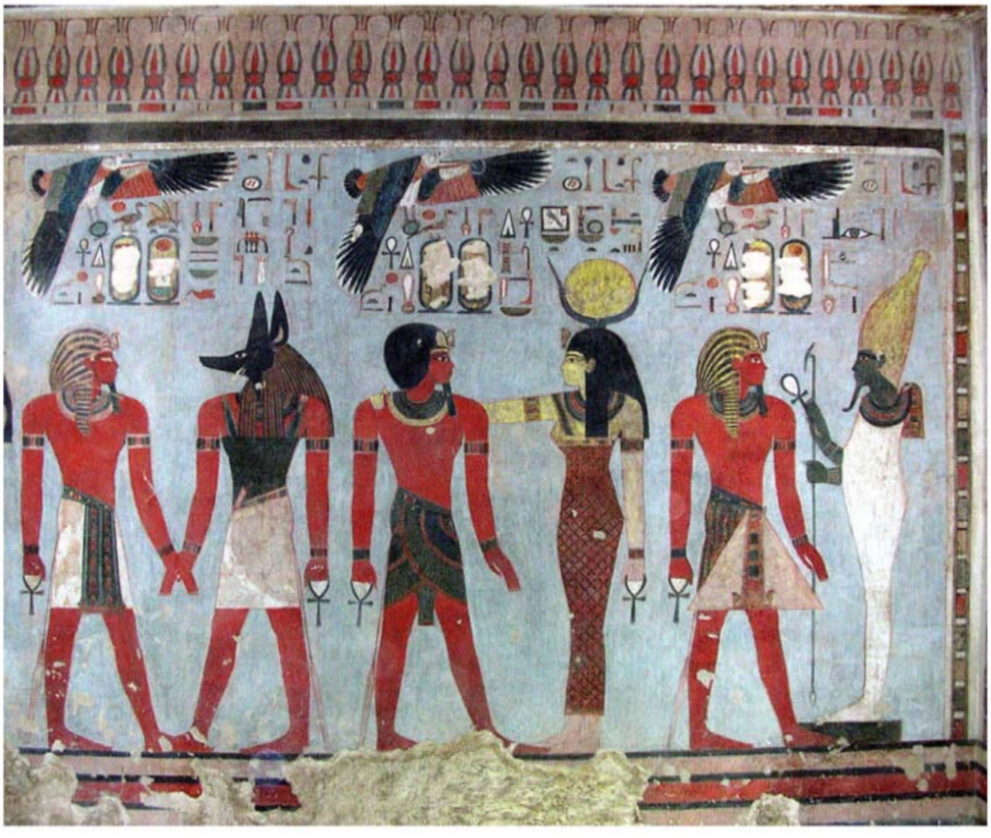

Fig.8 Room I west wall northern part after conservation

Fig.9 Room I north wall western part before conservation

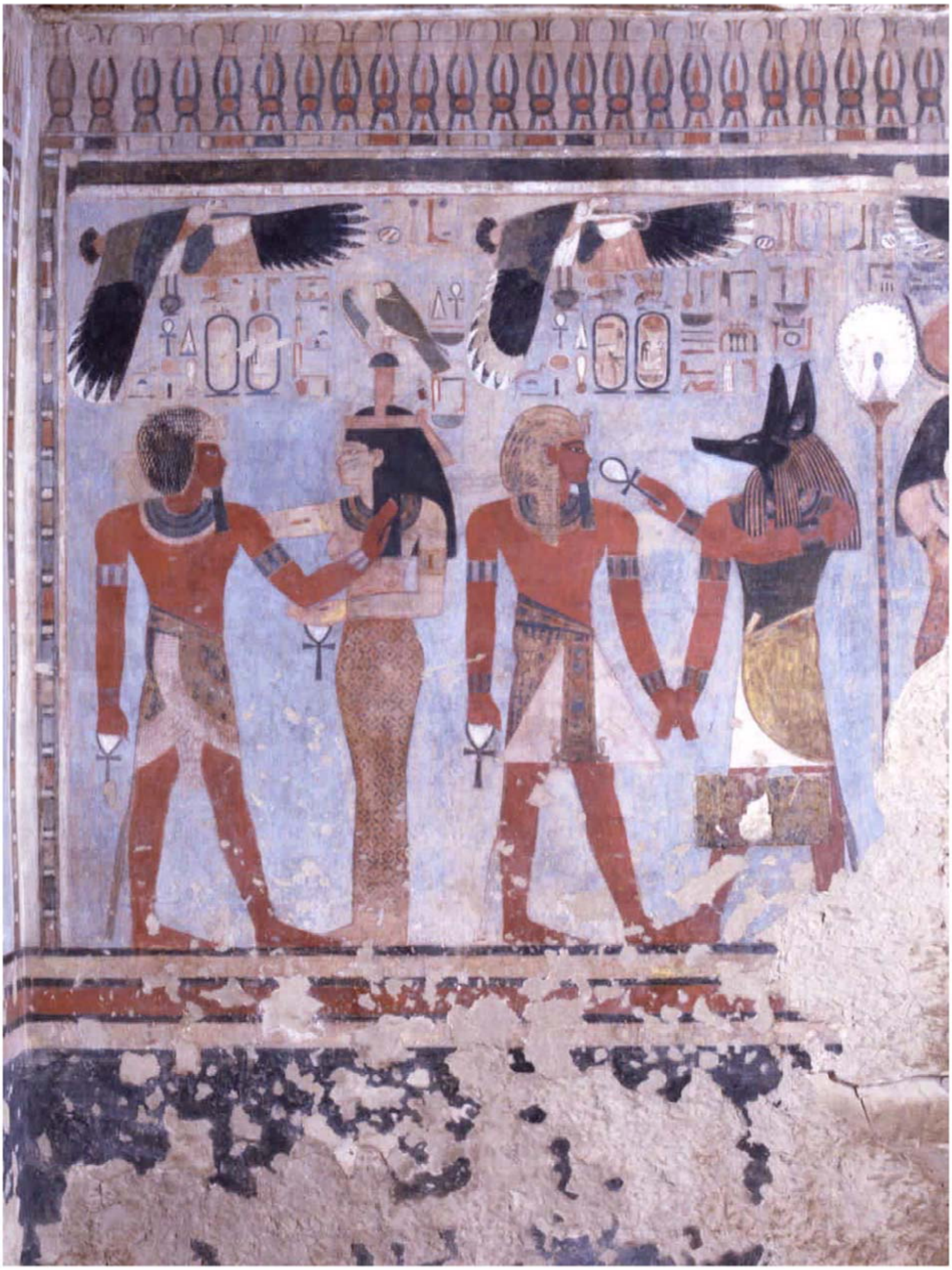

Fig.10 Room I north wall western part after conservation

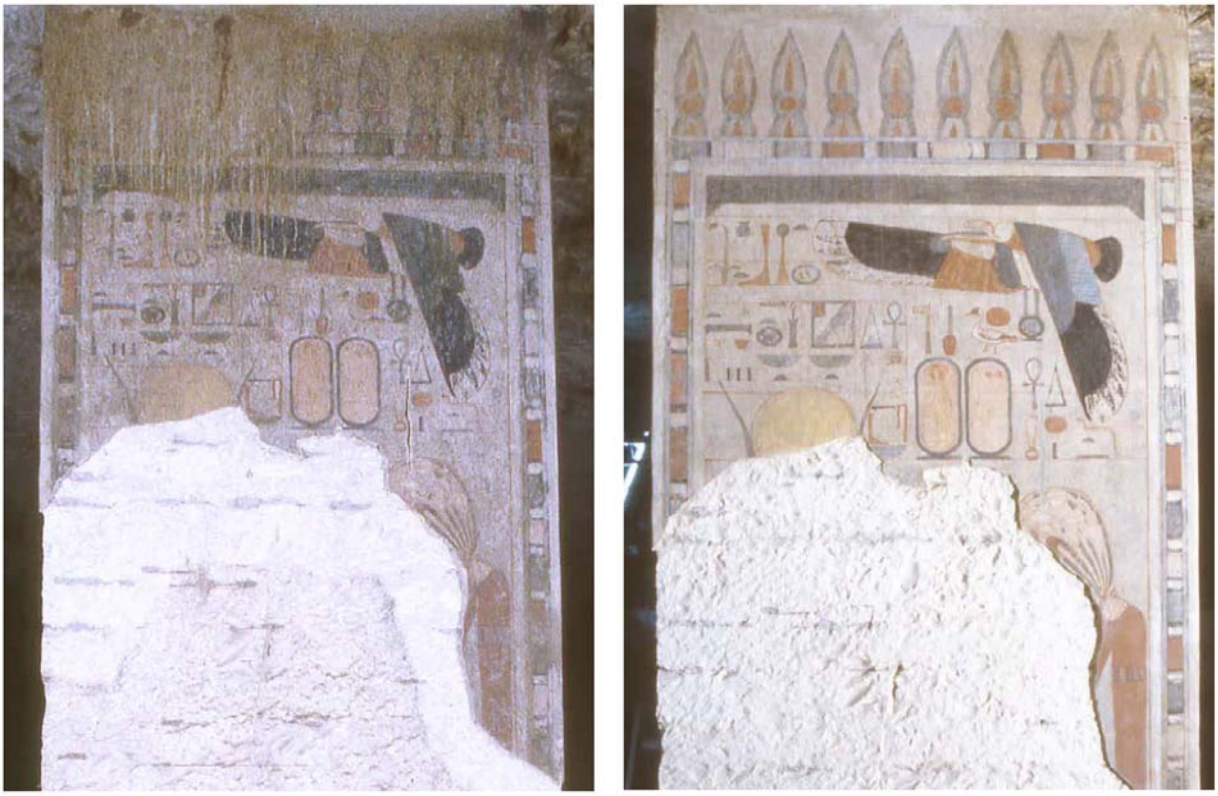

Fig.11 Room J pillar 3 west face before and after conservation

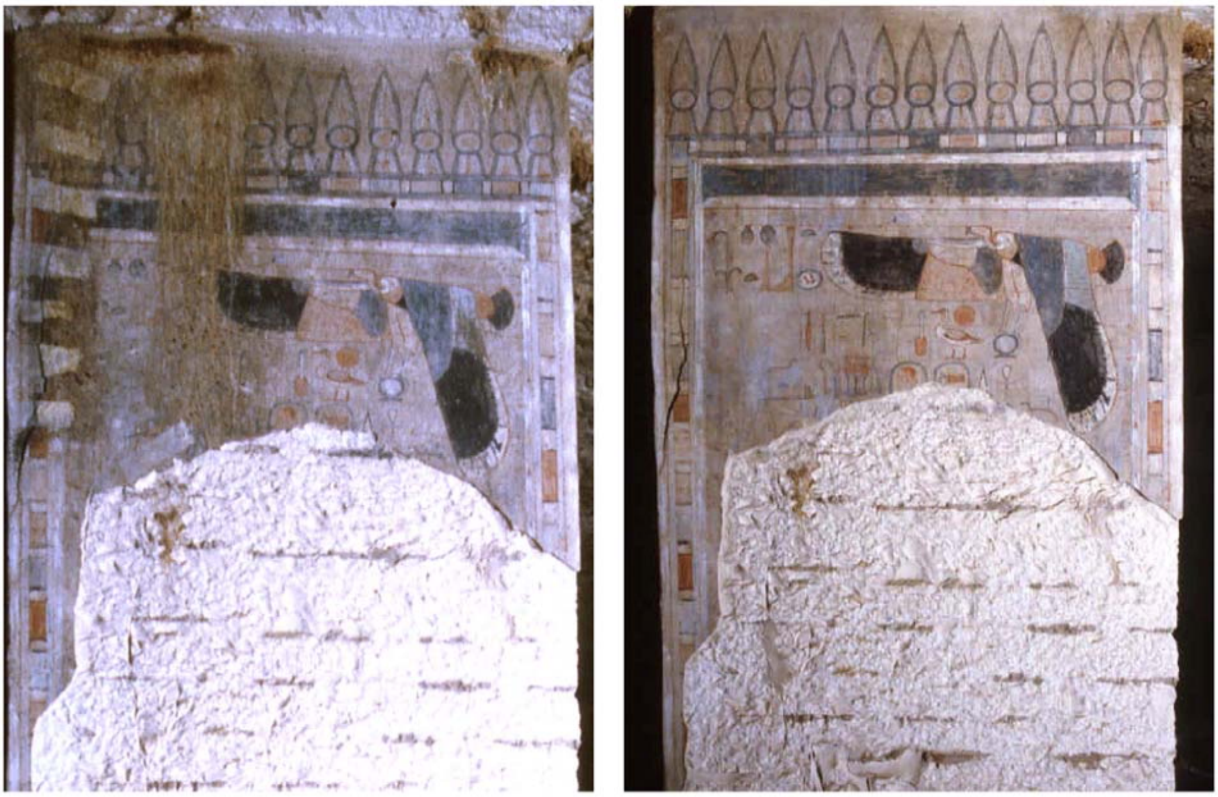

Fig.12 Room J pillar 3 north face before and after conservation

Fig.13 Room J south wall before conservation

Fig.14 Room J south wall after conservation

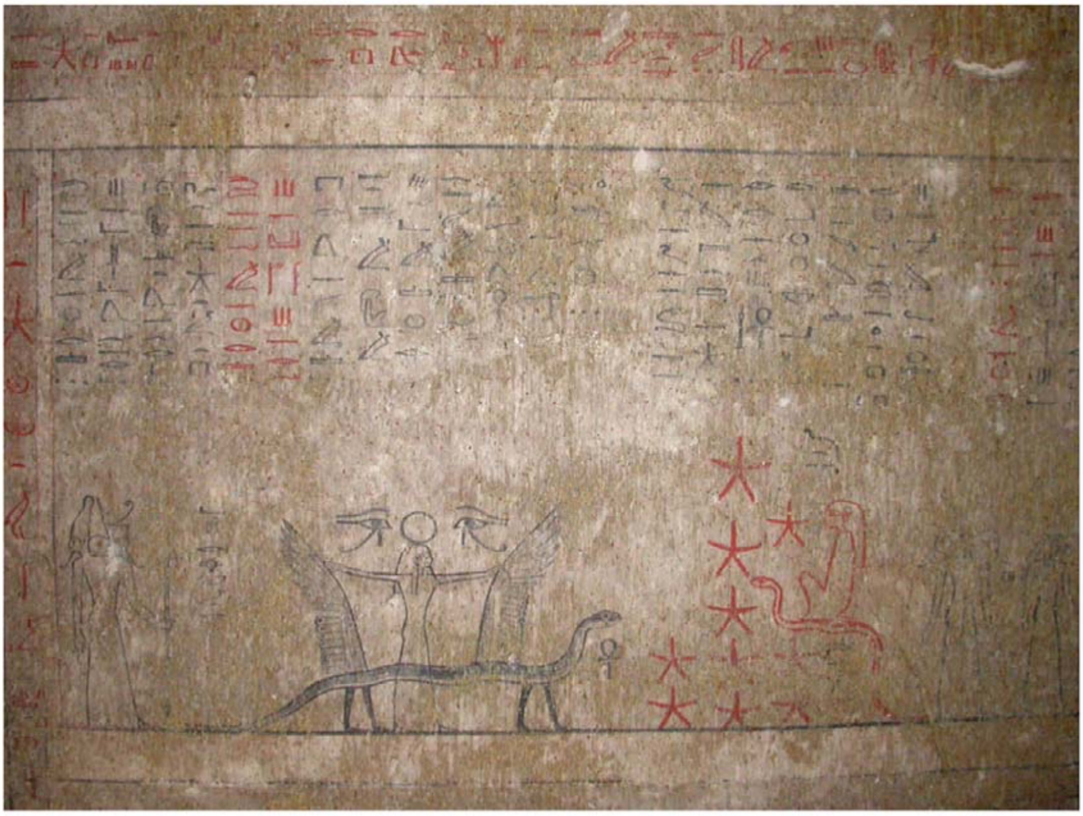

Fig.15 Room J north wall before conservation

Fig.16 Room J north wall after conservation

Fig.17 Trial cleaning of a face of the king in room E before conservation

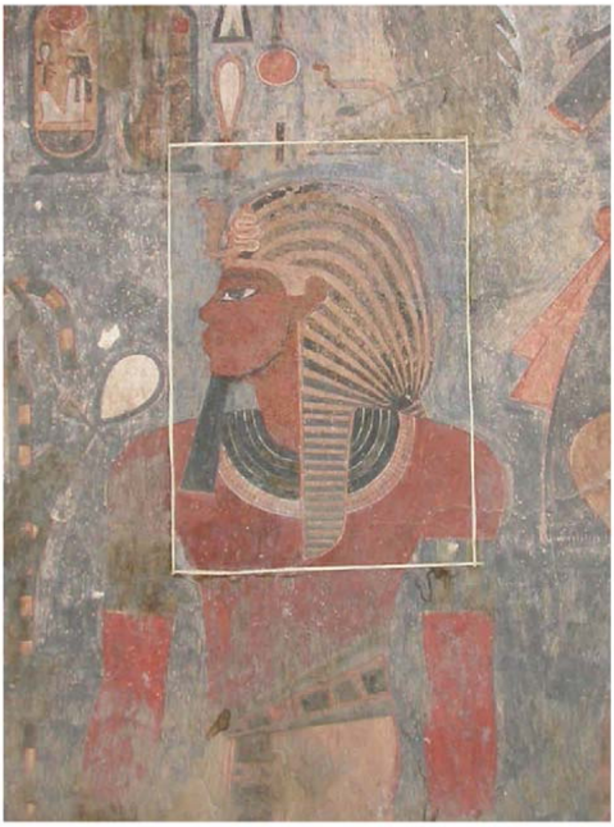

Fig.18 Trial cleaning of a face of the king in room E after conservation

2. Biological Investigation

A Report on the Biological Investigation

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Introduction

The project for the conservation of the wall paintings in the royal tomb of Amenophis III, situated at the Valley of the Kings in Luxor, Egypt, was started by the Waseda University of Japan directed by Prof. Dr. Sakuji Yoshimura in January, 2003 under the auspices of the UNESCO/Japan Trust Fund. As the author is in charge of biological problems of the tomb from the viewpoint of conservation science for cultural heritage, he carried out a biological investigation of the tomb from February 17 to 24, 2003.

1. Samples Collected

1) A beetle belonging to the order Coleoptela was found at room J of the tomb. Although the beetle is identified to belong to family Dermestidae (common name: skin beetle), identification of the species is still being continued.
2) A silverfish belonging to family Lepismatides was found at pillar 2 in room J. The silverfish was identified as belonging to the genus *Ctenolepisma* sp., suborder Zigentoma, family Lepismatidae.
3) Many black spots are visible on the limestone walls and on the wall paintings in the tomb. Samples of black spots on plaster were collected at the north wall of room I in the tomb. The author incubated the samples by two methods, the osmophilic nutrient agar and Aw petri dish methods.
   (i) Colorless and transparent bacterial colonies were grown in two plates of the osmophilic nutrient agar and blackish and velvety fungus was grown in the same plate. Isolation and identification of these microorganisms are being carried out.
   (ii) Black spots on limestone were incubated in an Aw petri dish regulated at Aw 0.94 at 25°C. Absolute tonophilic fungi are only growing on the black spots. Isolation and identification of these fungi are being carried out.
4) Black spots on wall paintings were collected from the west side of pillar 1 in room J. Incubation of the samples were performed.
   (i) Colorless and transparent bacterial colonies and whitish bacterial colonies were grown on osmophilic nutrient agar. Although isolation and identification are being carried out, the author has not yet concluded whether these bacteria are related to the cause of black spots or not.
   (ii) When black spots on limestone were incubated in an Aw petri dish regulated at Aw 0.94 at 25 °C, absolute tonophilic fungi are only growing on the black spots. Isolation and identification of these fungi are being carried out.

5) Fine whitish spots were found at pillar 1 in room J of the tomb. Although they were inoculated on osmophilic nutrient agar and incubated at 25°C, no growth of bacteria could be found.
6) Blackish colonies of fungi are growing on the wood which is used for the support of pillar 3 in room J. These fungi were identified to belong to *Cladosporium* sp.

2. Microbial Environment in the Tomb

Airborne microorganisms at the center of room J were measured before and after conservation work on February 19 to 20, 2003. The apparatus for measurement used was "Biotest HYCON, Standard RCS Air Sampler" (Germany). Three kinds of agar strips were applied to measure general bacteria, general fungi and xerophilic fungi. Measuring point in the tomb was fixed at room J and in the open air. Results of measurements are shown in Table 1.

Table 1 Airborne microorganisms before and after conservation work at room J

Date	**Microorganisms**	**Sampling points** Room J	Open air
February 20, 2003 (in the morning, before conservation work)	General non-filamentous microorganisms	300-375	150-163
	General filamentous microorganisms	75-138	475-488
	Xerophilic filamentous microorganisms	75-125	75-100
	Rate of *Cladosporium* (%)	35	51-66
February 19, 2003 (in the afternoon, after conservation work)	General non-filamentous microorganisms	950-1200	275-300
	General filamentous microorganisms	25-75	435-538
	Xerophilic filamentous microorganisms	75-175	363-400
	Rate of *Cladosporium* (%)	90	40-69

(1) Result at room J

The number of general non-filamentous microorganisms (mainly bacteria) per cubic meter found in the tomb increased 3-4 times after conservation work. However, the number of fungi did not show remarkable change before and after conservation work.

Although the number of bacteria increased remarkably in the tomb after conservation work, it decreased by one-third (1/3) the next morning. The number of fungi did not increase after conservation work. However, the rate of *Cladosporium* sp. after conservation work was 90%. It is well known that blackening effect on walls is caused frequently by *Cladosporium* sp. Therefore, care should be taken to keep the relative humidity in the tomb below 75%.

(2) Result in open air

The number of bacteria in open air was 150-163/m³ before conservation work (in the morning), and increased to 275-300/m³ after conservation work (in the afternoon). The number of fungi was 435-538/m³ and no remarkable change could be found before and after conservation work. However, the number of xerophilic fungi increased 3-4 times after conservation work (in the afternoon).

3. An Interim Report on the Analyses of the Contaminants on the Wall Paintings [1)]

(1) Purpose

Paintings and walls in the tomb are very contaminated by bat droppings. The author has collected the droppings from the east side wall in room I in order to identify the components of the droppings. It is important information for the conservation of wall paintings.

(2) Methods of the analyses

Three stages of analyses were applied. The following is the description of each stage.

(i) First Stage: Elementary analysis (conducted in May 19, 2003)
At first, the ratio of the chemical element which consist the attached contaminants was examined. Then, the origin of the contaminants was analyzed by using fluorescent X-ray analyzer. Fluorescent X-ray analyzer gives a spectrum consisting of a series of peaks; energy at which peaks occur indicate the elements present and the area of peaks relates to their apparent abundance in the sample.

(ii) Second Stage: Analysis of the physical features (conducted in June 24, 2003)
Observation under the microscope and the measurement of the physical features (specific gravity, hardness, etc.) were carried out.

(iii) Third Stage: Analysis of the chemical features (to be conducted in late July, 2003)
Measurements of the chemical features (pH, ash, organic materials, water etc.) of the material were conducted. The amount of the harmful components for the wall paintings (ammonia, sodium chloride, etc.) will be analyzed.

(3) The result of the first stage

As the result of the first stage examination by fluorescent X-ray analyzer conducted in May 19, several chemical elements were attested from two samples (Table 2). Ca, K, P, and S were detected from two samples, but the ratio of the composition of these samples is different (one from the ceiling and another from the wall).

Table 2 The result of elementary analysis

Elements	Sample 1: Room I (ceiling)	Sample 2: Room I (wall)
Ca (calcium)	48%	15%
K (potassium)	18%	27%
P (phosphorus)	15%	20%
S (sulfur)	12%	22%

(4) The result of the second stage
In the second stage examination held in June 24, samples were observed by phase-contrast microscope after being crushed and dissolved in glycerin alcohol. The samples were easily crushed and dissolved. It was realized that they showed weak viscosity. A number of micro-fragments originated from insects were detected under the microscope. They were defined as the fragments of chitinous substances from insects (Figs.1-3).

(5) Current remarks
No substances other than insect fragments were detected by the second stage examination. This result proves that the samples are mainly composed of bat droppings.

It is known that bat droppings become a substance called *guano* after having accumulated with minerals and soil for long time in a place like a cave. The chemical components of guano sampled in several caves in Japan are shown in Table 3. Guano does not contain macromolecular organic materials, such as protein, which existed at the time of excretion. Macro-molecular organic materials have been resolved when bat droppings become *guano*. This means that guano is a substance which can be easily cleaned. When a large amount of macromolecular organic substances still remain in *guano*, the cleaning method has to be designed carefully.

It would be necessary to analyze chemical components of the samples in order to know the stage of the droppings and whether it is guano or not. When the data in Table 2 was compared with the data in Table 3, the contents of the chemical elements seem to be largely different. But this is affected by substance extracted from the rock around them. For example, since sample 1 is similar to stalagmites in cave, this probably resulted from the mixture of bat droppings with the calcium which exudes from bedrock.

1) The analyses were conducted by Mr. Yoshimori Murai and Mr. Yusuke Mandai (Ikari Corporation)

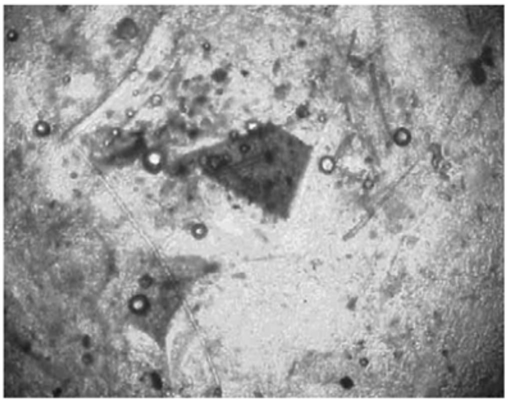

Fig.1 Chitinous fragments from insects

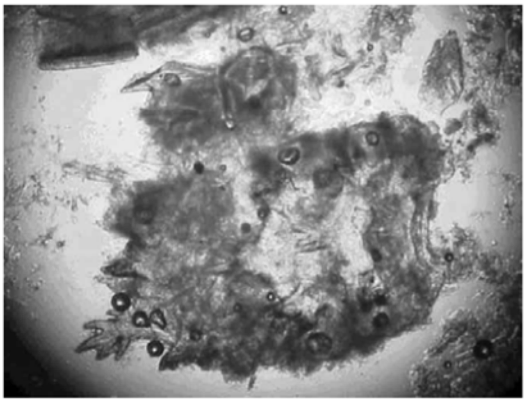

Fig.2 Mouth-parts of beetles (Coleoptela)

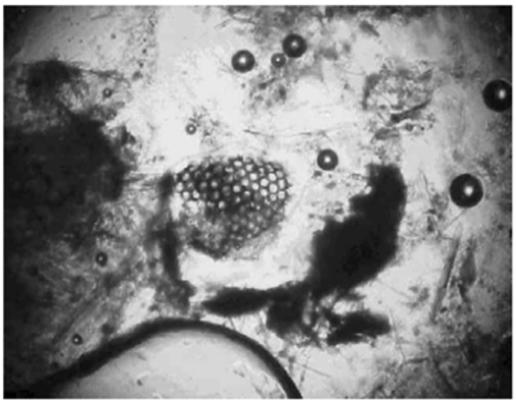

Fig.3 Compound eye-parts of insects

Table 3 Chemical components of bat guano

Components \ Bat guano	A (%)	B (%)	C (%)	D (%)
Water	38.68	32.712	23.565	38.78
Organic material	49.103	37.198	35.855	40.514
Ash content	12.217	30.09	40.58	20.7
Total nitrogen	4.625	3.481	3.959	4.618
Ammonia nitrogen	3.281	1.012	1.882	2.454
Nitrate nitrogen	-	-	-	1.076
Organic nitrogen	1.025	1.856	-	-
Total phosphoric acid	6.375	4.137	3.05	7.662
Water soluble phosphoric acid	3.748	-	-	-
Potassium	1.026	-	-	-
Lime	0.315	-	0.315	0.55

3. Microenvironmental Evaluation

A Research Report on the Working Conditions for the Conservation of the Wall Paintings in the Royal Tomb of Amenophis III

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2) Environment Specialist for Conservation, President, Fumitech Co., Ltd., Tokyo

Introduction

This is the report on the influence of the organic chemical solvents to the working conditions, used for the cleaning of the wall paintings in room I and room J of the royal tomb of Amenophis III.

In each room, the various kinds of organic chemical solvents are used for the cleaning and the conservation of the original beauty of these wall paintings. As it is supposed that these chemicals influence the conservators and/or the working conditions, we surveyed the density of organic chemicals to make the influences clear (Table 1) (Figs.1-3). Room I and room J are located 70 m from the entrance and 20 m underground.

Table 1 Measurement of the chemical density

Kinds \ Density	Density of Acceptable Limit (ppm)	Density during Working Hours (ppm)
Ammonia	25	500
Ethanol	1000	600
Acetone	200	300

1. Condition of these Rooms during the Cleaning

In these rooms (room I and room J), there is no natural ventilation, so two fans (2.2kw, 3HP) and a flexible duct (Figs.4-6) were used to remove the chemicals from these rooms. At the same time, one fan was placed to face the entrance at the observation point F, and four fans were used to stir the air in room I and room J.

2. The Betterment of Condition

We bettered the working conditions by reusing materials and machines. In order to decrease the density of chemicals during the working hours (Table 1), and to increase the very low velocity of the wind at the point of F, I, and J, we changed the direction of fans (Table 2). The direction of three wind fans

Table 2 Wind velocity and room temperature after betterment

Point	Wind Velocity (m/s)	Room Temperature (ºC)
A	0.37	18.8
C	0.36	22.6
E	0.19	25.2
F	0.16	27.7
I	0.16	28.2
J	0.12	28.8

Table 3 Wind velocity and room temperature before betterment

Point	Wind Velocity (m/s)	Room Temperature (ºC)
A	0.47	18.6
C	0.37	20.6
E	0.23	22.6
F	0.42	25.8
I	0.32	27.4
J	0.31	28.0

in room I and room J were changed to point towards conservators' faces and the walls being cleaned. The purpose of this change was to prevent conservators from being directly beaten by the organic chemical solvents (Fig.7). The direction of fans placed in room F and room I were changed from facing the entrance to face into room J, to make the velocity of winds decrease (Table 3).

After these adjustments, conservators reported that they felt cooler and less stuffy than before, though the oxygen density measuring instrument showed the same density 20.6% (Table 4) (Fig.8).

Table 4 Oxygen density after betterment

Location	Temperature(ºC)	Humidity (%)	Oxygen density in working places
Entrance of the Tomb	18.2	27	※20.6%
Room I – Room J	28.8	14	
			※Before the working hour: 21%

Table 5 Measuring instruments used

1. Portable Gas Meter GOA-40D-4 (Fig.8)	GASTEC CORPORATION
2. Data Logger SK-L200TH (Fig.9)	SATO KEIRYOKI MFG Co., LTD.
3. Anemometer NM-6004 (Fig.10)	KANOMAX JAPAN Inc.
4. Air Sampler Kit GV-100S (Fig.11)	GASTEC CORPORATION
5. Gas Tubes for measurement (Fig.11)	GASTEC CORPORATION

3. Conclusion

Though conservators consisted of six members, the number will increase to ten for the full-scale cleaning works. This means the increase of vaporized materials and expansion of air pollution, and will result an oxygen shortage (18%). Therefore, more fresh air will be needed.

As work starts at 7:00 in the morning and ends at 01:00 in the afternoon, in order to take the temperature balance between outside and inside the royal tomb (Fig.9), we propose to place the fresh-air take out mouth at D Point. More fans (3-4 machines) should be placed to send air for conservators.

Before opening the tomb to the public, a new air conditioning system is needed, but the present conditions are sufficient for continued conservation work.

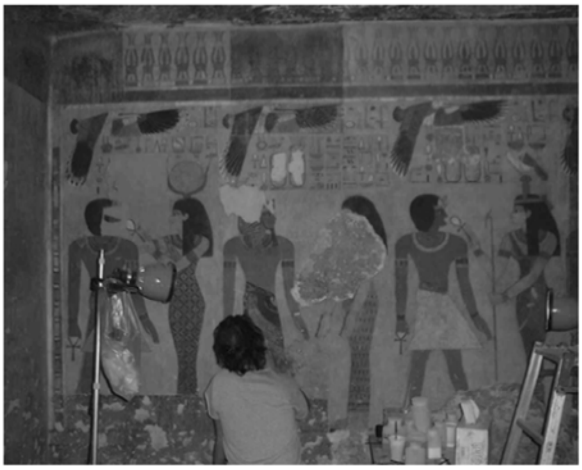

Fig.1 Conservator working in room I

Fig.2 Conservator working in room J

Fig.3 Conservators working in room J

Fig.4 Ventilation Motors outside the tomb

Fig.5 Flexible duct in room J

Fig.6 Flexible duct in room J

Fig.7 Wind fan settled to the conservator

Fig.8 Portable gas meter

Fig.9 Thermometer data logger at the entrance

Fig.10 Checking the velocity by anemometer

Fig.11 Measuring the chemical density by gas tubes

4. Analyses of the Pigments and Plaster

In situ Characterization of Pigments and Plaster in the Royal Tomb of Amenophis III using X-ray Diffractometer, Fluorescence, Spectrometer and Optical Microscope

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UNESCO Counterpart of the Project

1. Analytical Techniques and Equipments

The tomb walls of Amenophis III were investigated using three kinds of portable instruments. The first one is an optical microscope, Picture Folder for VH-5000 made by Keyence, which is characterized by computer-aided operation. Then magnification and color change for the microscope can be done under touch free conditions. The second one is an X-ray Fluorescence (XRF) Spectrometer, OURSTEX

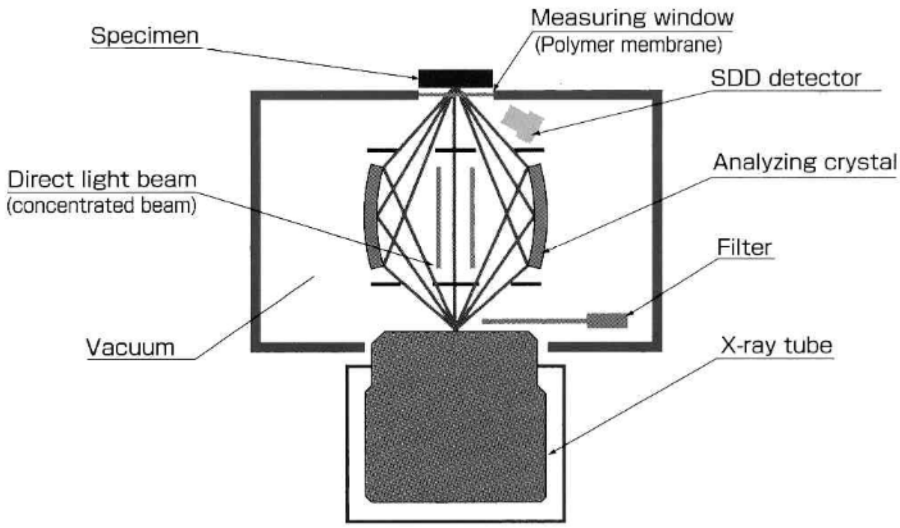

Fig.1 A schematic view of X-ray fluorescence spectrometer used in the tomb of Amenophis III

100 F commercially available from OURSTEX Corporation, shown in Fig.1, which is smallest in size, lightest in weight, and highest in performance in the world. The third one is an ED-XRDF (Energy Dispersive X-ray Diffraction and Fluorescence) spectrometer, which was specially designed and prepared by Waseda University and RIKEN KEIKI for this investigation. The same areas investigated by the OURSTEX 100 F and the ED-XRDF were also studied using the optical microscope, Picture Folder for VH-5000 (5 to 40 times in magnification) which has long focal length, i.e. 500 mm.

In the ED-XRDF a Cu or W tube was installed as an X-ray emitting source, and a Si-PIN photodiode was used for detecting diffracted and fluorescence X-rays. Here the energy dispersive diffraction was performed using white X-rays emitted from the Cu tube, where diffraction conditions can be written as Eq.1. This means that the measuring principle of the ED-XRDF is completely

$$2d\sin\theta = n\lambda = nhc/E \qquad (1)$$

different from that of a diffractometer commercially available, which is operated under an angle dispersive condition. The Cu tube and the X-ray detector installed at the fixed angles of 10° and, if necessary, 12.5°, 15°, 17.5°, and 20° were used for detecting both diffracted and fluorescence X-rays, but the W tube installed at the angle of 60° was employed to record pure X-ray fluorescence spectra which are free from diffracted X-rays and elastically scattered Cu K X-rays. In this report only the diffraction data taken at the angle of 10° are given to avoid reader's overwork.

The ED-XRDF is characterized with 1) short measuring time, typically 100 sec. even for X-ray diffraction, 2) non-contact and non-destructive measurements, 3) no restriction on sample size and shape, 4) small size (300×250×60 mm), 5) light weight (2kg), 6) no coolant for the X-ray tube, i.e. an air cooling system, and 7) operation assisted with a personal computer. This means that the ED-XRDF is a very strong weapon for field investigations such as *in situ* X-ray investigation for wall paintings.

The ED-XRDF and the OURSTEX 100F were used in open air in the tomb of Amenophis III, indicating that only the X-rays with energies of 2 keV or more, i.e. higher atomic number elements than P, can be detected. This is because X-rays with energies of 2 keV or less were absorbed by air during passage between samples and the detector, i.e. the Si-PIN photodiode. Parallel and coherent X-ray beams were prepared using two capillaries with a 0.2 or 0.15 mm diameter installed in front of a sample and the X-ray detector, respectively, which were made of stainless steel or glass. A schematic view of the ED-XRDF is shown in Fig.2.

2. Results

A preparatory investigation for analyzing pigments in the tomb of Amenophis III was carried out in 2002 using OURSTEX 100 F, i.e. X-ray fluorescence (XRF) spectrometer. We got information on atomic species used for painting. However, the XRF data give only elemental names and their concentrations, but do not offer enough information about the materials contained within the pigments. For identification of materials or determination of crystal structures of materials, X-ray diffraction experiments are indispensable. In laboratory experiments an angle dispersed diffraction apparatus has been used, which is commercially available. However, the apparatus needs much time, i.e. 1 hr. or

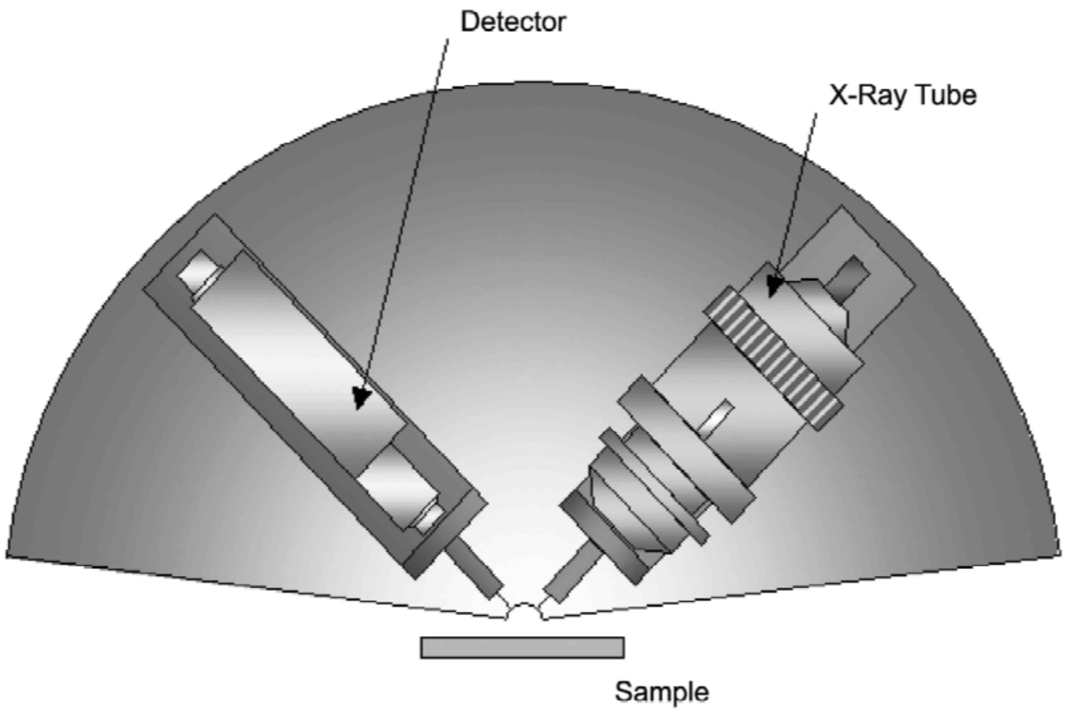

Fig.2 A schematic view of the laboratory-made energy dispersive X-ray diffraction and fluorescence (ED-XRDF) spectrometer used in the tomb of Amenophis III

more, to take one diffraction pattern. Then we used a diffractometer equipped with XRF, named ED-XRDF. It needs only 100 seconds to get both a diffraction pattern and an XRF spectrum from one area.

The painted walls of the Amenophis III investigated here are shown in Figs.3, 4, and 5. These photographs were taken from the room E south wall, the room I north wall and the room I west wall, respectively. The room J south wall and the room J north wall, not shown here, were also investigated. Analytical results are given here for every point (small areas) investigated.

(1) Plaster

The walls of the tomb of Amenophis III were coated with plaster for painting, which was composed of two layers, and in a few cases, of three layers. An outer surface layer appears to be whitish yellow, shown in Fig.6 as "point 36", and is composed of fine grains. An XRF spectrum taken from "point 36" is shown in Fig.7, from which S, Ar, Ca, and Fe K X-rays were found, together with L X-rays of W. Here Ar and W are originated from air existing between the X-ray tube and the X-ray detector, and from the W X-ray tube, respectively, because a series of XRF experiments using the ED-XRDF were performed in air using an X-ray emitter made of W.

Energy dispersive X-ray diffraction (XRD) patterns accompanied by X-ray fluorescence (XRF) spectra are shown in Figs.8-10, which were taken from reference materials (pure chemicals) i.e. anhydrite, $CaSO_4$, calcite, $CaCO_3$ and quartz, SiO_2. Fig.11 shows XRD and XRF spectra taken from "point 36". From the comparison of Fig.11 with Figs.8-10, it is concluded that plaster at the "point 36" is composed of anhydrite, $CaSO_4$ and quartz, SiO_2. The main component of the plaster was anhydrite but not gypsum, $CaSO_4 \cdot 2H_2O$. This suggests that the original form of $CaSO_4$ was not $CaSO_4 \cdot 1/2H_2O$ but $CaSO_4$ itself, because volume change from $CaSO_4 \cdot 2H_2O$ to $CaSO_4$ due to aging is too much to keep a wall's form without breakdown. From repeated experiments for analyzing plaster components around "point 36", it was found that mixing ratios of $CaSO_4$ to quartz, SiO_2 were different from place to place. This suggests that surface compositions are not homogeneous even if colors of plaster are similar.

The wall of the room Je appears incomplete, indicating that some parts of the wall were coated twice ("point 36") and coated only once ("point 37") as shown in Fig.6. An XRF spectrum, and XRD and XRF spectra shown in Figs.12 and 13, respectively, were taken from "point 37" which is exposed to surface, and appears to be yellowish white and to be composed of coarse grains. These indicate that an inner plaster is mainly of calcite, $CaCO_3$ together with small amounts of $CaSO_4$.

(2) Pigments

Kilt white, room E south wall, second figure from the right (male, Pharaoh), as shown in Fig.14.

"Point 3" is a part of a kilt painted by a white pigment originally. However, the white layer looks exfoliated partially and a substrate, i.e. plaster comes to the surface. XRF and XRDF spectra taken from "point 3" is shown in Figs.15 and 16, respectively, indicating that elemental components of "point 3" are K, Ca, and Fe, and chemical species found here are mainly $CaCO_3 \cdot 3MgCO_3$, i.e. huntite, mineral name, together with small amounts of $CaSO_4$ and SiO_2. Optical micrographs (×5, ×10, ×20, and ×40) are shown in Fig.20 from which an exfoliated part can clearly be seen and substrate plaster with whitish yellow in color is exposed to the surface.

Kilt yellowish or pinkish brown, room E south wall, second figure from the right (male, Pharaoh), as shown in Fig.14.

Ca, Fe, As, and S were found on an XRF spectrum shown in Fig.17 taken from "point 4". Only SiO_2 was detected as a crystalline phase on XRDF spectra shown in Fig.18. Optical micrographs shown in Fig.21 tell us that "point 4" was painted at least twice successively by yellowish brown and pinkish brown pigments. Judging from rather intense peak at Fe K- and week peak at As K-X-rays, and also from detection of SiO_2, an inner layer might be painted by ocher mixed with mud and a surface thin layer by realgar, AsS.

Male skin brown, room E south wall, second figure from the right (male, Pharaoh), as shown in Fig.14.

Intense Fe K- and moderate intense Ca- X-rays were found in an XRF spectrum taken from "point 5" as shown in Fig.19. Optical micrographs shown in Fig.22 are characterized by smooth and homogeneous painting with brown color. This tells us that the male's skin might be painted, as in many cases of ancient Egyptian painting, by ocher, though the skin's brown layer is not thick enough to give a good diffraction pattern.

Female arm pinkish yellow, room E south wall, third figure from the right, as shown in Fig.23.
Ca and Fe K X-rays were found together with moderate intense As K X-rays from "point 6" as shown in Fig.24. Pinkish yellow color might come from As bearing compounds such as orpiment, As_2S_3 (yellow) and/or realgar, AsS (light red). The use of As bearing compounds as pigments is to be discussed later. On optical micrographs shown in Fig.28, small spots were found which appears to be stain due to bat droppings.

Background light blue, room E south wall, between second and third figures, as shown in Fig.23.
Only Ca and Fe K X-rays were found from "point 7", as shown in Fig.25, on an XRF spectrum. $CaSO_4$ and SiO_2 were detected on an X-ray diffraction pattern shown in Fig.26. There are two possibilities; 1) a light blue layer which was too thin to give information on pigments and 2) a light blue color which originated from organic materials. Optical micrographs on Fig.29 show that a light blue part was very thin and was contaminated with bat droppings.

Dress pinkish red, room E south wall, third figure from the right, as shown in Fig.23.
From "point 8" rather intense As- and Fe K-X-rays were found as shown in Fig.27. The pinkish red layer was very thin and then gave diffraction patterns characteristic of $CaSO_4$ and SiO_2, i.e. components of plaster. No diffraction data were obtained, which are responsible for the pinkish red color. The optical micrographs of "point 8" are shown in Fig.30.

Pharaoh's beard dark blue, room E south wall, fourth figure from the right, as shown in Fig.31.
From "point 9" very intense Cu K X-rays were found, as shown in Fig.32, together with Ca and Fe K X-rays. Main colorant might be Egyptian blue, as will be discussed later. "Point 9" was much contaminated with bat droppings as can be seen on optical micrographs shown in Fig.33.

Kilt white (partially exfoliated), room E south wall, second figure from the right, as shown in Fig.34.
The chemical compositions of "point 11" must be the same as those of "point 3" shown in Figs.15, 16, and 20 except for poor degree in adhesion of pigments to plaster. As could be understood from Figs.35 and 36, a white layer was composed of $CaCO_3 \cdot 3MgCO_3$, huntite, but in the diffraction pattern shown in Fig.36, contributions from plaster or substrate were 50% or more. Another word, 50% of the white layer was removed from the surface.

Jackal head black, room E south wall, fifth figure from the right, as shown in Fig.37.
From "point 12" Ca and Fe K X-rays were detected as shown in Fig.38. Diffraction patterns shown in Fig.39 were assigned to $CaSO_4$ and quartz, SiO_2 or graphite, C. This is because quartz, SiO_2 and graphite, C give only one intense diffraction peak at d= 3.3 Å and could not be distinguished from each other using the ED-XRDF. Optical micrographs as shown in Fig.40 suggest repeated paintings of thin black layers. Then it is quite probable that the black pigment used here was soot or graphite.

Jackal kilt yellow, room I north wall, fourth figure from the left, as shown in Fig.41.
"Point 17" looks gold yellow in color and is rich in Ca, Fe, and As (see Fig.42). Orpiment, As_2S_3 was

found from a diffraction pattern taken from "point 17" as shown in Fig.43. Large yellow grains can be seen on optical micrographs shown in Fig.44. Such a feature is characteristic of painting with orpiment, As_2S_3.

Female hand yellow, room I north wall, second figure from the left, as shown in Fig.45.
The chemical compositions shown in Fig.46 and optical micrographs as shown in Fig.47 of "point 13" are much similar to those from "point 17". This indicates that most of the yellow parts in the tomb of Amenophis III were painted with a brilliant yellow pigment, orpiment, As_2S_3.

Sun disc light red or yellowish red, room I north wall, a upper part of the doorway, as shown in Fig.48.
"Point 42" gave an XRF spectrum shown in Fig.49, which is characterized with S, Ca, Fe, and As K X-rays. The chemical compositions of "point 42" are similar to those of "point 6" pinkish yellow shown in Figs.24 and 28, and of "point 8" pinkish red shown in Figs.27 and 30.

Fan white, room I north wall, a upper part of the doorway, as shown in Fig.48.
"Point 43" showed similar XRF and XRD spectra, as shown in Figs.50 and 51, to those of "point 3" kilt white. This means that a white pigment used for painting "point 43" is assigned to $CaCO_3 \cdot 3MgCO_3$, huntite.

Kilt white, room I west wall, fifth figure from the left, as shown in Fig.52.
"Point 14" was characterized with a rather low Fe concentration as can be seen from an XRF spectrum shown in Fig.53. Diffraction peaks from $CaSO_4$ and SiO_2 are very low in intensities, as shown in Fig.54. These indicate that a white layer, optical micrographs being shown in Fig.59, is thick enough to give diffraction peaks only of $CaCO_3 \cdot 3MgCO_3$, huntite.

Kilt white (partially exfoliated), room I west wall, fifth figure from the left, as shown in Fig.52.
On "point 15" a white pigment appeared to be partially exfoliated and then substrate might be exposed to the surface. XRF and XRD spectra taken from "point 15" are shown in Figs.55 and 56, respectively. Exposure of plaster to the surface is clearly seen from optical micrographs shown in Fig.60, which is confirmed by detection of $CaSO_4$ in a diffraction pattern shown in Fig.56.

Male skin brown, room I west wall, fifth figure from the left, as shown in Fig.52.
XRF and XRD spectra taken from "point 16" are shown in Figs.57 and 58, respectively. They gave very intense Fe K X-rays and diffraction peaks from hematite, α-Fe_2O_3 together with peaks from $CaSO_4$. This indicates that a brown layer is painted on plaster using hematite, α-Fe_2O_3 and a black pigment, presumably soot. From optical micrographs shown in Fig.61, we understood that the brown layer was thick and homogeneous.

Kilt dark blue, room I west wall, third figure from the left, as shown in Fig.62.
"Point 18" is characterized with intense Cu, week Mn and moderate intense Fe K X-rays, as shown in Fig.63, from which Egyptian blue, $CaO \cdot CuO \cdot 4SiO_2$ was found on a diffraction pattern shown in

Fig.64. These experimental results suggest that the dark blue was prepared by mixing Egyptian blue with a black or dark pigment. The latter might be manganese ferrite, $MnFe_2O_4$ and/or soot. Optical micrographs are shown in Fig.67, which showed existence of blue and black colored grains, presumably the former being Egyptian blue and the latter being manganese ferrite.

Pharaoh beard dark blue, room I west wall, third figure from the left, as shown in Fig.62.
An XRF spectrum taken from “point 19” showed intense Fe K X-ray peaks together with moderately intense Cu K X-ray peaks. The chemical compositions of “point 19” was completely different from those of “point 9” i.e. black beard shown in Figs.31-33. The XRF data suggest the use of magnetite, Fe_3O_4 as a black pigment.

Kilt dark green, room I west wall, third figure from the left, as shown in Fig.62.
“Point 20” is distinguished from “point 18” in color, the former being dark green and the latter being dark blue. However, the chemical compositions of “point 20” shown in Fig.66 is fundamentally the same as those of “point 18” shown in Fig.63 except for Mn content. However, in these experiments detection sensitivity to light elements such as Na and C was low, and then a green pigment might be a mixed oxide of Na, Si, Ca, and Cu. This is because Egyptian blue is an end member of a series of mixed oxides of Na, Si, Ca, and Cu. As can be seen on optical micrographs shown in Fig.68, numbers of blue grains are small compared to those found on Fig.67.

Jackal vest dark green, room I west wall, eighth figure from the left, as shown in Fig.69.
“Point 21” gave a much intense Cu K X-ray peaks, as shown in Fig.70, compared to those of Ca and Fe K X-rays. Three colors appear to be used for this painting, as can be seen on optical micrographs shown in Fig.71. One is greenish brown, second yellowish brown, and third blue.

Female robe green, room I west wall, sixth figure from the left, as shown in Fig.72.
Green color at “point 27” was characterized with three elements, Ca, Fe, and Cu as shown in Fig.73. This color appeared to be composed of two pigments, as can be seen on optical micrographs shown in Fig.77, which are yellowish brown and green pigments, presumably being goethite, α-FeO • OH and Egyptian blue.

Female robe blue, room I west wall, sixth figure from the left, as shown in Fig.72.
Chemical compositions at “point 28” shown in Fig.74 were fundamentally the same as those at “point 27”. Optical micrographs shown in Fig.78 tell us that numbers of blue grains are larger for “point 28” than for “point 27”.

Female robe dark green, room I west wall, sixth figure from the left, as shown in Fig.72.
Chemical compositions, as shown in Fig.75, at “point 29” are similar to those at “point 27” and “point 28” except for As. Optical micrographs shown in Fig.79 indicate that yellowish and dark areas at “point 29” were large compared to those at “point 27” and “point 28”. This is the reason why “point 29” looks dark green.

Background light blue, room I west wall, between sixth and seventh figures from the left, as shown in Fig.72.
“Point 30” appeared to be the same as “point 7” shown in Figs.25, 26, and 29. An XRF spectrum is shown in Fig.76 which is fundamentally the same as that of “point 7”.

Male kilt white, room I west wall, fifth figure from the left, as shown in Fig.80.
“Point 31” appeared to be white but its brightness is very low and is completely different from that of “point 3”, “point 14” and “point 43”. An XRF spectrum at “point 31” is shown in Fig.81, in which rather strong peaks from As K X-rays were found. No diffraction peaks from huntite were found from XRDF spectra, not shown here. Roughness at “point 31” as shown in Fig.81 was very high compared to that at “point 3”, “point 14” and “point 43”. These facts suggest that “kilt white” in Fig.80 was painted using an As bearing compound, but its original color is not necessarily white because it is not easy to find As bearing compounds with white color except for As_2O_3.

Male kilt white (partially exfoliated), room I west wall, fifth figure from the left, as shown in Fig.80.
Intensities of As K X-rays detected from “point 32” was small, as shown in Fig.82, compared to those from “point 31”. This is because some white layers were removed from “point 32” as can be seen on Fig.86.

Female robe light red, room I west wall, fourth figure from the left, as shown in Fig.80.
An XRF spectrum taken from “point 33” is shown in Fig.83. The spectrum is similar to that taken from “point 8” shown in Fig.27. The use of As bearing compound is noteworthy for painting light red color.

Female arm pinkish yellow, room I west wall, fourth figure from the left, as shown in Fig.80.
An XRF spectrum is shown in Fig.84, which was taken from “point 34”. The intensity ratios of Ca/Fe and Ca/As in Fig.84 are fundamentally the same as those in Fig.24 taken from “point 6” which is a part of arm pinkish yellow.

Gold in a scratch, room I west wall, between legs of seventh figure from the left, as shown in Fig.87.
A scratch can be seen between the legs of seventh figure from the left, as shown in Fig.87. A yellowish small piece was found in the scratch, whose XRF spectrum is shown in Fig.88. Au L X-rays can clearly be seen in the spectrum together with Ca and Fe K X-rays, in which no Ag and Cu X-rays were found. Ca and Fe are to be originated from light blue background, as in the cases of “point 7” and “point 30”. Optical micrographs taken from “point 35” are shown in Fig.89, in which yellowish leaflet can be seen. Then the yellowish piece left in the scratch must be pure gold.

Cleaned wall, room J south wall shown in Fig.90.
An XRF spectrum taken from a cleaned wall is shown in Fig.91. Large and medium amounts of Ca and Fe, respectively were found together with tiny amounts of S and Sr. Judging from chemical components of plaster shown in Fig.36, the wall at “point 38” is free from contaminations.

Untreated wall, room J south wall shown in Fig.90.
Rather intense K and Fe K X-rays were found in Figs.92 and 93, taken from "point 39" and "point 40", respectively. These must be originated from bat droppings. S and Sr were detected in non-negligible amounts from "point 41" shown in Fig.94. This must be caused by liquid, including bat droppings, flowing from upper parts of the wall investigated.

3. References

1) M. Uda, S. Sassa, K. Taniguchi, S. Nomura, S. Yoshimura, J. Kondo, N. Iskandar, B. Zaghloul, Naturwissenschaften (2000) 87, 260-63, "Touch-free in situ investigation of ancient Egyptian pigments"
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3) M. Uda, S. Sassa, S. Yoshimura, J. Kondo, M. Nakamura, Y. Ban, H. Adachi, Nucl. Instr. Meth. Phys. Res. B, (2000), 758-61, "Yellow, red and blue pigments from ancient Egyptian palace painted wall"
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Fig.3 Room E south wall

Fig.4 Room I north wall

Fig.5 Room I west wall

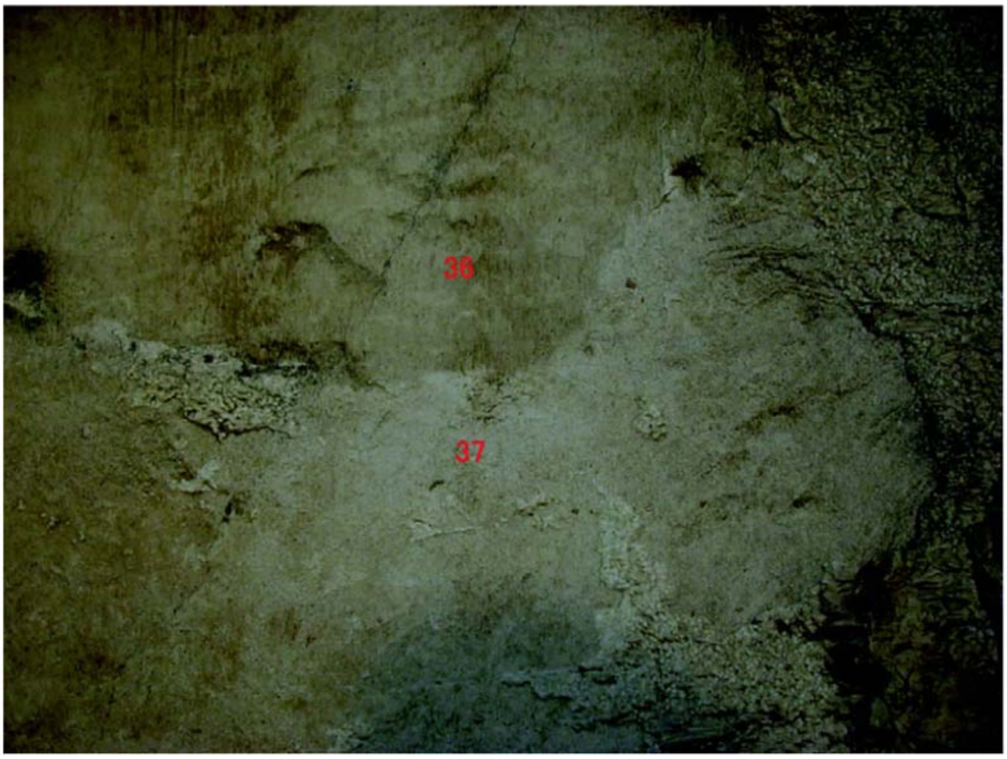


Fig.6 Room Je north wall

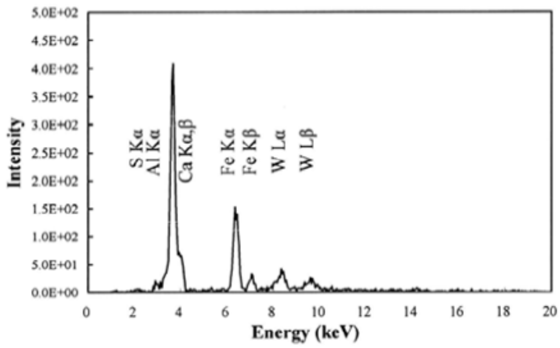


Fig.7 Point 36 XRF

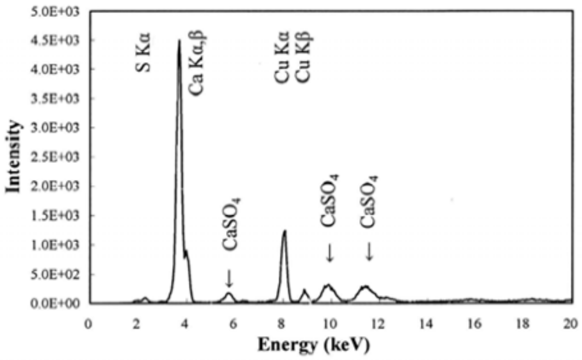


Fig.8 Reference $CaSO_4$ XRD+XRF

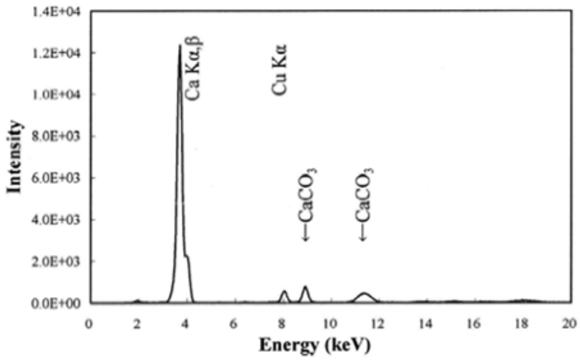


Fig.9 Reference $CaCO_3$ XRD+XRF

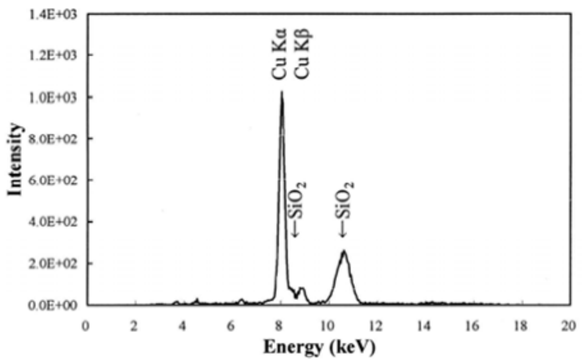


Fig.10 Reference SiO_2 XRD+XRF

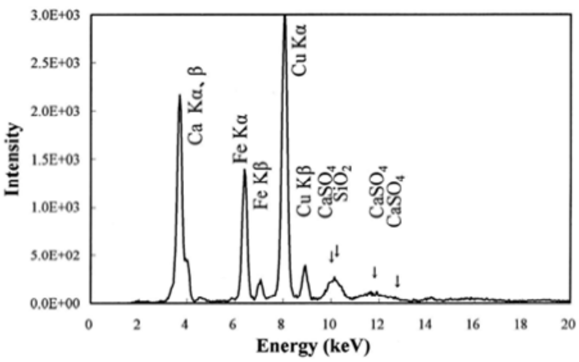


Fig.11 Point 36 XRD+XRF

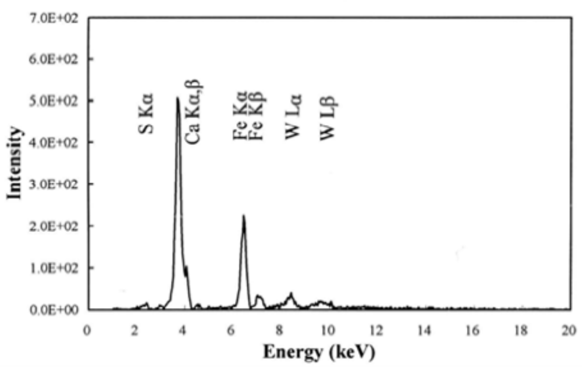


Fig.12 Point 37 XRF

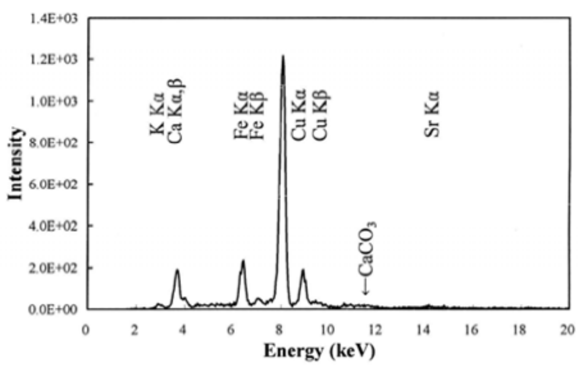


Fig.13 Point 37 XRD+XRF

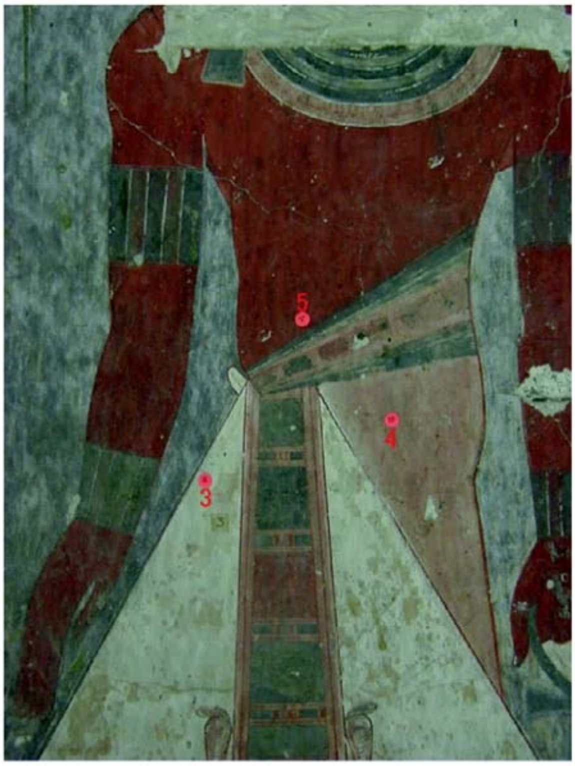


Fig.14 Room E south wall

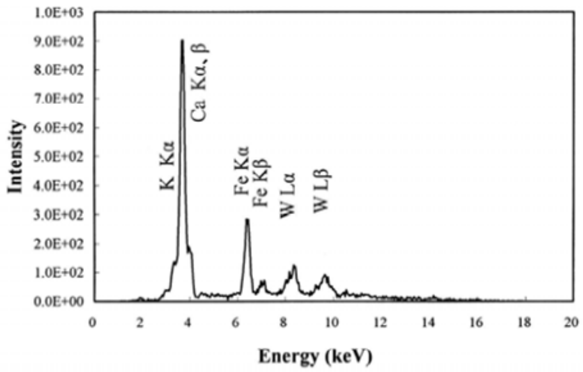


Fig.15 Point 3 XRF

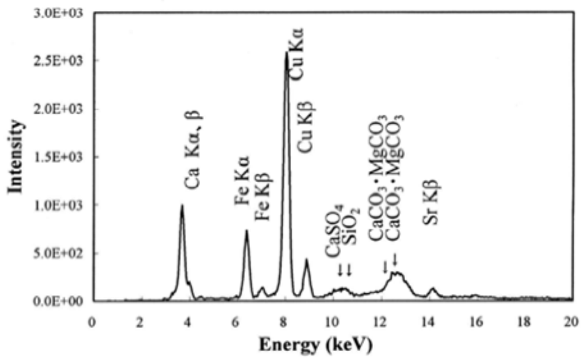


Fig.16 Point 3 XRD+XRF

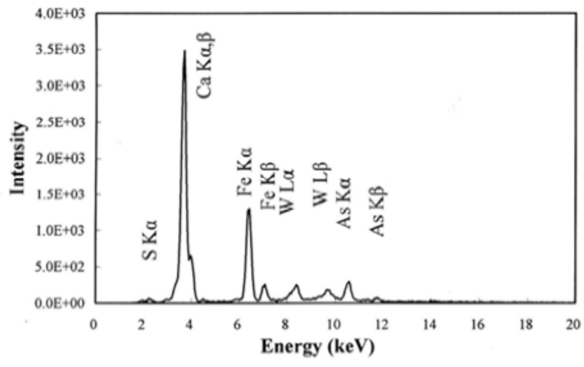


Fig.17 Point 4 XRF

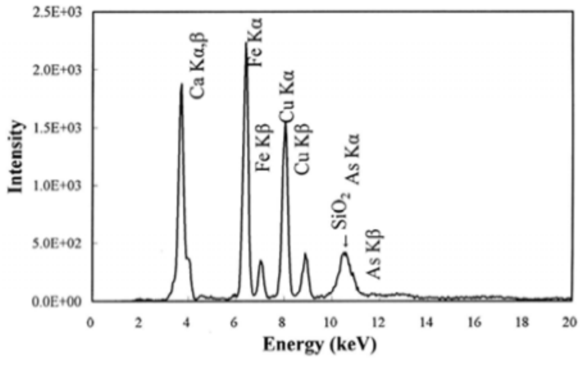


Fig.18 Point 4 XRD+XRF

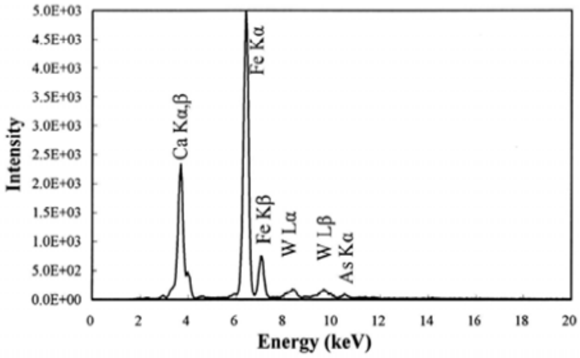
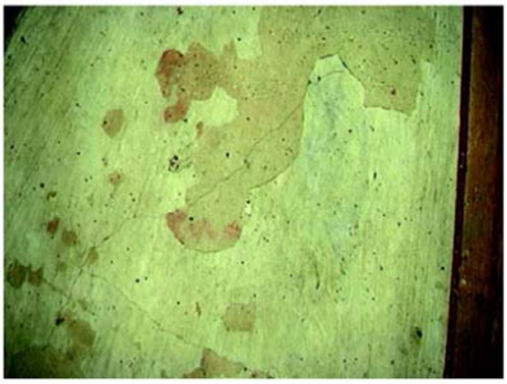


Fig.19 Point 5 XRF



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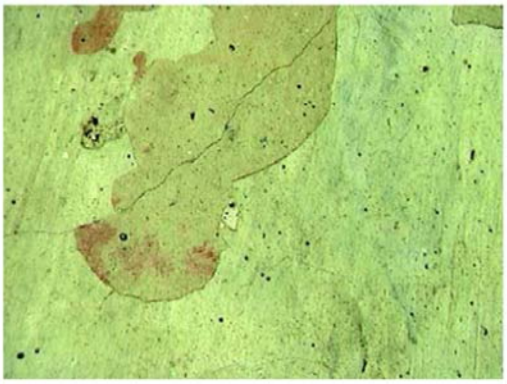

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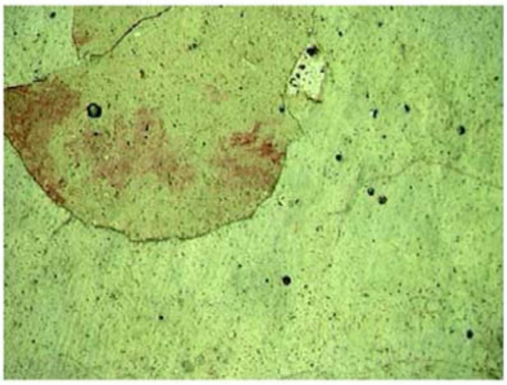

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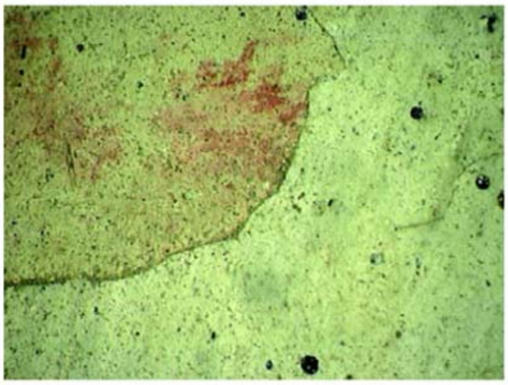

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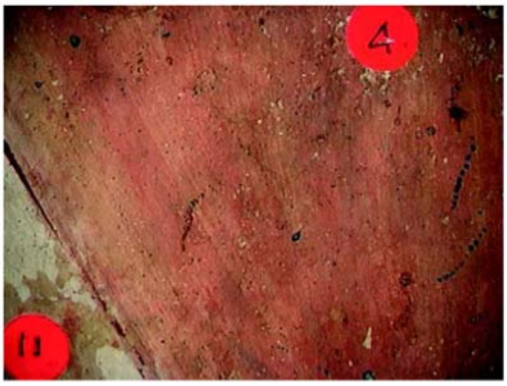
Fig.20 Point 3



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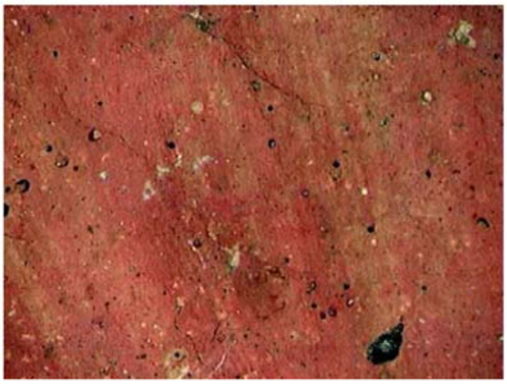

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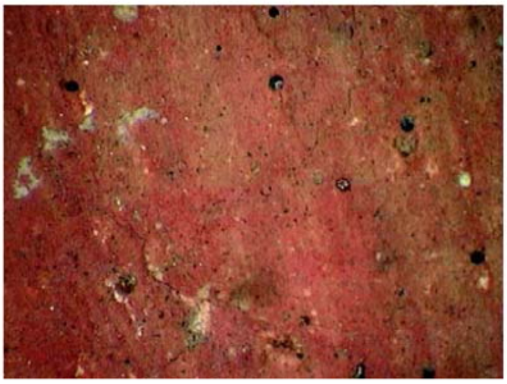
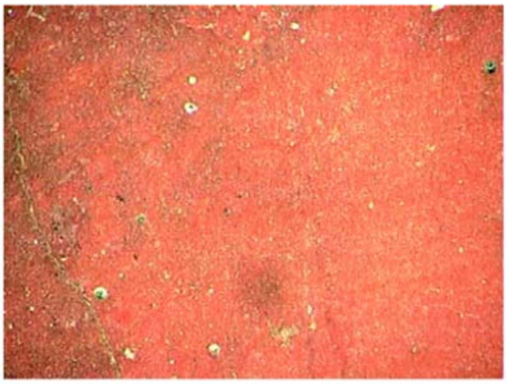


×40

Fig.21 Point 4

×5

×10



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×40

Fig.22 Point 5

Fig.23 Room E south wall

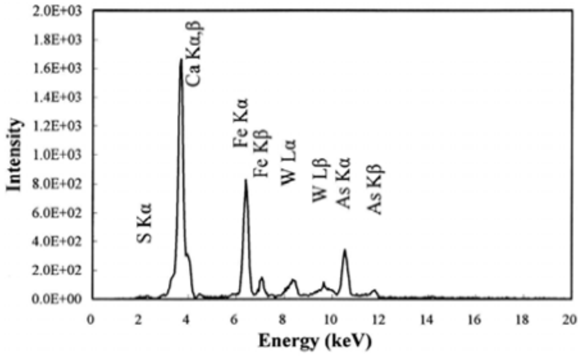

Fig.24 Point 6 XRF

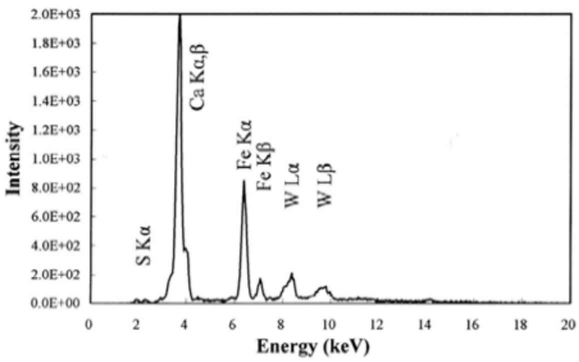

Fig.25 Point 7 XRF

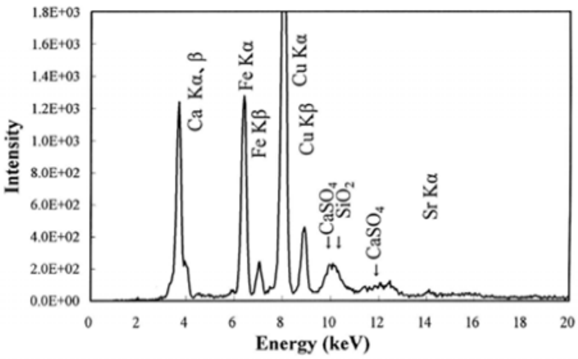

Fig.26 Point 7 XRD+XRF

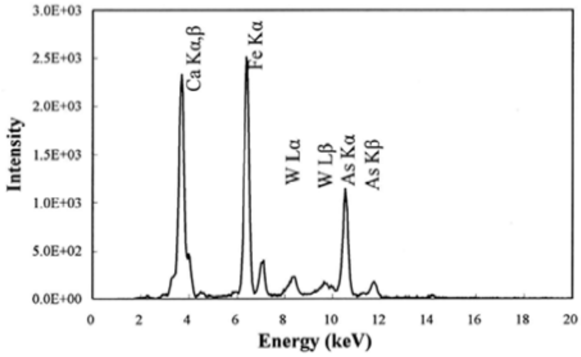

Fig.27 Point 8 XRF

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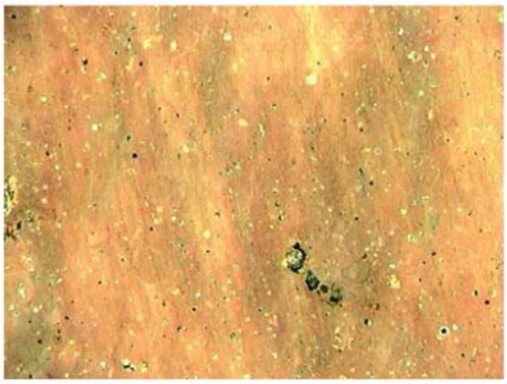

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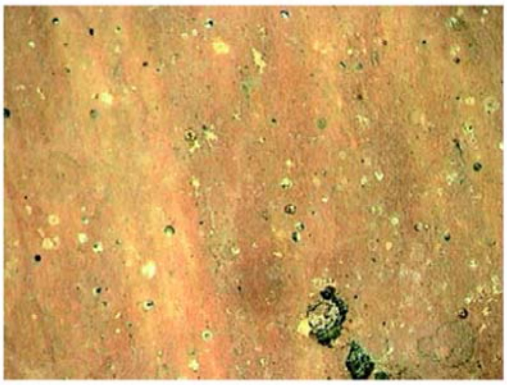

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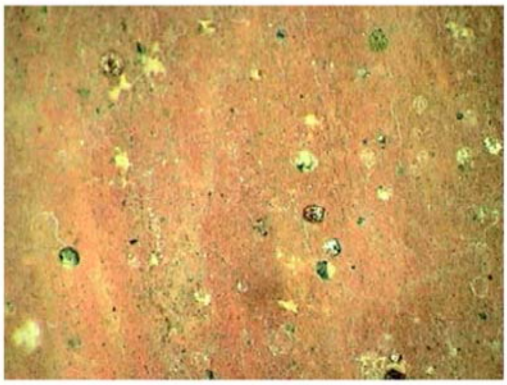

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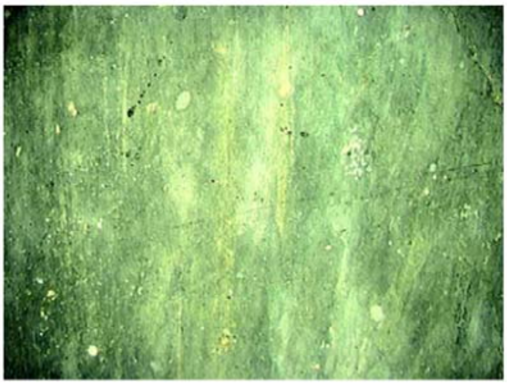
Fig.28 Point 6



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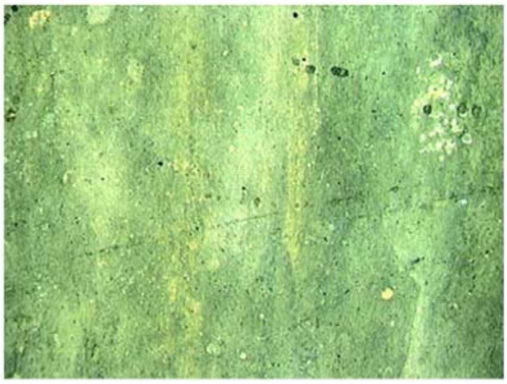

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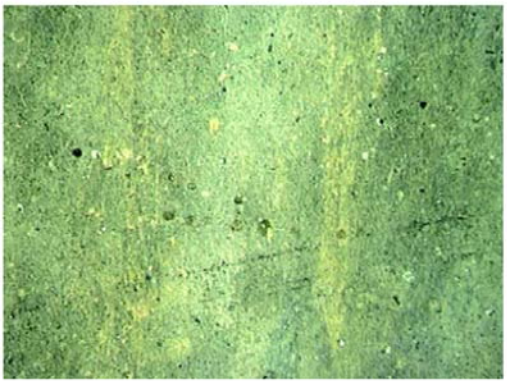

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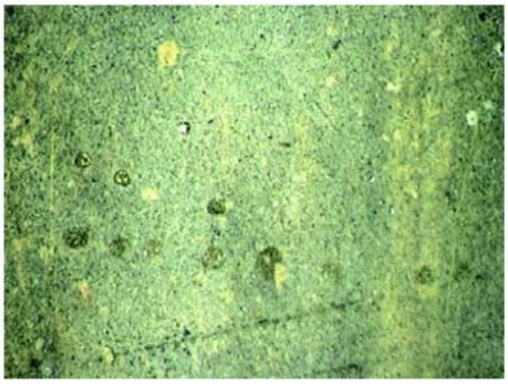

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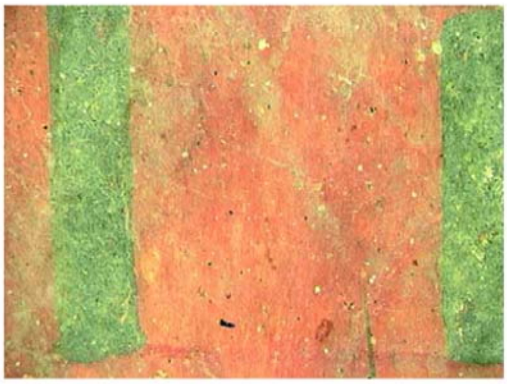
Fig.29 Point 7

×5



×10

×20

×40

Fig.30 Point 8

Fig.31 Room E south wall

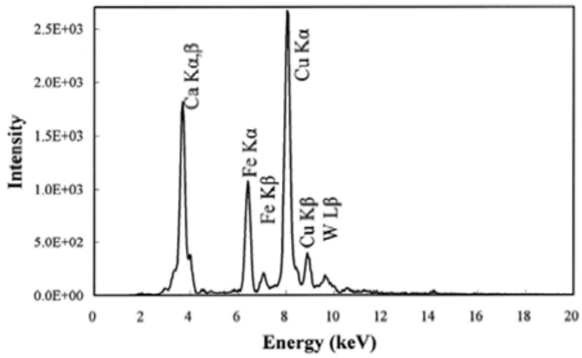
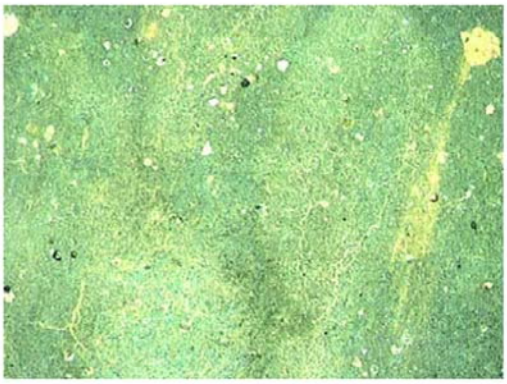


Fig.32 Point 9 XRF

×5

×10



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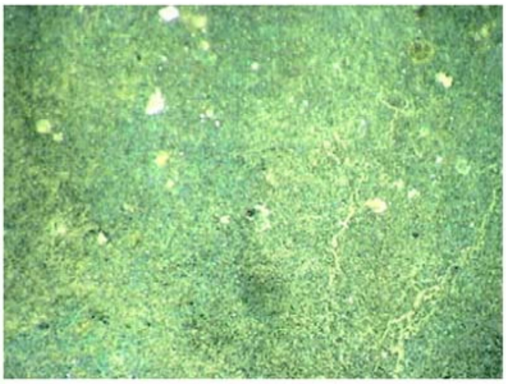

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Fig.33 Point 9

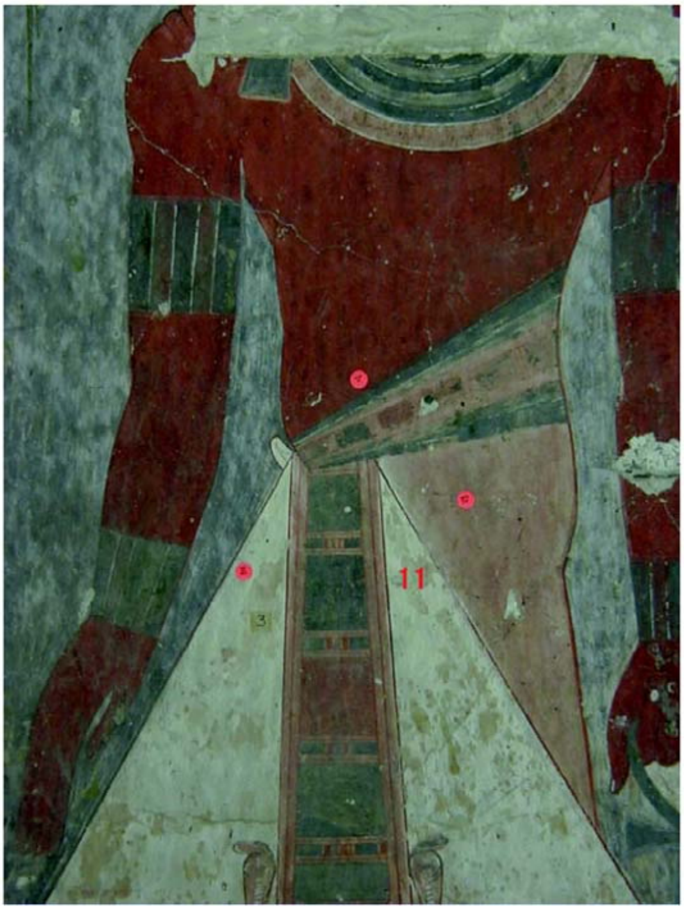


Fig.34 Room E south wall

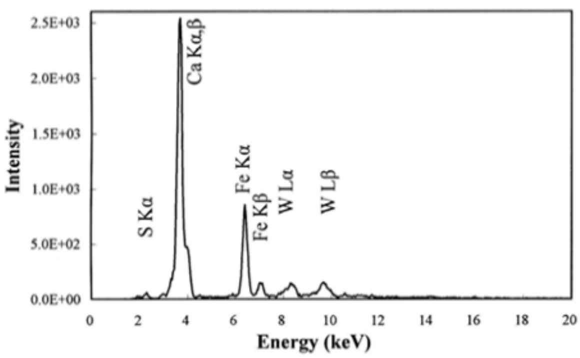


Fig.35 Point 11 XRF

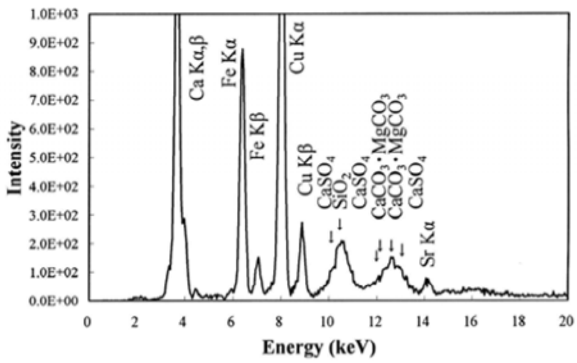


Fig.36 Point 11 XRD+XRF

Fig.37 Room E south wall

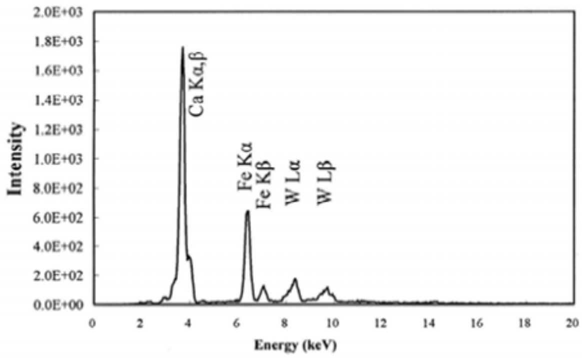


Fig.38 Point 12 XRF

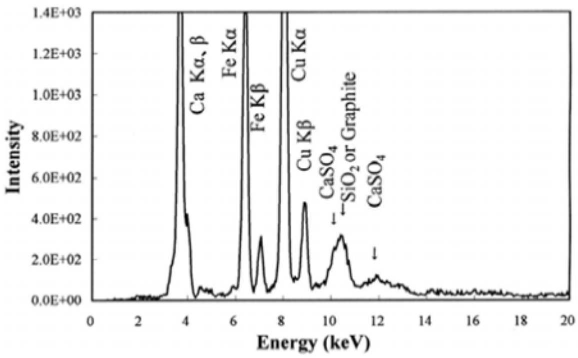


Fig.39 Point 12 XRD+XRF

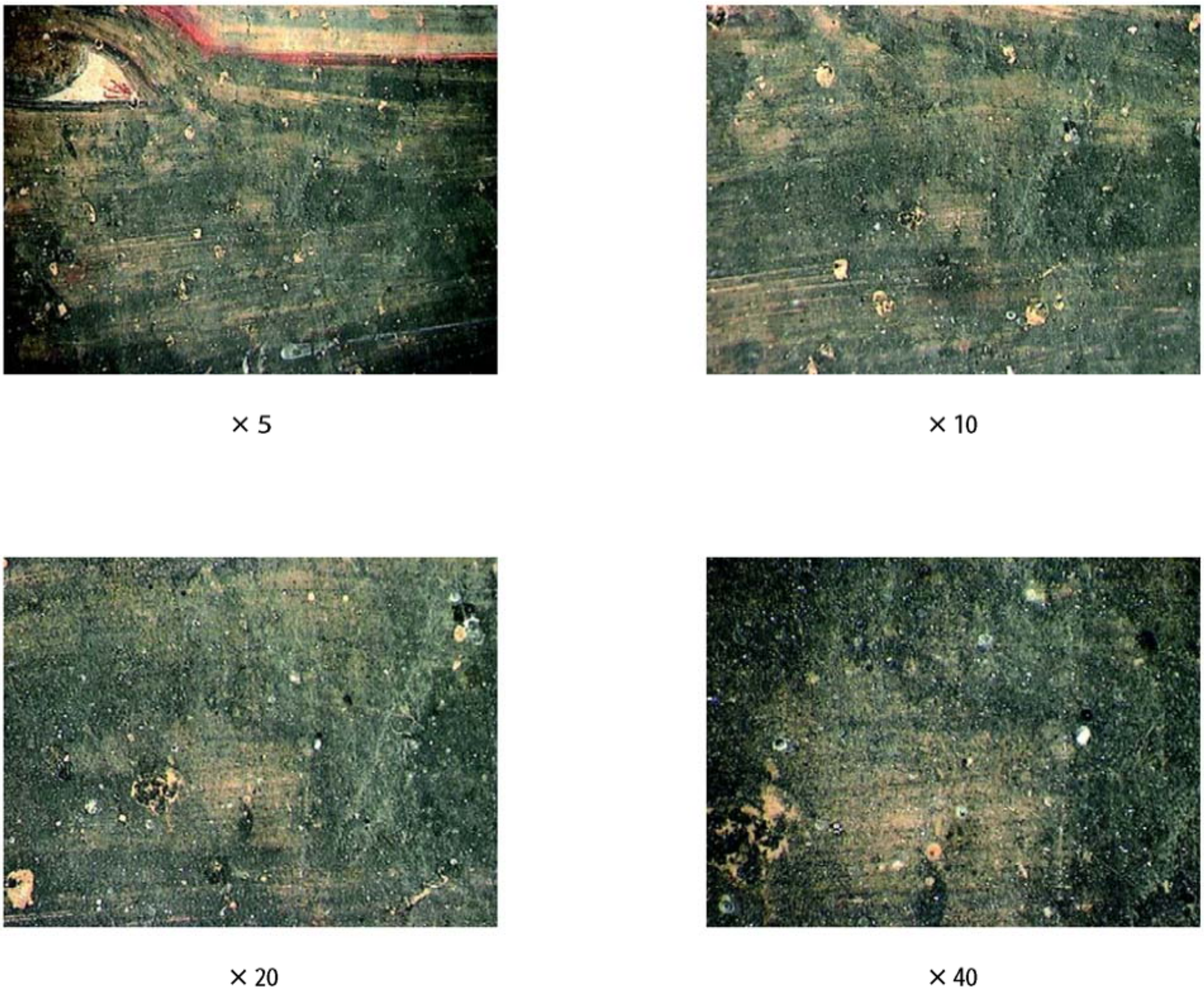


Fig.40 Point 12

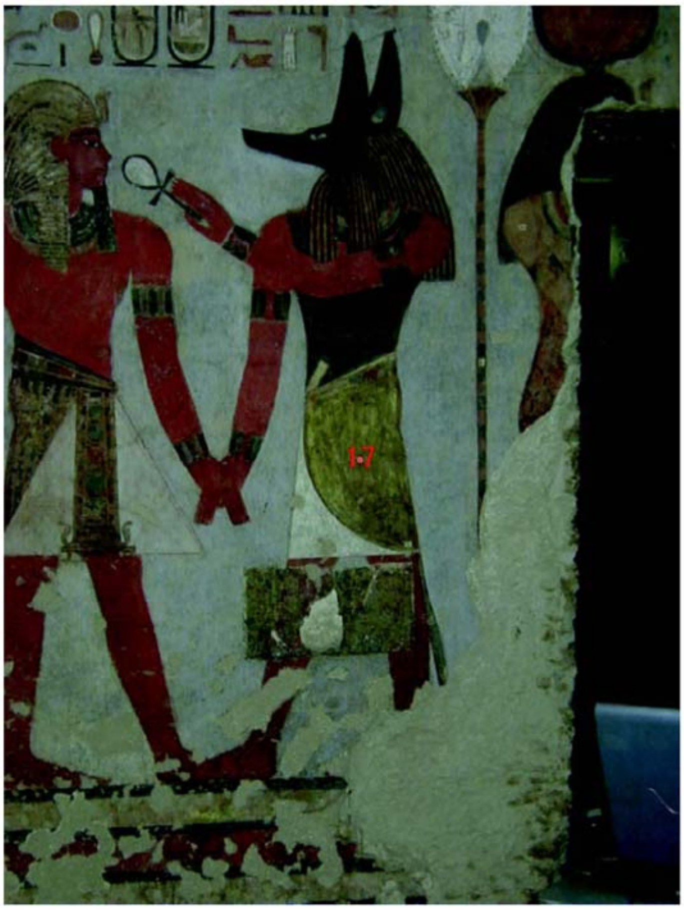


Fig.41 Room I north wall

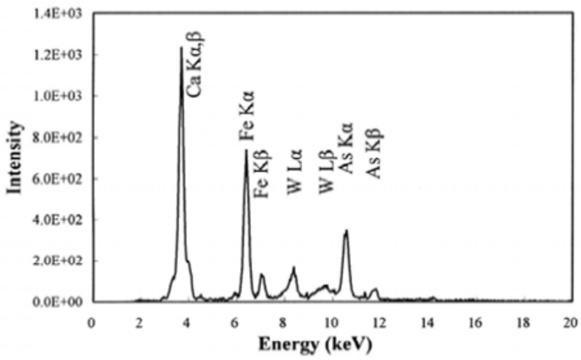


Fig.42 Point 17 XRF

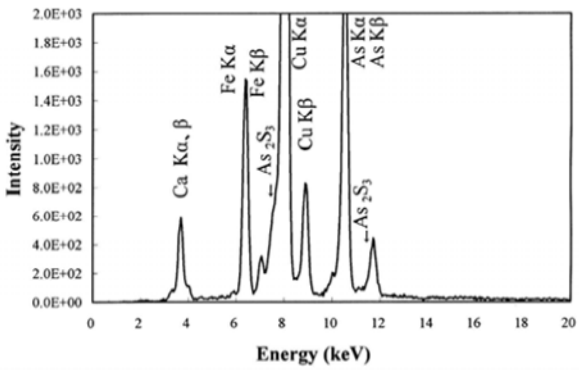
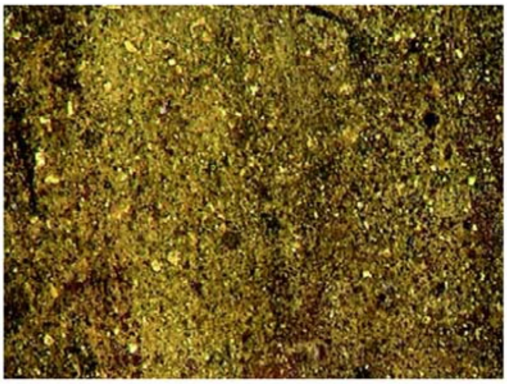


Fig.43 Point 17 XRD+XRF

×5

×10



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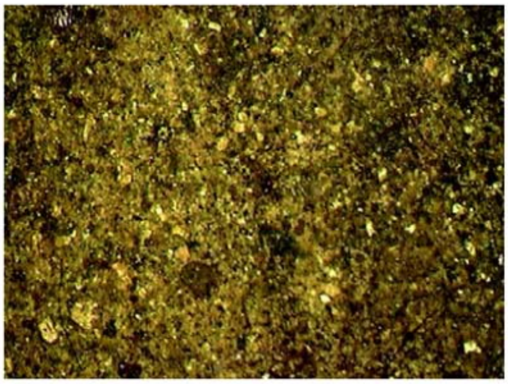

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Fig.44 Point 17

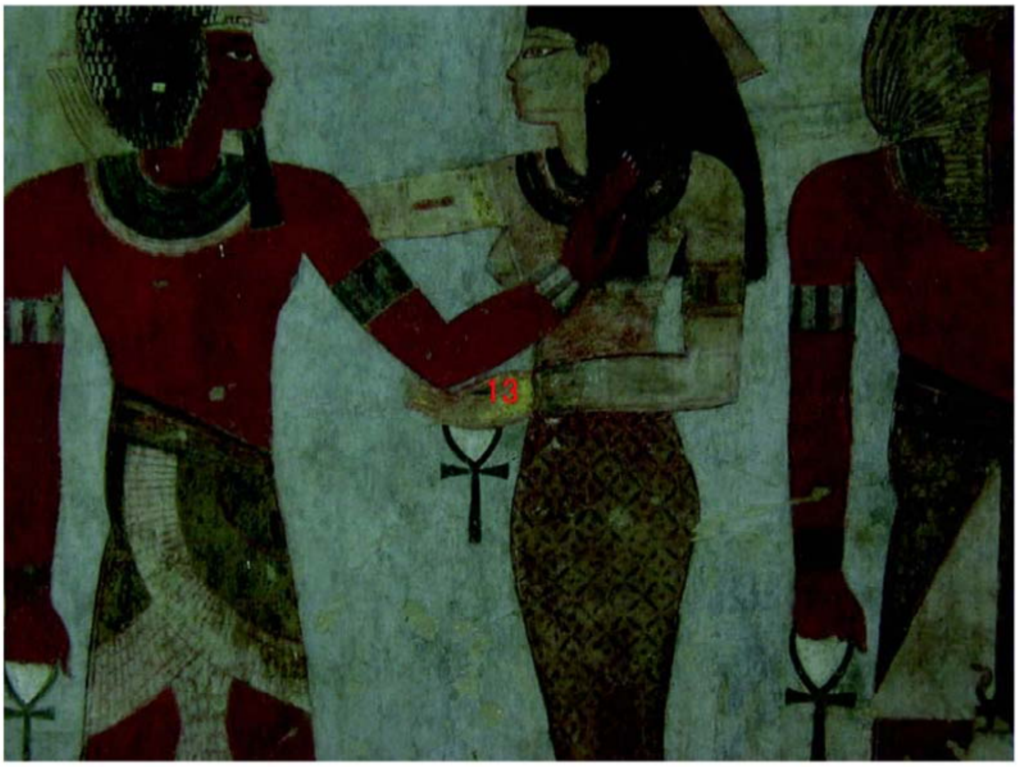


Fig.45 Room I north wall

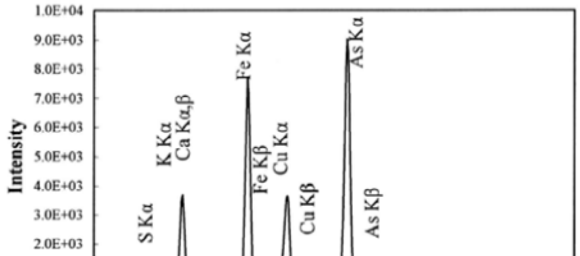
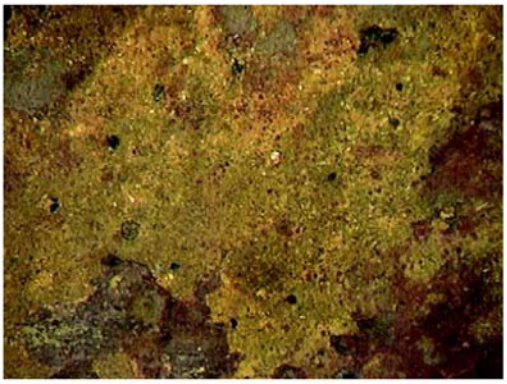


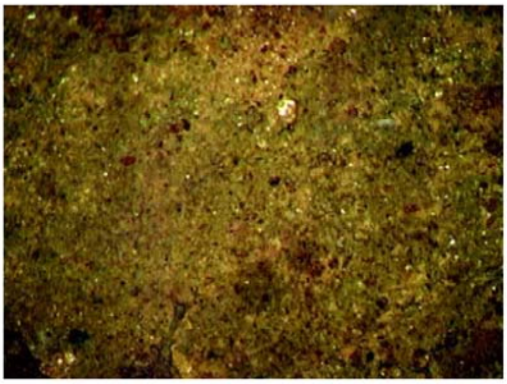
Fig.46 Point 13 XRF

×5

×10



×20



×40

Fig.47 Point 13

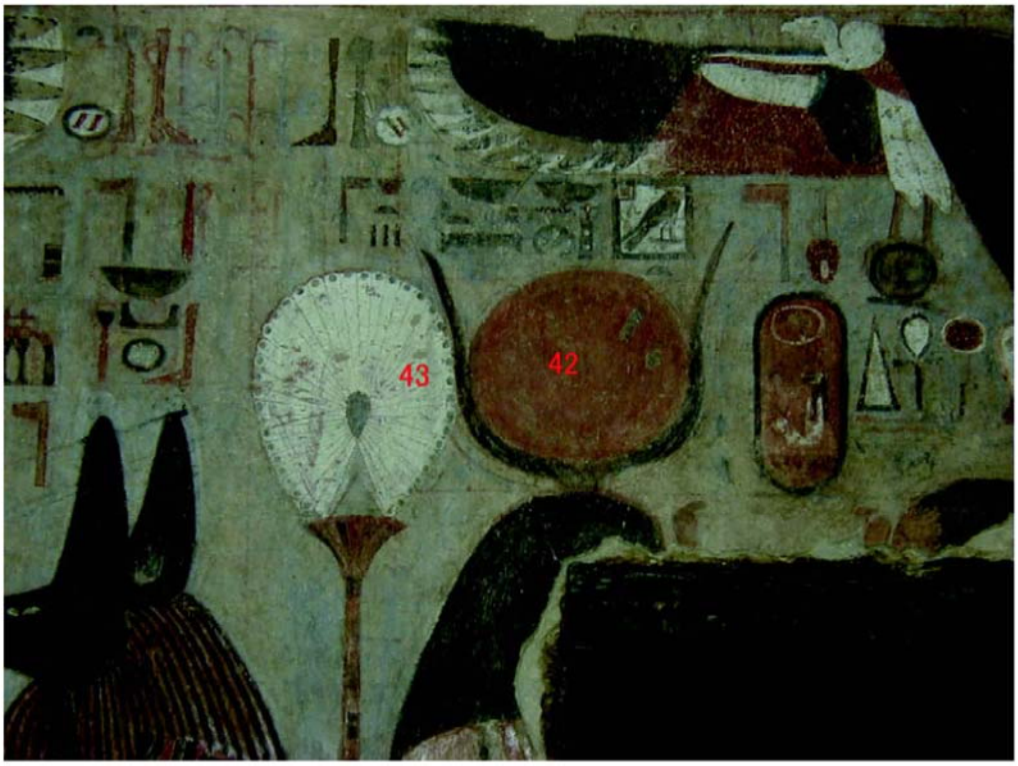


Fig.48 Room I north wall

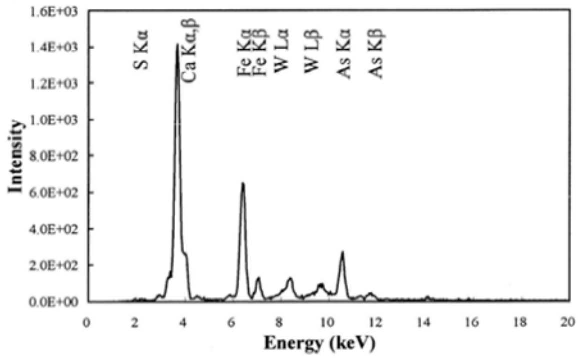


Fig.49 Point 42 XRF

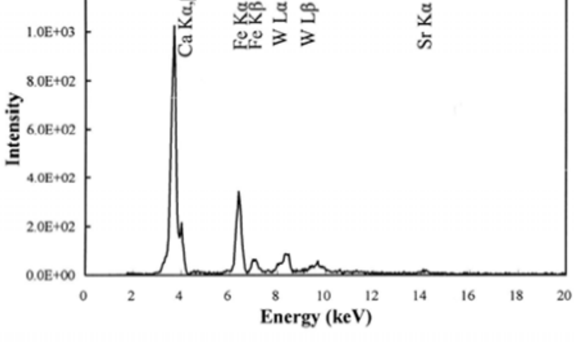


Fig.50 Point 43 XRF

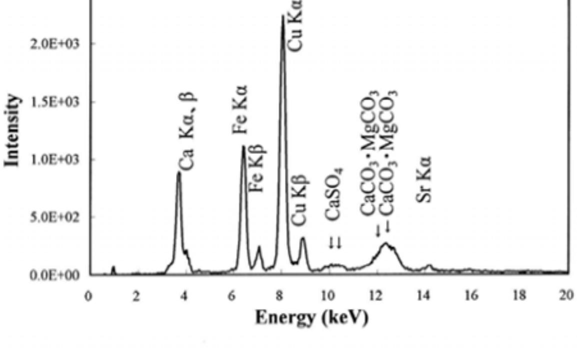


Fig.51 Point 43 XRD+XRF

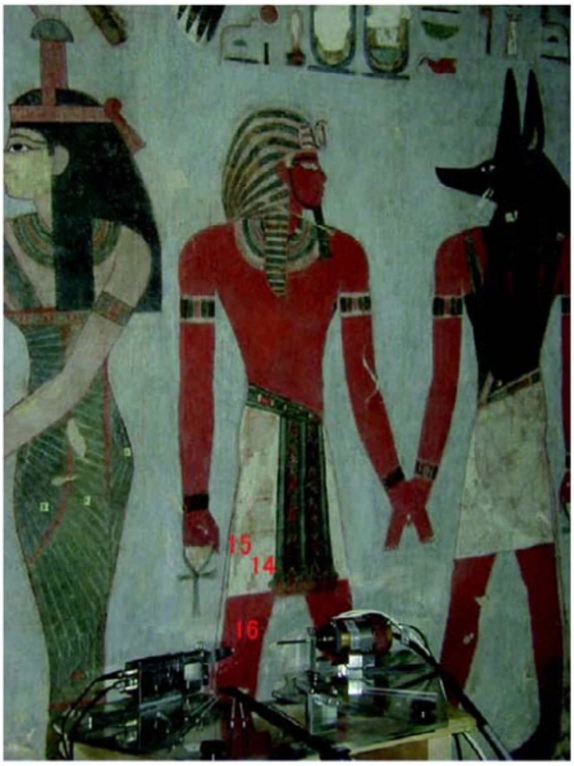


Fig.52 Room I west wall

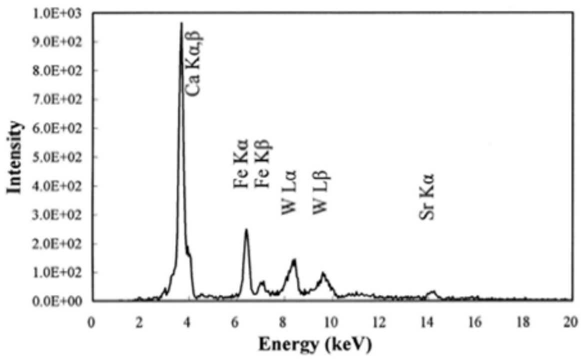


Fig.53 Point 14 XRF

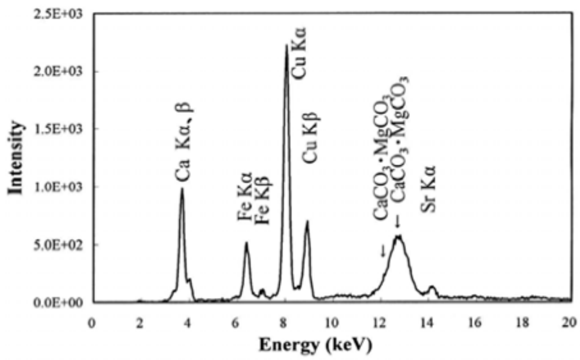


Fig.54 Point 14 XRD+XRF

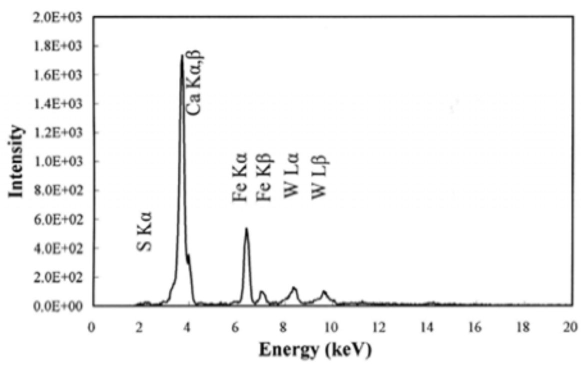


Fig.55 Point 15 XRF

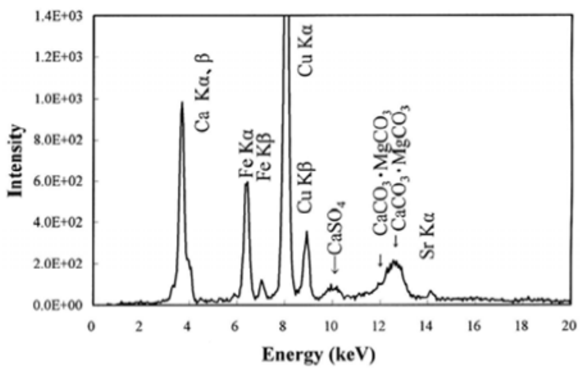


Fig.56 Point 15 XRD+XRF

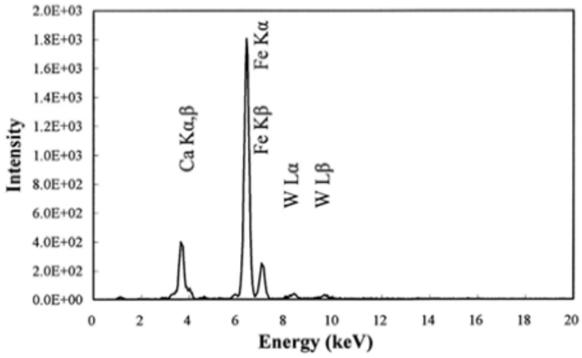


Fig.57 Point 16 XRF

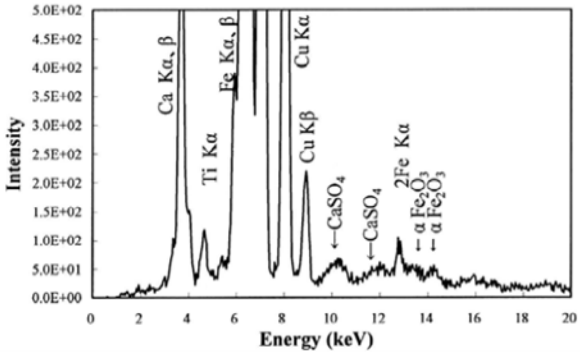
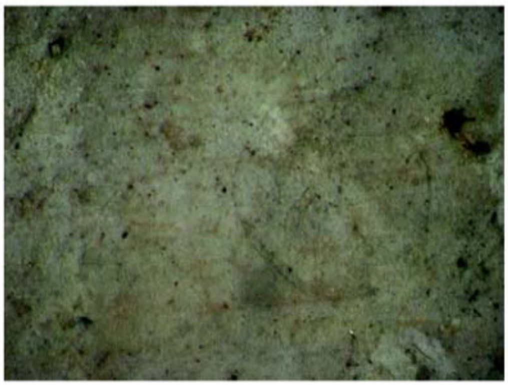


Fig.58 Point 16 XRD+XRF

×5

×10

×20



×40

Fig.59 Point 14

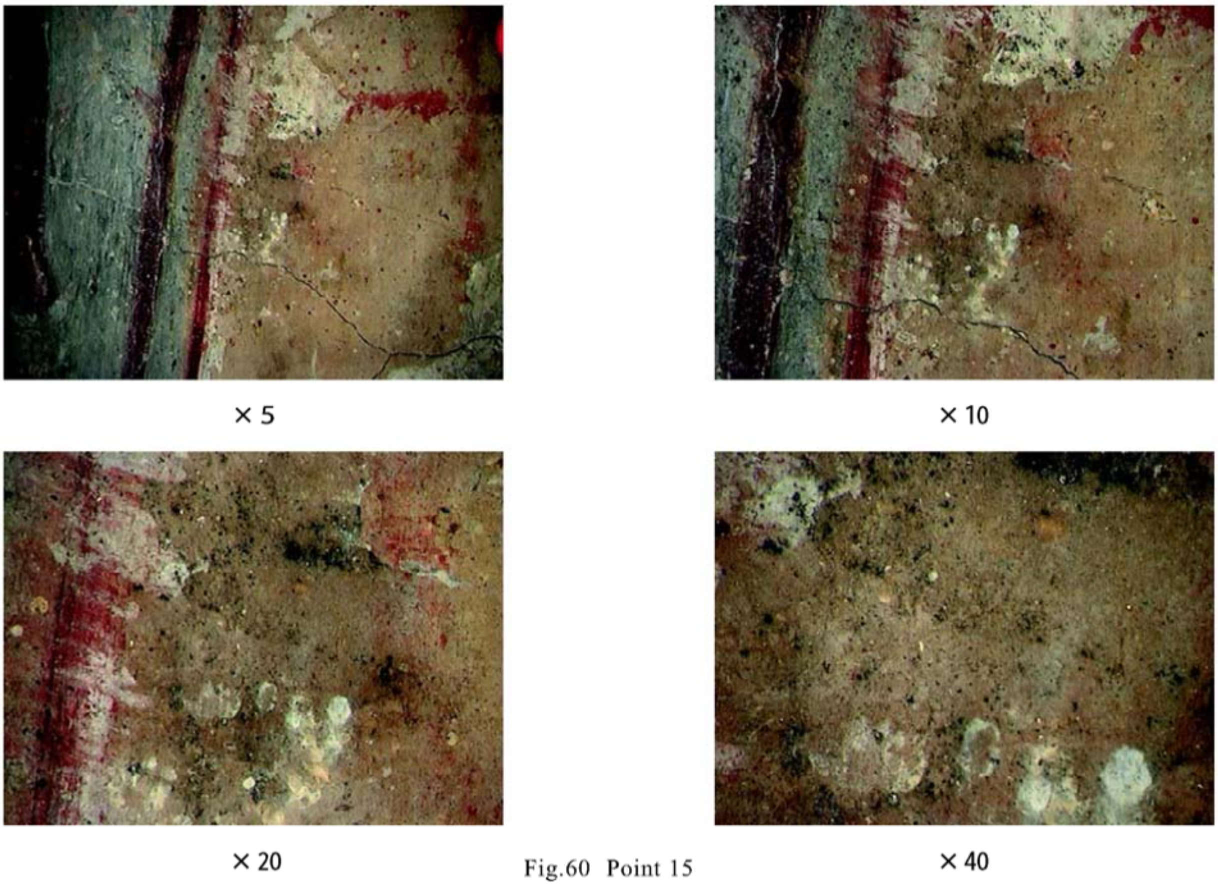


Fig.60 Point 15

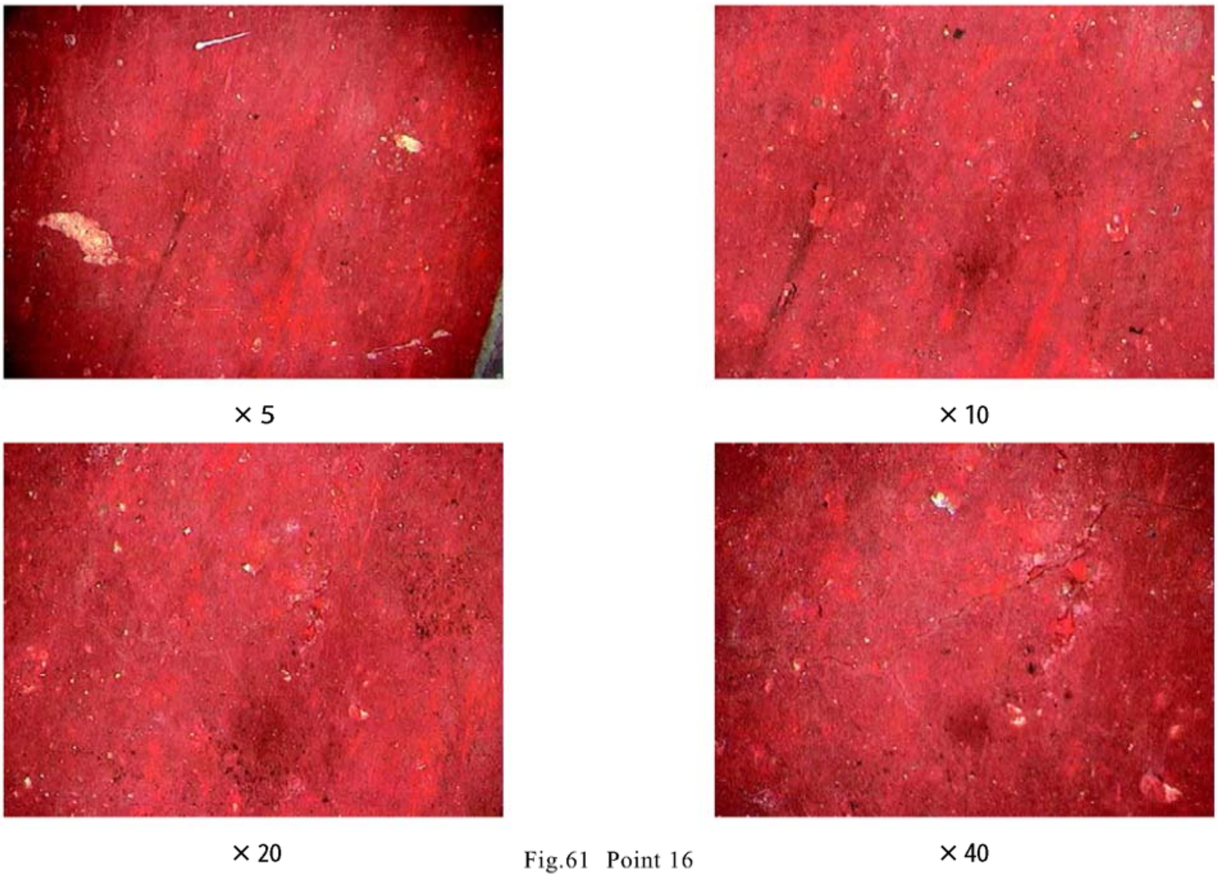


Fig.61 Point 16

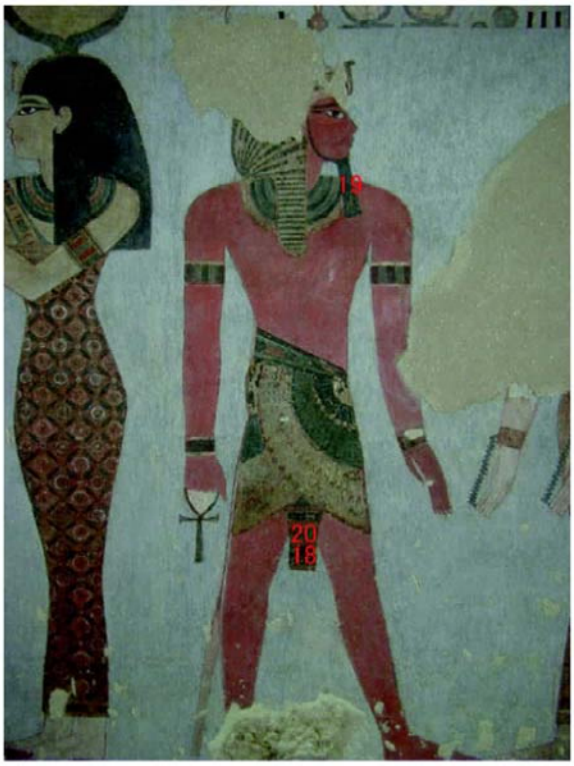


Fig.62 Room I west wall

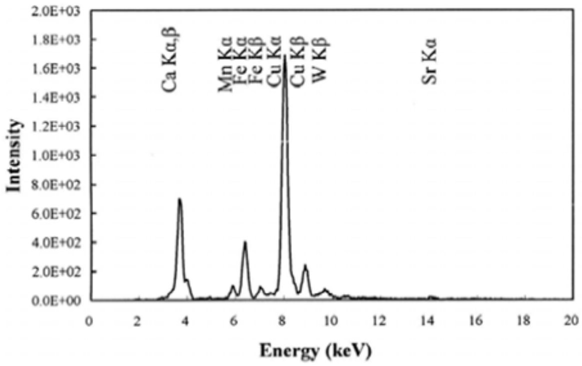


Fig.63 Point 18 XRF

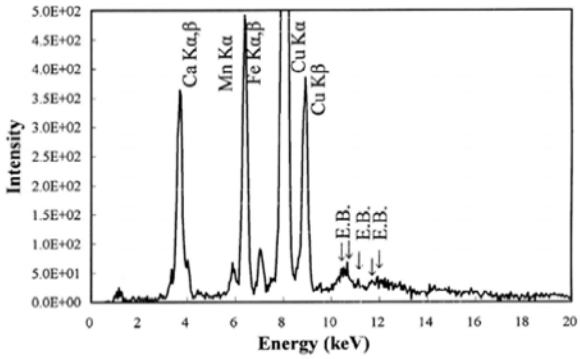


Fig.64 Point 18 XRD+XRF

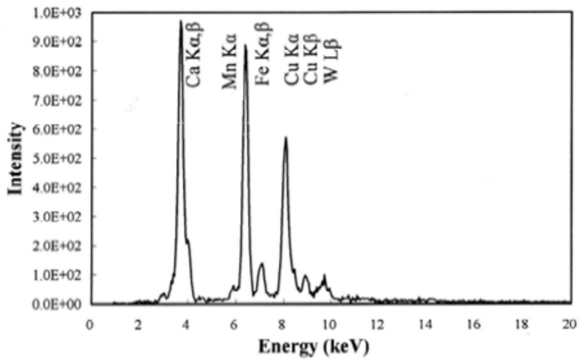


Fig.65 Point 19 XRF

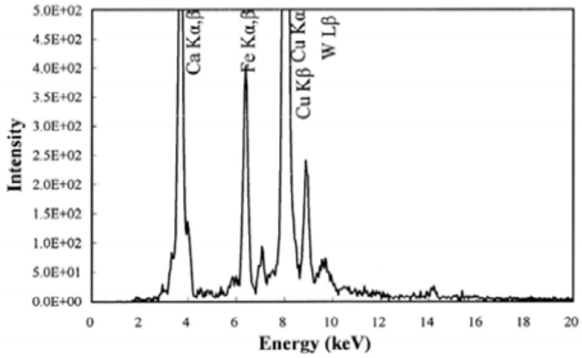
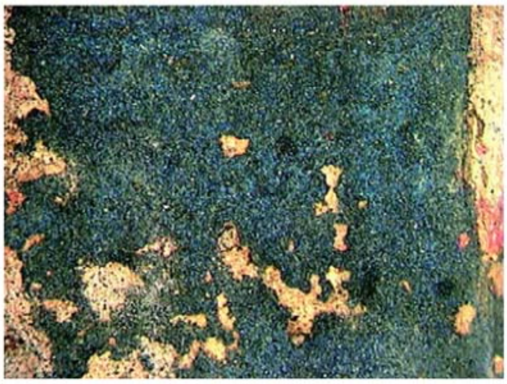


Fig.66 Point 20 XRF

×5



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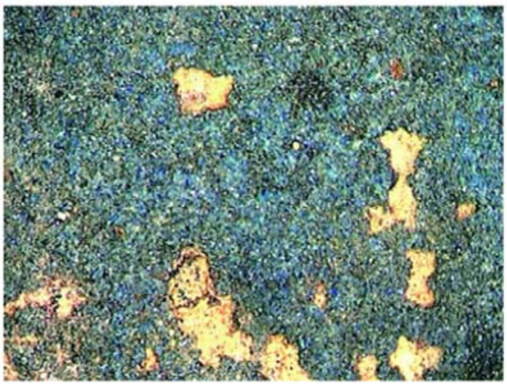

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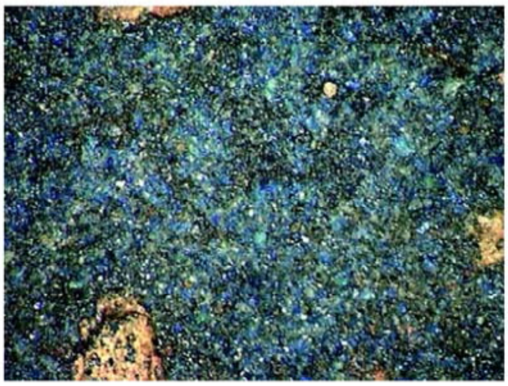


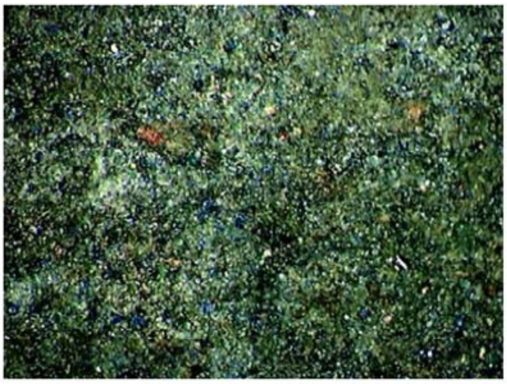
×40

Fig.67 Point 18

×5

×10

×20



×40

Fig.68 Point 20

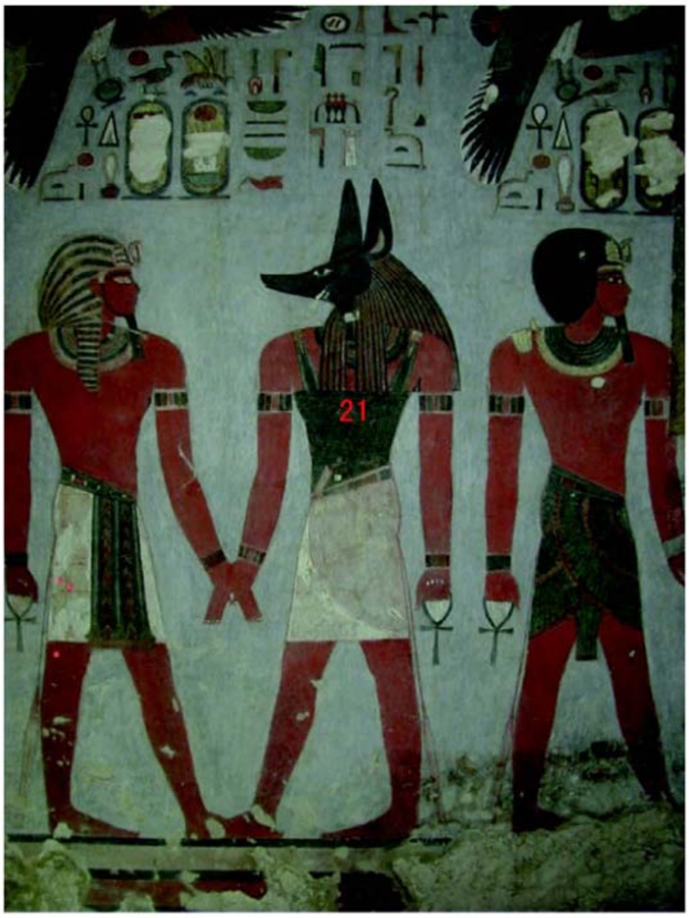


Fig.69 Room I west wall

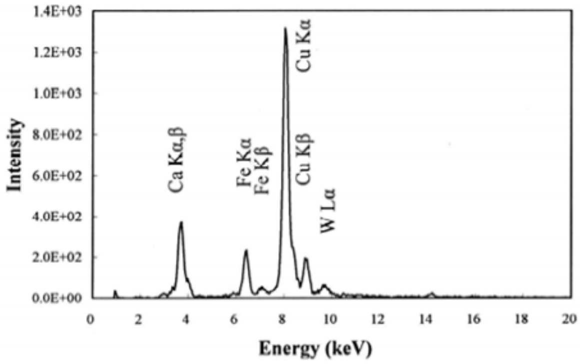
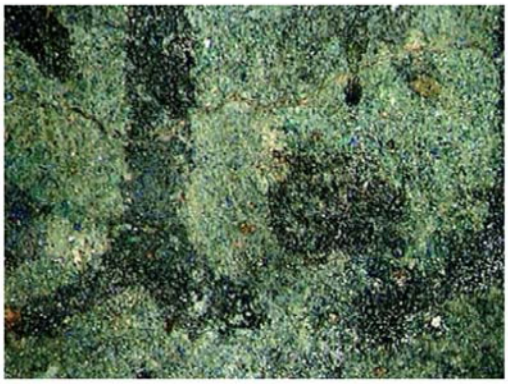


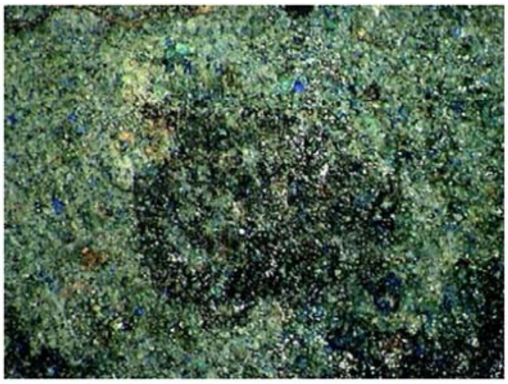
Fig.70 Point 21 XRF

×5

×10



×20



×40

Fig.71 Point 21

Fig.72 Room I west wall

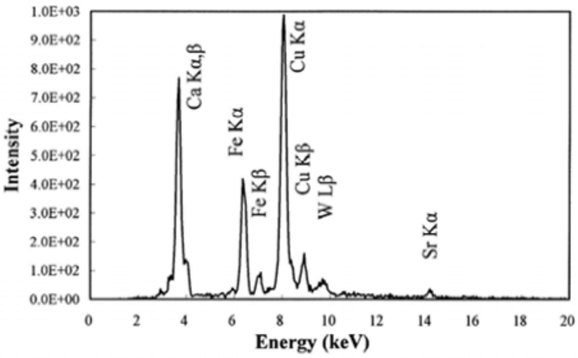


Fig.73 Point 27 XRF

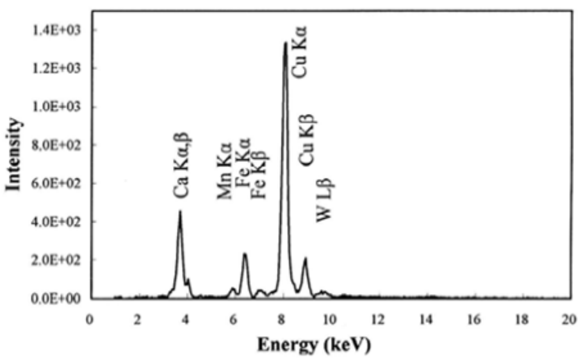


Fig.74 Point 28 XRF

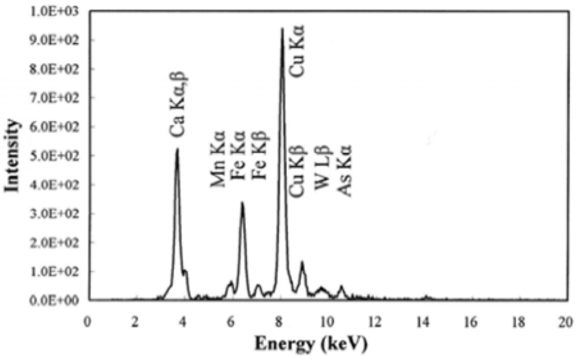


Fig.75 Point 29 XRF

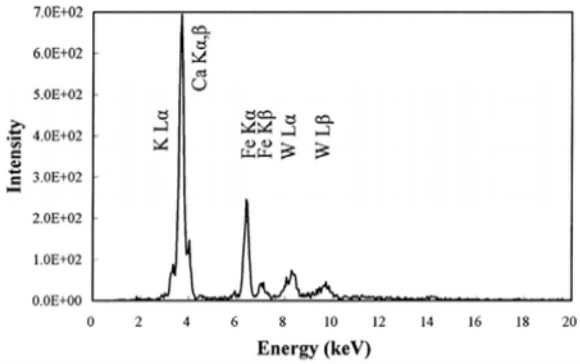
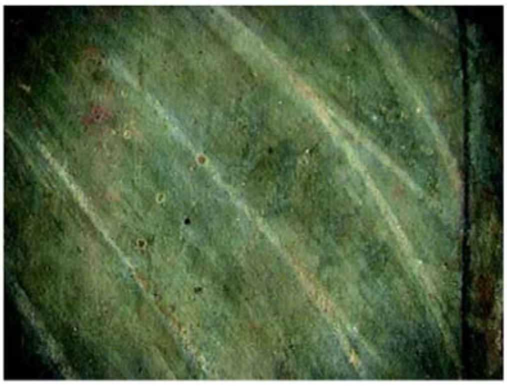


Fig.76 Point 30 XRF



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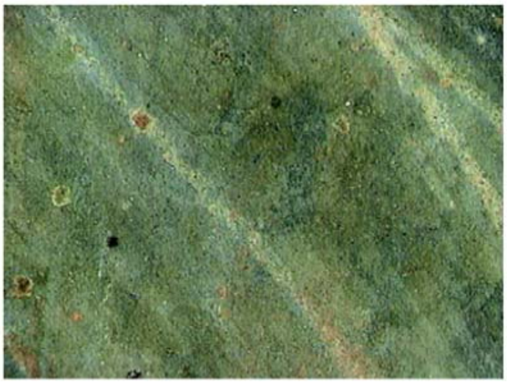


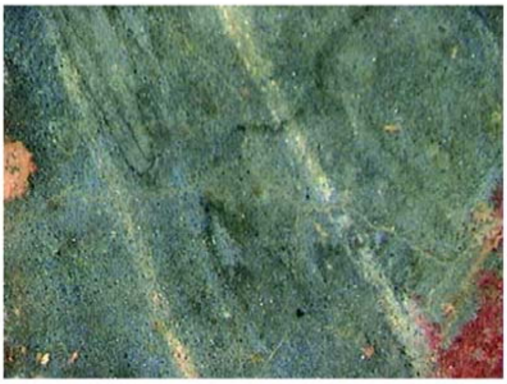
×10

×20

×40

Fig.77 Point 27

×5



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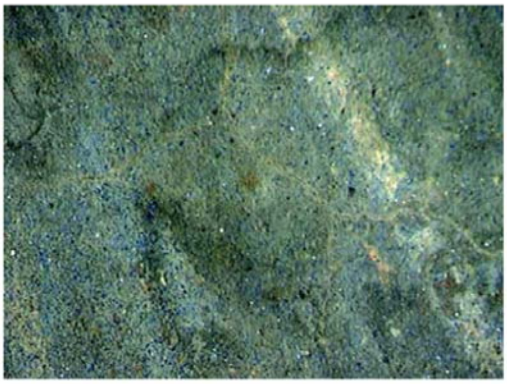

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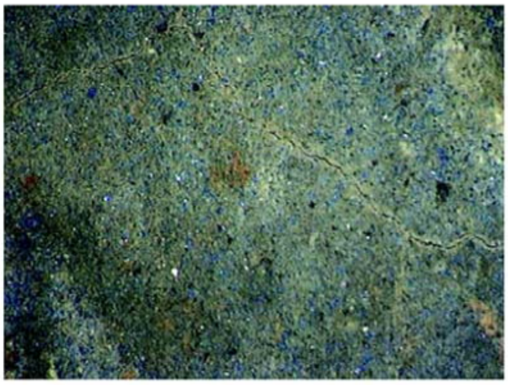
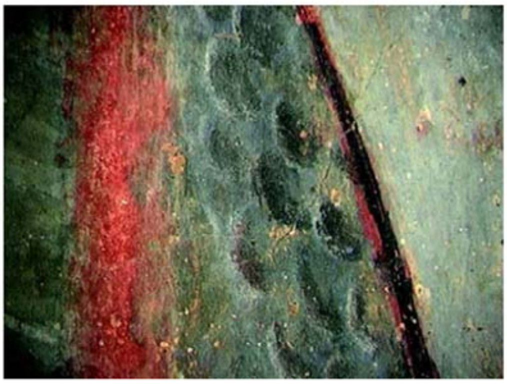


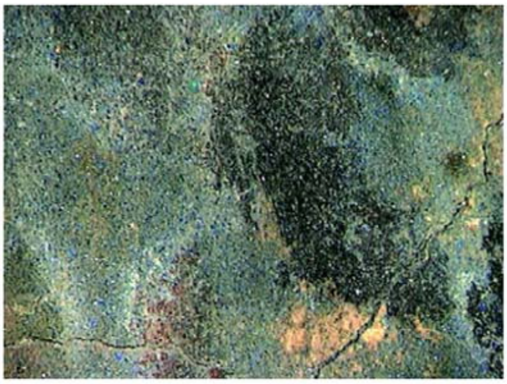
×40

Fig.78 Point 28



×5

×10



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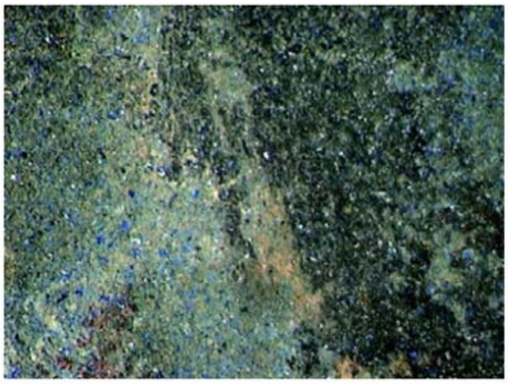


×40

Fig.79 Point 29

Fig.80 Room I west wall

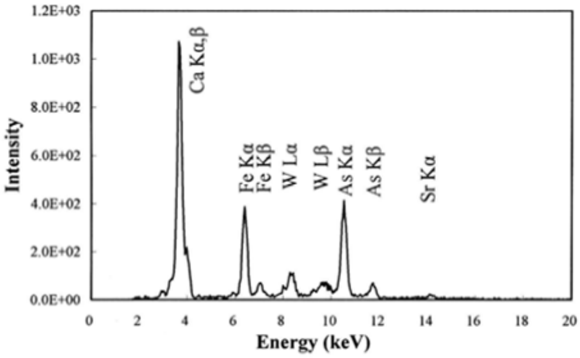


Fig.81 Point 31 XRF

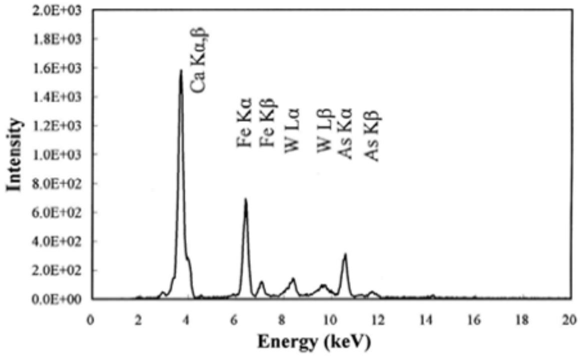


Fig.82 Point 32 XRF

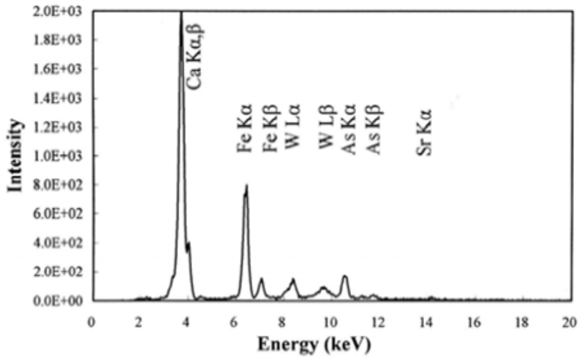


Fig.83 Point 33 XRF

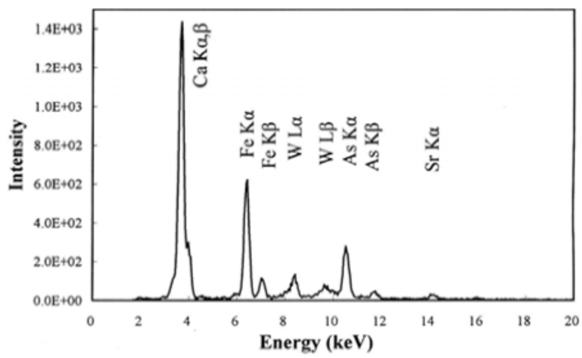


Fig.84 Point 34 XRF

×5

×10

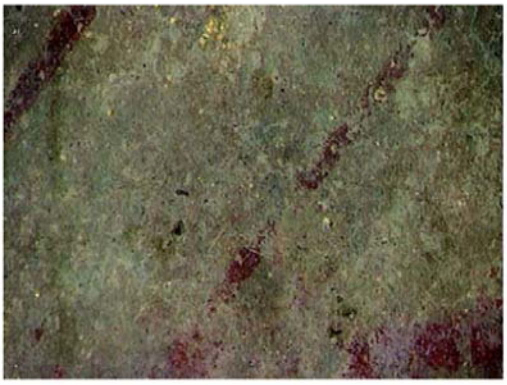
×20

×40

Fig.85 Point 31

×5

×10



×20

×40

Fig.86 Point 32

Fig.87 Room I west wall

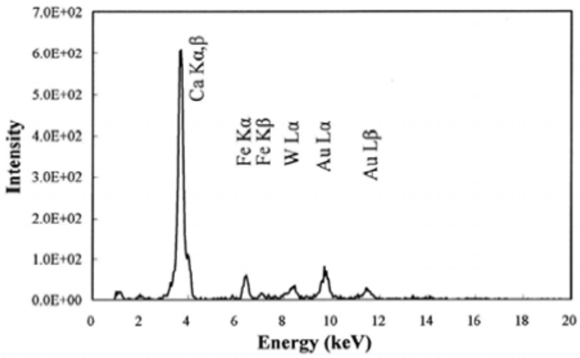


Fig.88 Point 35 XRF

×5

×10

×20

×40

Fig.89 Point 35

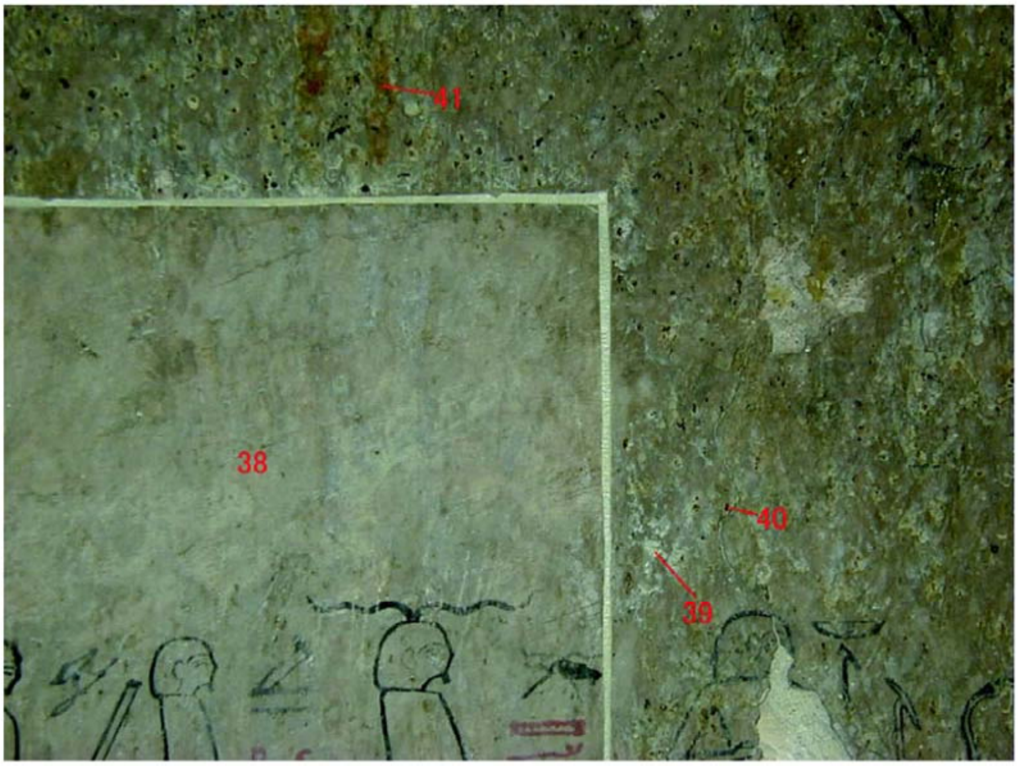


Fig.90 Room J south wall

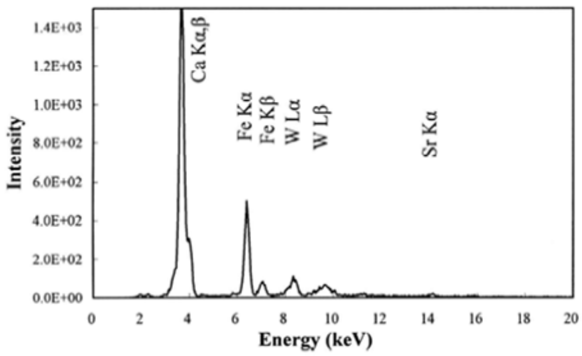


Fig.91 Point 38 XRF

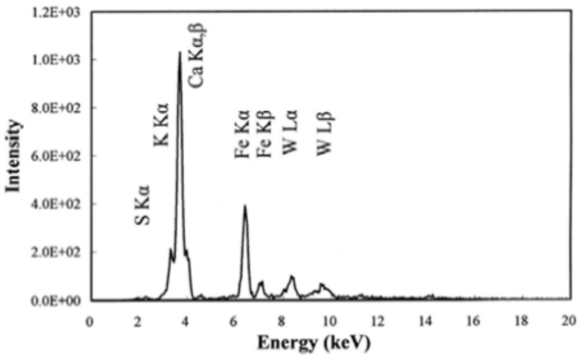


Fig.92 Point 39 XRF

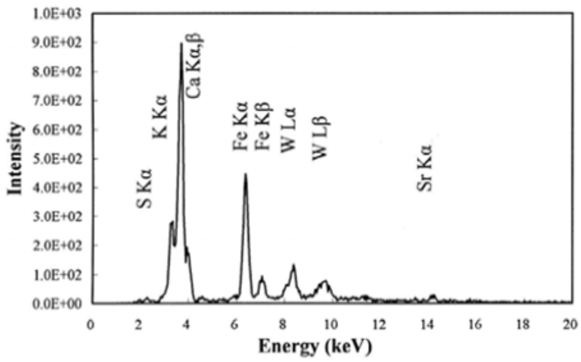


Fig.93 Point 40 XRF

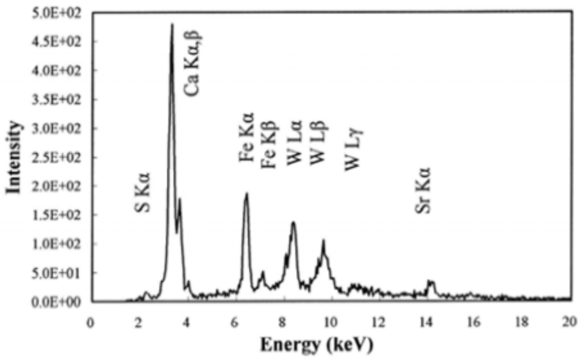


Fig.94 Point 41 XRF

5. Rock Mechanical Investigation

A Report on Environmental and Rock Mechanical Investigations for the Conservation Project in the Royal Tomb of Amenophis III

Masanori HAMADA[1], Ömer AYDAN[2], and Hisataka TANO[3]

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3) Professor, Department of Civil Engineering, Nihon University

1. Purpose

The tomb of Amenophis III has been deteriorating and some fracturing of pillars and walls have already taken place. The most important goal of the investigations is to understand the present state of the underground cavity and to suggest the most appropriate measures for retaining the stability of underground tomb if necessary. The main steps and contents of investigations are as follows.

1) Assessment of geological, hydro-geological and environmental conditions
This item involves gathering past documents on geological, hydro-geological and environmental conditions. Survey in outcrop for geological rock units, the state of weathering, jointing etc., *in situ* monitoring such as installing temperature and humidity sensors in the cavern at appropriate locations for environmental conditions.

2) Rock mechanics investigations
Index tests, short and long term thermo-hydro-mechanical properties of surrounding rock, joint surveying, classifications etc., crack propagation and its monitoring, initial stress state assessment.

3) Stability assessment
This may involve several different types of empirical methods and numerical analyses. The analyses may be uncoupled or coupled short and long-term thermo-hydro-diffusive mechanical analyses through numerical methods such as the finite element method.

4) Proposal for counter measures
If the assessment analyses indicate that the underground cavity is unsafe, the group would suggest appropriate counter measures for the restoration and preservation of the underground tomb with the considerations of local conditions and archeological aspects.

The group visited the site during March and April in order to carry out the investigation concerning the *in situ* condition of rock mass, thermo-diffusive-mechanical properties of rock, *in situ* performance of surrounding rock mass and instability problems of the rooms of the underground tomb. The investigators report the results of various investigations and monitoring during the periods of their visit in this report.

2. Geography

Egypt is situated at the north-east corner of African Continent. It has 997,740 sq. km and its population is more than 68 million. The population is concentrated within the green belt of the Nile River and Nile Delta. It is a quite flat land and more than 96 percent of the land is desert (Fig.1). Egypt is bordered by Libya on the west, by Sudan on the south, and by the Red Sea and Israel on the east.

Egypt is divided into two unequal, extremely arid regions by the landscape's dominant feature, the northward-flowing Nile River. The elevation between the estuary of Nile and Aswan is about 200 m. The highest lands are in the south and the land slopes gently toward the Mediterranean Sea. There are some mountains located on the southern Sinai Peninsula. Some of these reach over 2600 meters. The land at the Mediterranean is at sea level.

The climate is very dry and there is almost no rainfall on a regular basis (Fig.2). Prior to the construction of the Aswan Dam, the people depended on the annual summer floods of the Nile River for water. The floods used to begin in June and end in October.

The flat plain on the West Bank of the Nile River at Thebes stretches from the river to a mountain chain with numerous valleys that threaded through tall, soft stone cliffs. Furthermore, the Valley of the Kings was fairly remote with its narrow access.

The Valley opens up at its narrowest point and runs west and northwest until it turns south before reaching its two main branches (Fig.3). The Valley of the Kings itself, known as Biban al-Muluk, is actually made up of two separate wadis, or ravines, including the main eastern branch and a larger western branch. Most of the royal tombs are located in the smaller, eastern branch, where they have traditionally been coded as KV (King's Valley). The few known tombs in the western branch, which obviously leaves the main branch in a westerly direction, may also be designated as having KV tombs, but are just as often referenced as WV (Western Valley) tombs. It continues to the southwest through towering rock formations and ends in a large natural amphitheater where the rock walls rise dramatically above the desert plateau.

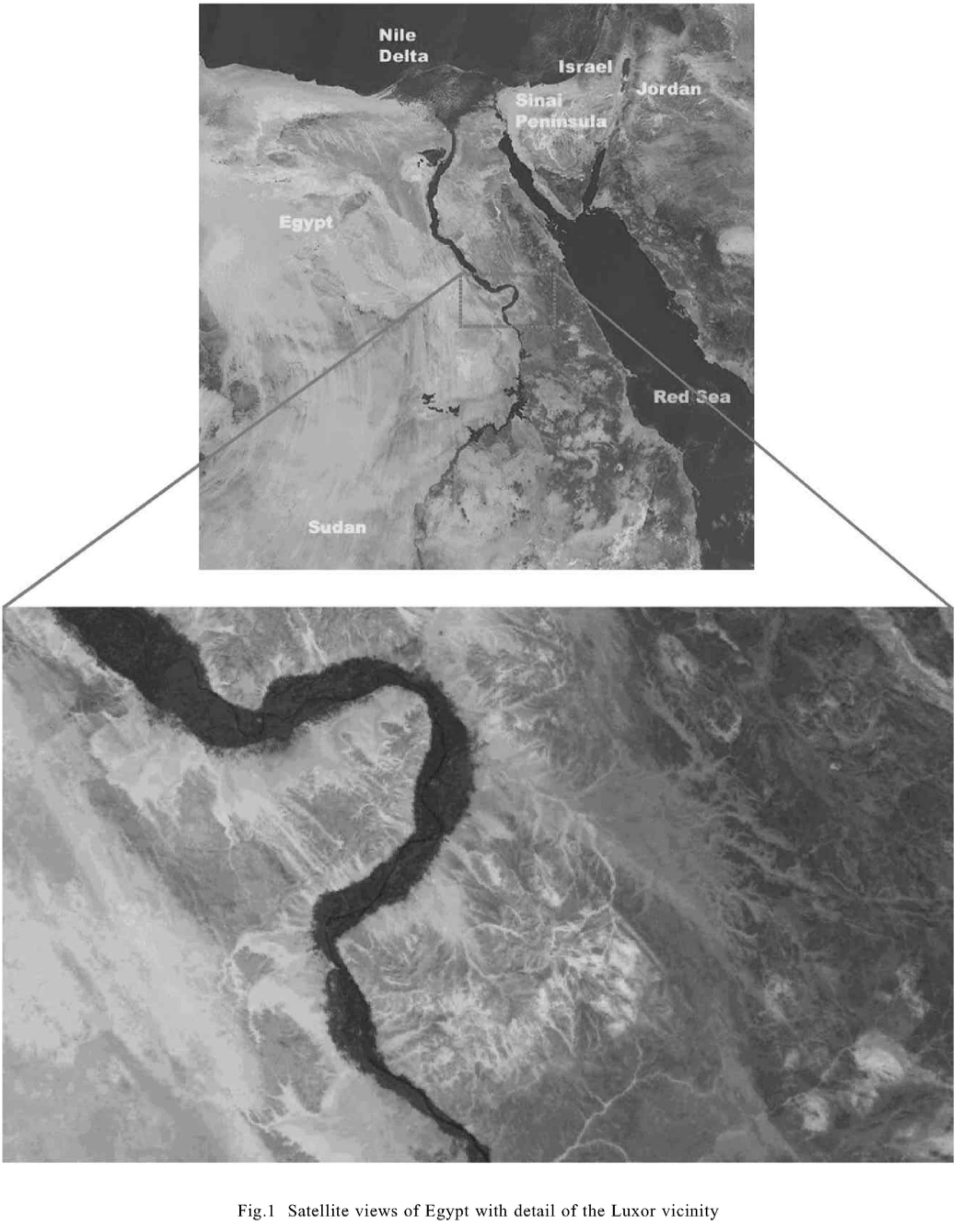


Fig.1 Satellite views of Egypt with detail of the Luxor vicinity

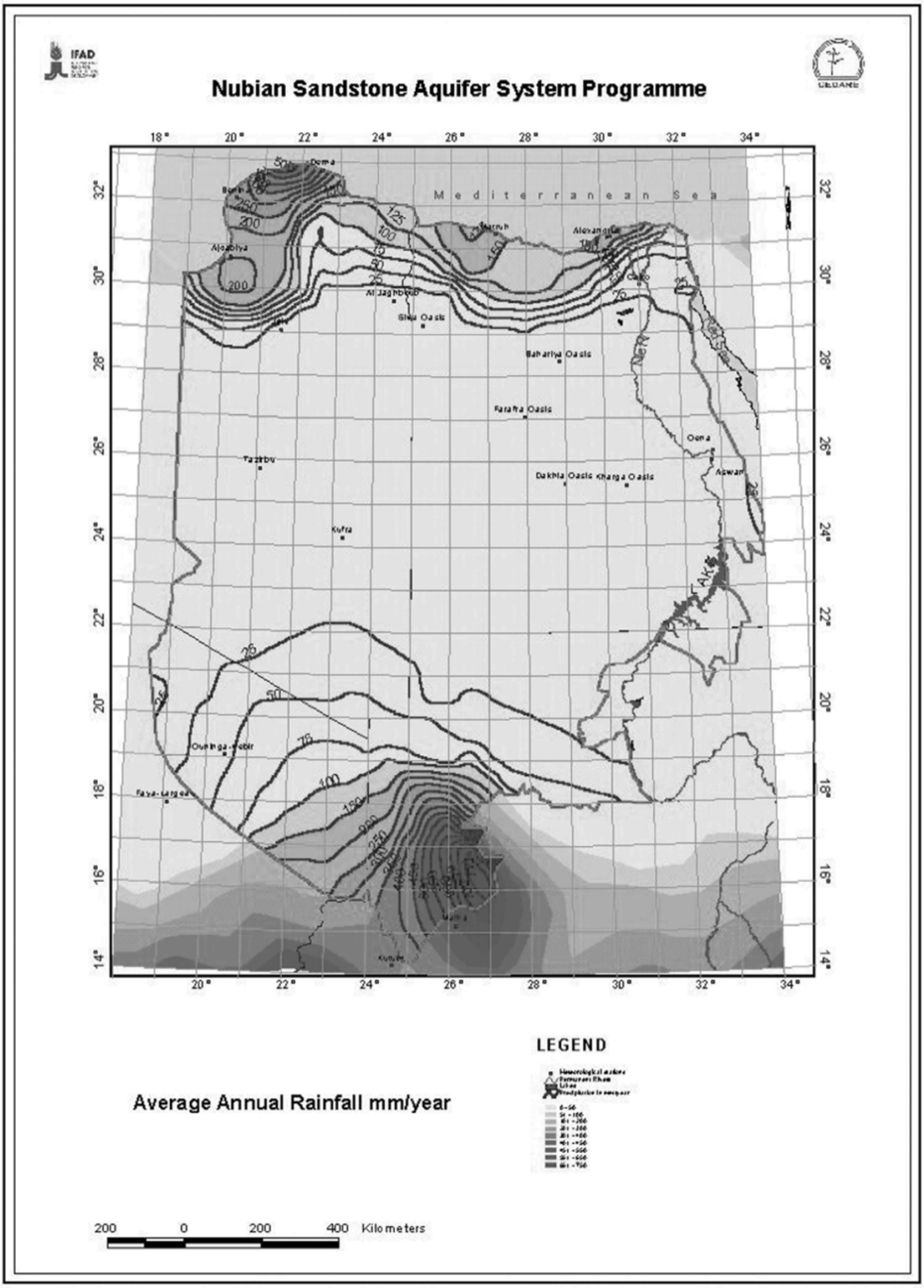


Fig.2 Average annual rainfall of Egypt

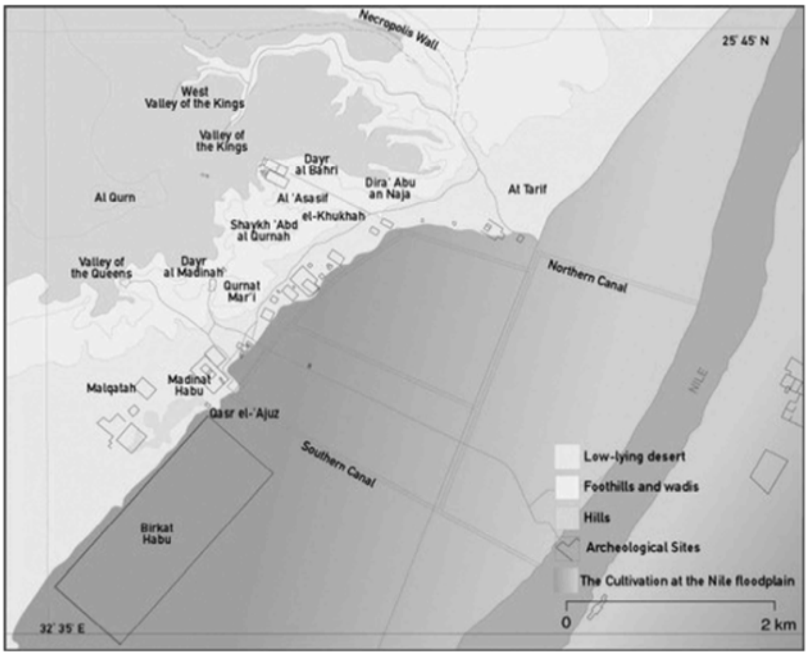


Fig.3 Topography and aerial view of Thebes and its valleys

3. Geology

The region consists of three distinct sedimentary rock formations referred as Dakhla chalk, Esna shale and Theban limestone, which date from between 35 and 56 million years ago. The West Bank at Luxor (ancient Thebes) is primarily made up of these last two layers. The thickness of the limestone formation varies between 60 to 300 meters. A spectacular view of these two formations can be seen at Deir al-Bahri (Fig.4). A transition zone consisting of shale and limestone exists between these two distinct sedimentary formations. Limestone consists chiefly of the mineral calcite, but it can also contain other constituents such as quartz, chart, clay, iron oxides, organics and dolomite. Limestone can be further divided into soft limestone, which may also be called marly limestone, and hard limestone. Marly limestone contains clay while the hard limestone has a crystalline structure (Fig.5). While the shale layer can be observed near the bottom of the Eastern Valley, it does not outcrop in the Western Valley (Fig.6).

Hard limestone is jointed while soft limestone is almost non-jointed. Probably for this reason, the builders of the tombs selected the soft limestone as the most suitable rock unit for excavating the underground tombs. However, they found this rock unit through some trials and errors. The clear evidences of this trial and error procedure can be observed particularly at Deir al-Bahri. It seems that the builders first selected soft shale formation for siting the underground tombs in earlier stages in view of available excavation tools at that time. Since shale easily slakes, the tombs suffered from some stability problems in the roof, as seen in Fig.7. For this reason, they probably later chose the limestone as the roof layer while sidewalls and floor were within the shale layer (Fig.8). However, the limestone layer just above the shale formation (transition zone) is highly jointed, so they again experienced roof stability problems for large span excavations as seen in Fig.9. The advance in excavation techniques and tools and better knowledge of rock characteristics with time led the tomb builders to choose the soft limestone layer for siting underground tombs. In some underground tombs, the builders seem to have designed and built the tombs by following the geometry of the soft limestone layer.

The shale formation could not be observed in either the tomb of Amenophis III or the Western Valley in the vicinity of the tomb. The hard and soft limestone layers can be easily differentiated through the difference in the slopes of the cliffs. The slope of the cliff is very steep for hard limestone layers while it is gentle for soft limestone layers, as seen in Fig.10. In the close vicinity of the tomb several normal faults are observed. One such fault is also seen in Fig.10. The layers with flint nodules are almost horizontal (Fig.11).

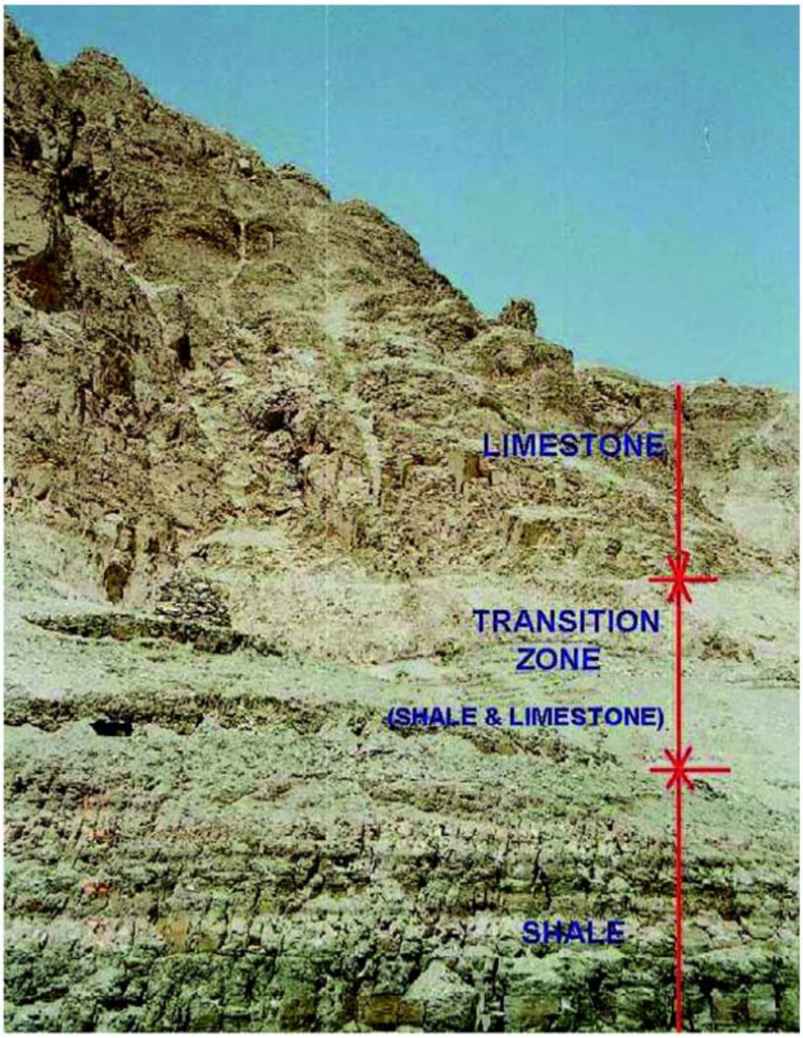


Fig.4 A view of rock formation at Deir al-Bahri

Fig.5 Views of soft and hard limestones from the tomb of Amenophis III

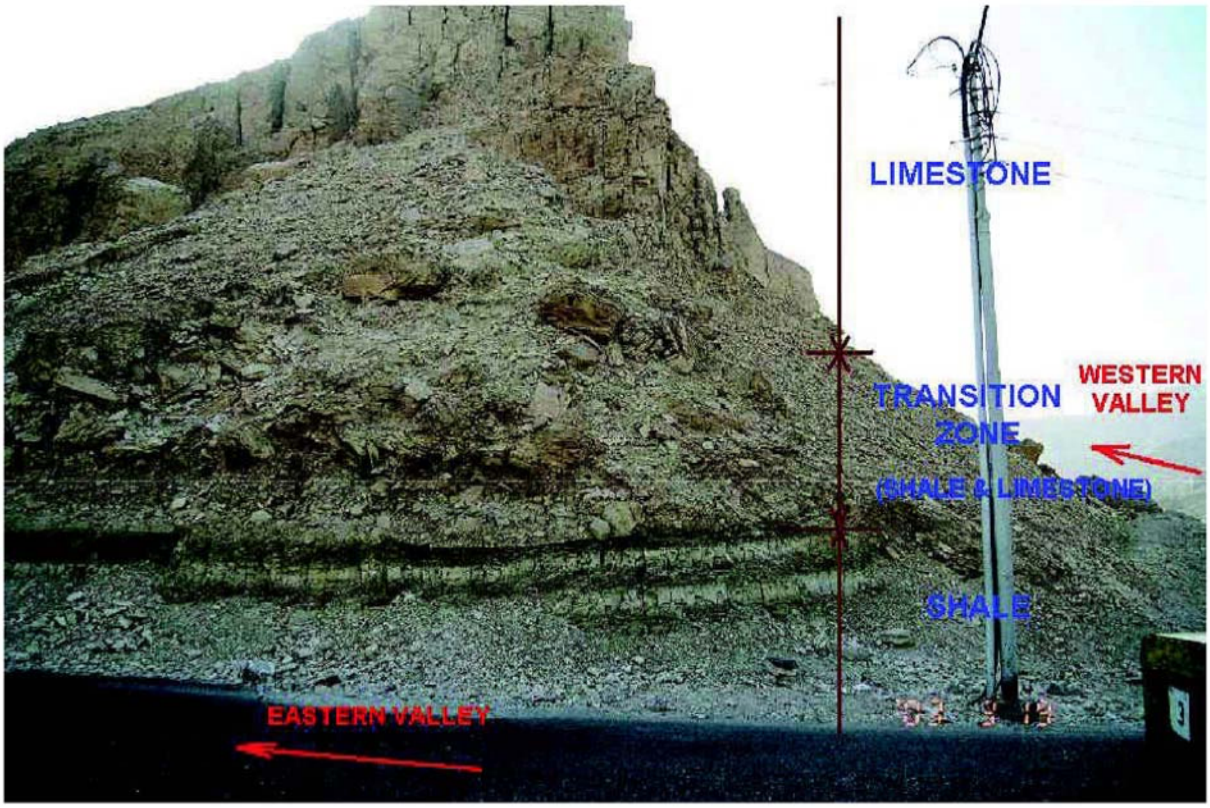


Fig.6 A view of a rock formation at the junction of Eastern and Western Valleys

Fig.7 Entrance to underground tomb at Deir al-Bahri in Esna shale (note the fracturing and separation in the roof)

Fig.8 A small underground cavity with a limestone roof at Deir al-Bahri

Fig.9 Roof stability problems of underground tombs with limestone roofs at portals at Deir al-Bahri

Fig.10 A general view of rock units in the close vicinity of the tomb of Amenophis III

Fig.11 A view of layering in the east wall of room Je with flint nodules

4. Tectonics and Seismicity

There are three major plate boundaries, namely, the African-Eurasian plate margin, the Levant transform fault, and the Red Sea plate margin (Fig.12). A piece of the African plate, called the Sinai block or sub-plate, is partially separated from the African plate by the rifting along the Gulf of Suez. In addition to these plate boundaries, there is a mega-shear zone running from southern Turkey to Egypt.

The *African and Eurasian plates* (Anatolian) converge across a wide zone in the northern Mediterranean Sea. The zone is characterized by folding within the Mediterranean Sea floor and subduction of the northeastern African plate to the north beneath Cyprus and Crete. To the north of the margin, there is a complex zone of convergence (folding and reverse faulting) and strike-slip faulting. The effects of the plate interaction are mainly north of and remote from the Egyptian coastal margin.

The Arabian plate is continuing to rotate away from the African plate along the *Red Sea* spreading center. Current sea-floor spreading has been identified as far north as about 20° to 22° north, from the continuous presence of basaltic crust in the axial rift of the Red Sea, and the geophysical signatures of newly emplaced oceanic crust (Cochran, 1983). This axial rift represents the boundaries between the Arabian and African plates.

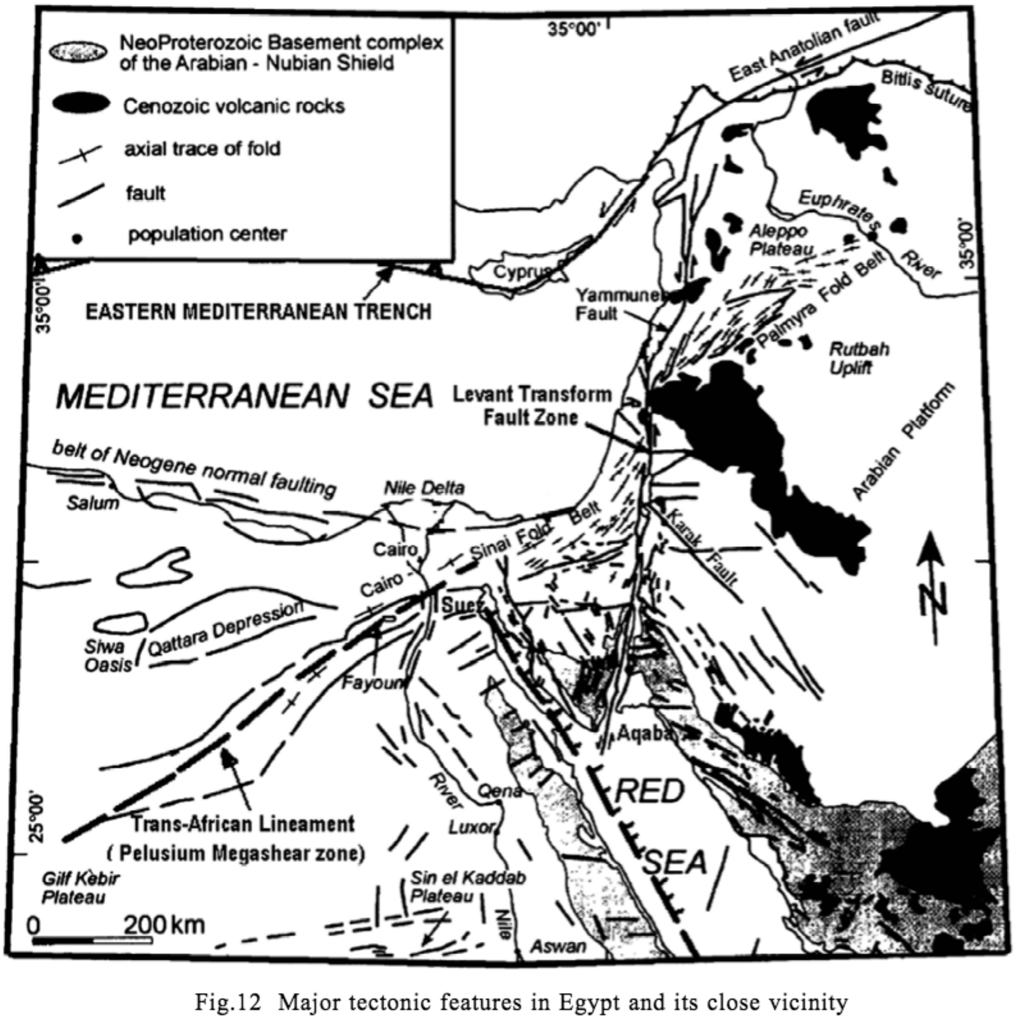


Fig.12 Major tectonic features in Egypt and its close vicinity

Table 1 Destructive earthquakes in Egypt

Date			Lat	Lon	Io	Mb	Remarks
Year	Month	Day					
2200 B.C.			30.5	31.7	VII	5.4	Lower Egypt
1210 B.C.			23.6	32.6	VII	5.4	Abu Simbel
600 B.C.			27.6	33.9	VIII	6.1	Thebes
28 B.C.			27.6	33.9	VIII	6.1	Thebes
320			32.0	30.0	VII	6.0	Alexandria
956	1	1	32.0	30.0	VII	6.0	Alexandria
967			25.5	34.5	VII	5.4	Luxor (VI), Aswan (V)
1111	5	26	30.0	32.0	VIII	5.4	Cairo
1303	8	8	29.9	31.0	VIII	5.4	Alexandria, Al Faiyum
1754	9	10	30.0	32.0	VII	5.4	Cairo (2/3 destroyed)
1847	8	7	29.5	30.5	VII	5.4	Cairo
1955	9	12	32.2	29.6	VII	6.0	Alexandria
1969	3	31	27.6	32.9	VII	6.1	Nile Valley & Nile Delta
1981	11	14	23.6	32.6	VII	5.6	Aswan
1992	10	12	29.9	31.0	VIII	5.4	Cairo (Dahshur Earthquake)
1995	11	22	28.8	34.5	VIII-IX	7.0	Cairo (Aqaba Earthquake)
1999	12	28	30.3	31.5	V	4.5	Cairo

The Sinai block and Arabian plate are separated by the *Levant transform fault zone*, along which left-slip faulting has been observed. North of the head of the Red Sea, the Levant transform fault extends along the lineament marked by the Gulf of Aqaba and the Dead Sea. Prominent left-slip faulting has been observed on this zone. The total amount of left-slip was proposed to be 110 km.

The Gulf of *Suez* is controlled by a *rift* that extends northwest into the African plate from the junction of the Red Sea rift and the Levant transform fault. It separates northeastern Egypt from the Sinai Peninsula. The Suez rift may have become active as early as the late Mesozoic or late Eocene, and established its depression by early Miocene. The Suez rift is a tectonically active structure that is considered to be a sub-plate boundary that formed as relic of the early opening of the Red Sea.

A major transcurrent shear zone that belongs to the Pelusium *Megashear* system across Africa passes through Egypt. This *megashear* zone, which extends from Turkey to the south Atlantic, runs sub-parallel to the eastern margin of the Mediterranean Sea then curves southwest across Africa from the Nile Delta to the Delta of Niger. This zone may correspond to the Eastern Mediterranean-Cairo-Faiyum zone in northern Egypt, which recently showed seismic activity.

Egypt has a historical record of earthquake activity extending over the past 4,800 years. It was found that, for Egypt, a total of 58 earthquakes were reported, with intensities of V-IX, during the period 2200 B.C. - 1900 A.D. Some of these earthquakes are reported without much information regarding the epicentral area; some have locations outside the Egyptian border. Altogether, 22 of the earthquakes have reliable information concerning the location. 11 of these earthquakes caused destruction (Table 1).

Badawy (1991) plotted the epicenters of earthquakes between 1900 and 2000 compiled from

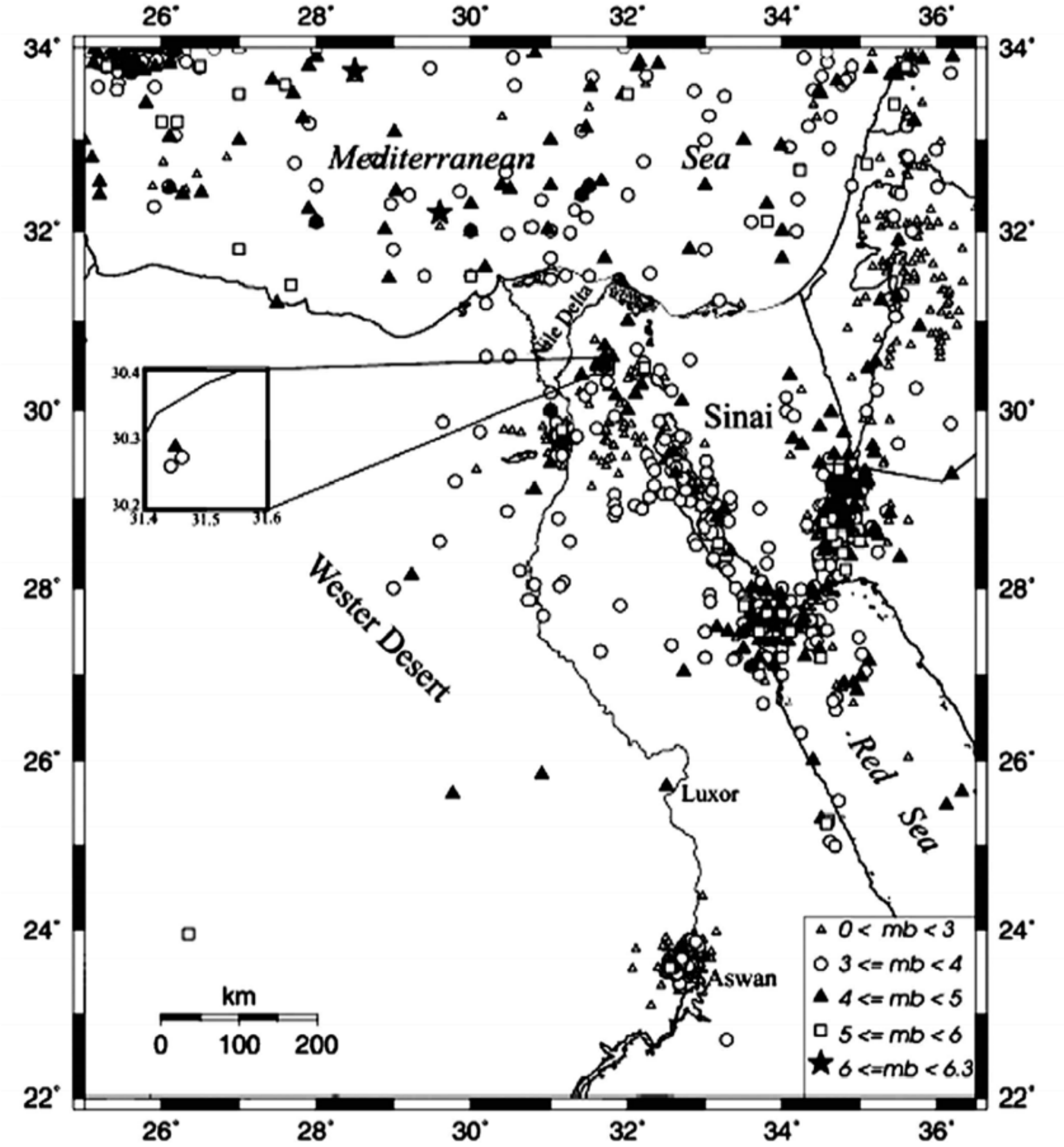


Fig.13 Epicenters of earthquake in Egypt and adjacent areas for 1900-2000 (after Badawy 2001)

different sources and results are shown in Fig.13. From these plots he drew the following conclusions:
1) There is a concentration of earthquakes in four major zones. These zones are known as Northern Red Sea-Gulf of Suez-Cairo-Alexandria trending NW-SE, Gulf of Aqaba-Levant Fault, NNE-SSW, Eastern Mediterranean-Cairo-Faiyum, NE-SW and Egypt-Mediterranean Coast, E-W.
2) Four destructive earthquakes occurred in 1955, 1969, 1981, and 1992 (See Table 1).
3) There are noticeable clusters of activities at the north end of the Gulf of Aqaba, the entrance of the Gulf of Suez into the Red Sea and the eastern Nile Delta.
4) Occurrence of both mainshock-aftershocks and swarm types of activity exists. An example of the mainshock-aftershocks is the earthquake activity in the Gulf of Suez starting on March 31, 1969. The destructive main shock had a magnitude of 6.9 and the epicenters of the aftershock sequence correlate

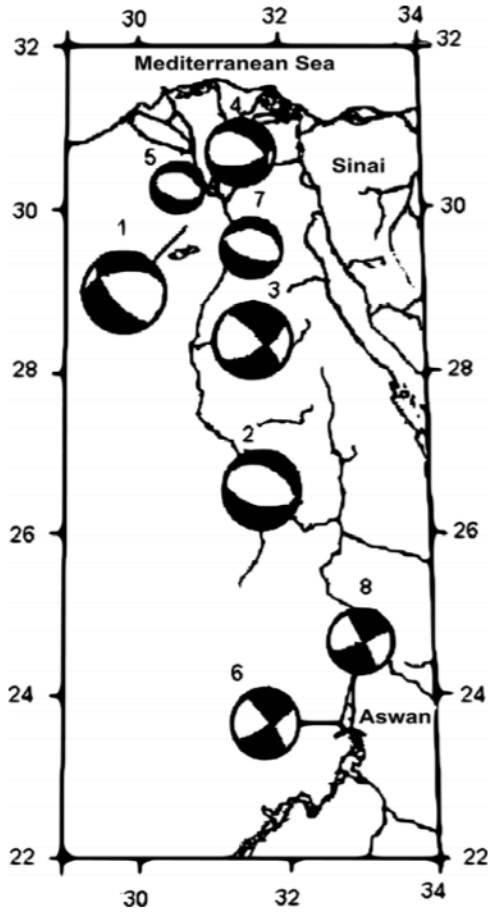


Fig.14 Epicenters and the focal mechanism solutions available for the Nile valley and its delta in the time period 1992-2001 (NRIGAG, 2001). The numbers in the figure are arranged in ascending order according to the date of the earthquake. The size of each beach ball is proportional to the magnitude of the earthquake (Mb=3-5.3)

with a major NE-SW oriented strike-slip fault that crosses the Red Sea close to the Gulf of Suez. Also the destructive earthquakes of November 14, 1981 and October 12, 1992 were followed by many aftershocks. The epicenters of the 1981 sequence can be correlated with a WNW-ESE oriented fault system that dominates the Aswan area. For the 1992 event, described in the following section, 26,397 aftershocks with magnitude 4.0 were reported. The distribution of the largest aftershocks, reported by PDE, was aligned along the WNW-ESE oriented Northern Red Sea-Gulf of Suez-Cairo-Alexandria fault system, showing surface lineaments. Sequences in the Gulf of Aqaba in 1983 and 1993 show examples of swarms, each lasting several months. The swarms were associated with a strike-slip fault system and upwelling magma in the Gulf of Aqaba.

5) Isoseismals for large earthquakes can extend along the Nile Valley. For example, the event of September 12, 1955 near Alexandria had an intensity of V as far away as Luxor (at 650 km distance), but was not felt at a 150 km distance east and west of the valley. The event of March 31, 1969 in the northern Red Sea showed high intensity attenuation in the north-south direction, but was felt along the Nile Valley between Aswan and Alexandria.

6) The events in 1210 B.C. and 1854 close to Aswan, as well as tectonic studies for the Aswan High

Dam area support the fact that significant seismic activity of tectonic origin has occurred. Water and sediment loads could have been triggering factors. The recent micro-seismicity is likely to have been induced by the reservoir.

The origin of the Nile Valley has been a subject of controversy. Some suggested that the Nile Valley is of erosional origin. On the other hand, many researchers consider it of tectonic origin. The tectonic origin of the Nile Valley is supported by the fault scarps bordering the cliffs of the Nile Valley, by the numerous faults recognized on its sides and by the focal mechanisms of the most recent earthquakes. Moreover, recent studies indicate that the Nile Valley of Egypt occupied the marginal part of two tectonic zones, and it is considered to have been a barrier preventing the extension of the activity of the East African orogenic belt to the west. From the evolution of the Nile River from its sediments in Eonile Canyon since the late Miocene (Messinian) age, five episodes affected by meteorological and tectonic activity were identified. The most intense seismic activities reported for the Nile Valley are related to the tectonic activity of the Red Sea axial zone and with the eastern Mediterranean recent tectonism. No evidence of major faulting or seismic activity is known from northern Egypt since the early Miocene, although the valley extends along a seismo-active zone. Fault plane solutions for selected events with a fairly good records in the Nile Valley indicate that the normal faulting mechanism of WNW strike is the dominating mechanism along the Nile Valley and its delta, while a strike slip mechanism of ENE is more common around Lake Nasser (Fig.12). These mechanisms are in agreement with the known tectonics along the Nile Valley.

As noted from Fig.12, earthquakes are quite scarce in the vicinity of the tomb of Amenophis III. The largest event had a magnitude less then 5.

5. Initial Stress in the Vicinity of the Tomb

(1) Summary of previous studies

The mechanical stability analysis of the tomb requires information on initial stress state in its close vicinity. There are currently no *in situ* stress measurements near the tomb. However, Badawy (2001) recently tried to infer the stress state for Egypt by using borehole breakouts and earthquake focal mechanisms. Fig.15 and Fig.16 show the inferred maximum horizontal stress directions suggested by Badawy (2001). From these figures, the maximum horizontal stress direction would be NW-SE in the close vicinity of the tomb. However, it is almost impossible to obtain the required information on the *in situ* stress state for structural stability analyses for the tomb.

(2) Inference of initial stress in the vicinity of the tomb

Since no-direct stress measurements are available for the site, some *in situ* stress inferences from structural geological features and earthquake faulting mechanisms are reported herein. During site

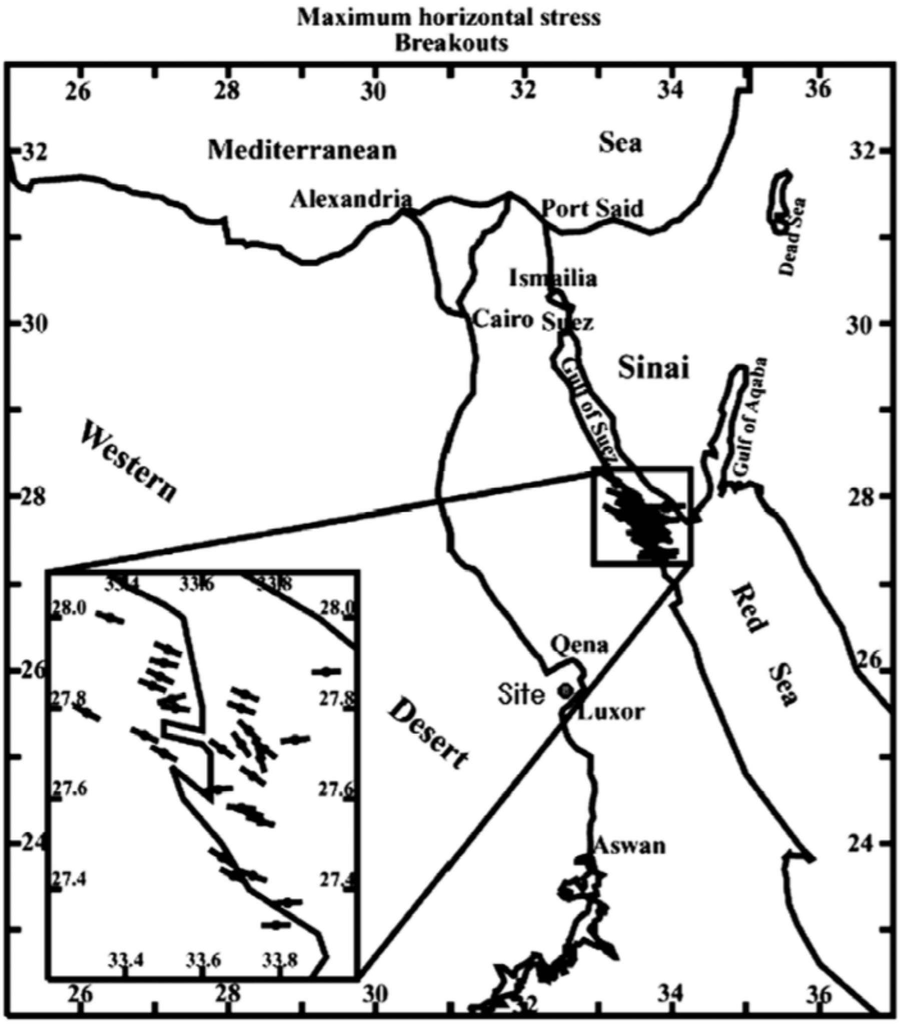


Fig.15 Inferred maximum horizontal stress directions from borehole break outs (modified after Badawy 2001)

investigations, the authors noticed two major faults and several minor faults (Fig.17). The measurements on fault parameters are given in Table 2.

The stress states for faults FI-1 and FI-2 inferred by using Aydan's method (Aydan 2000) are shown in Fig.18 and Fig.19. Both computed results are very similar. They imply that vertical stress is the major principal stress while horizontal stresses are intermediate and minor principal stresses. The largest horizontal stress will act in the direction of NW-SE (304.41) while the least horizontal stress will act in the direction of NE-SW (34.1), which is nearly parallel to the flow direction of Nile River in the region.

As discussed previously, the earthquake activity is quite scarce in the vicinity of the tomb. The nearest (126km) recent event with a magnitude (Mw) of 5.1 occurred on July 2, 1984. Fig.20 shows the inferred stress state for this earthquake by using Aydan's method (Aydan et al. 2002, Aydan and Kim 2002). The results are strikingly close to those inferred from fault striations observed in the tomb. A large earthquake, known as the Cairo earthquake, occurred in December 28, 1999. Although this earthquake is far away from the site, the inferred stress state is once again is quite similar to those presented above (Fig.21).

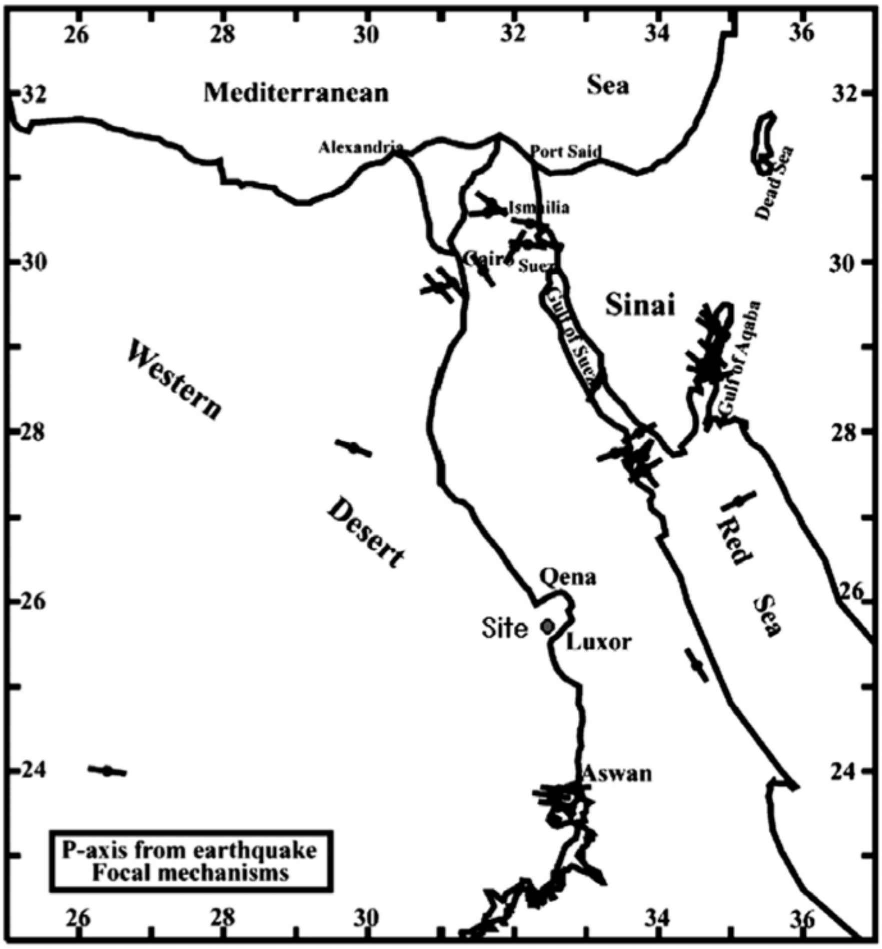


Fig.16 Inferred maximum horizontal stress directions from the focal plane solutions (modified after Badawy 2001)

Table 2 Fault parameters

Fault-No	Dip-direction	Dip	Striation	Location
FO-1	88	56	98	Outside above entrance
FO-2	16	70	100	Outside opposite cliff
FI-1	46	60	65	Room F (main)
FI-2	210	72	100	Room G (conjugate)
FI-3	26	80	Not measured	Room G (secondary)
FI-4	120	64	80	Room Je (pillar)

(a) FO-1 fault above the entrance of the tomb

(b) FI-1 fault in room F next to room E

Fig.17 Views of some faults

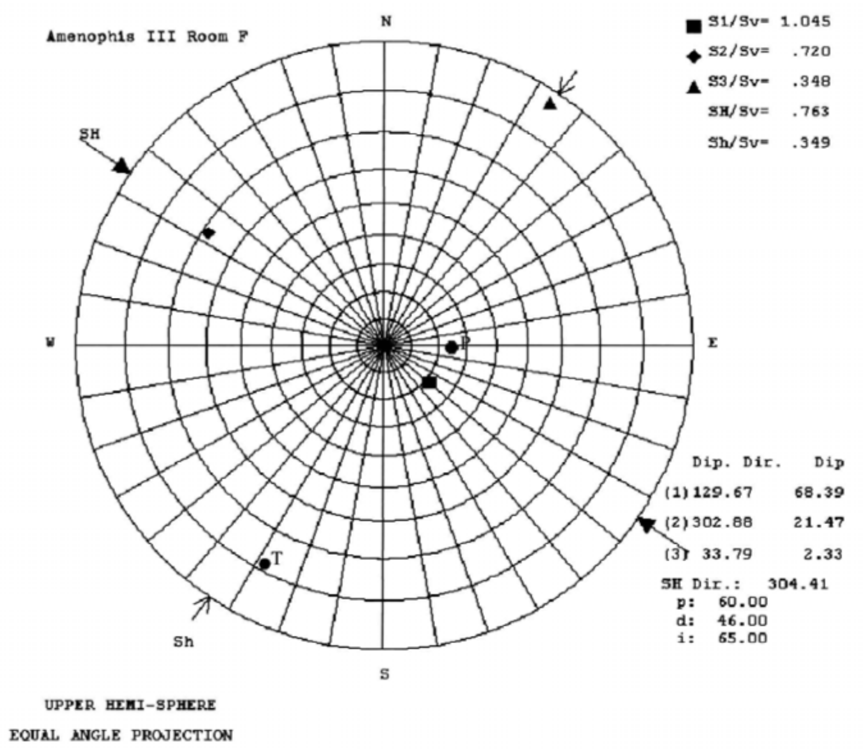


Fig.18 Inferred stress state for FI-1 fault in room F

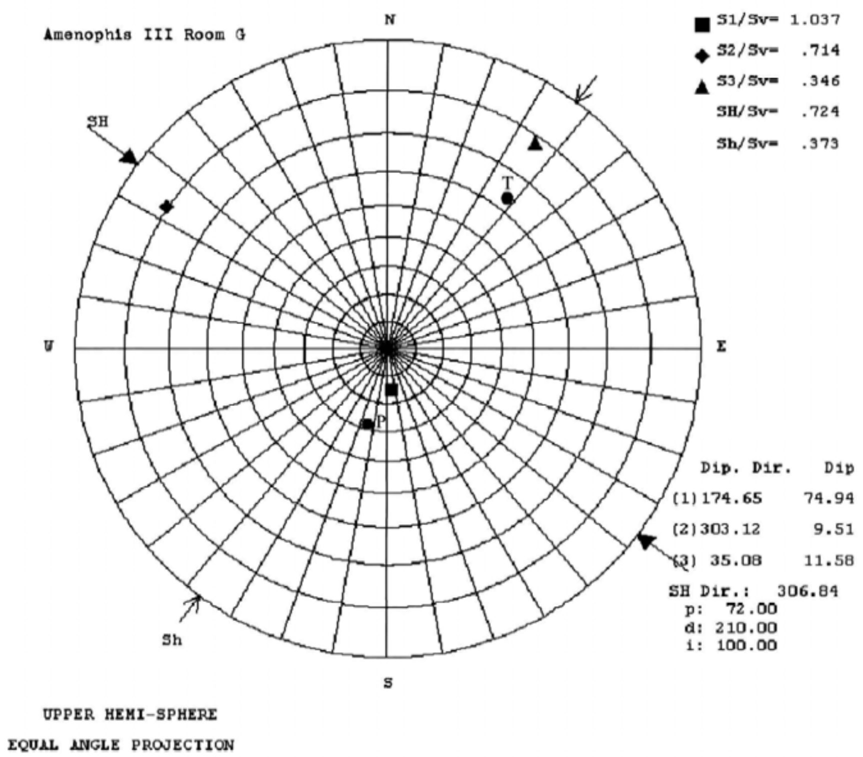


Fig.19 Inferred stress state for FI-1 fault in room G

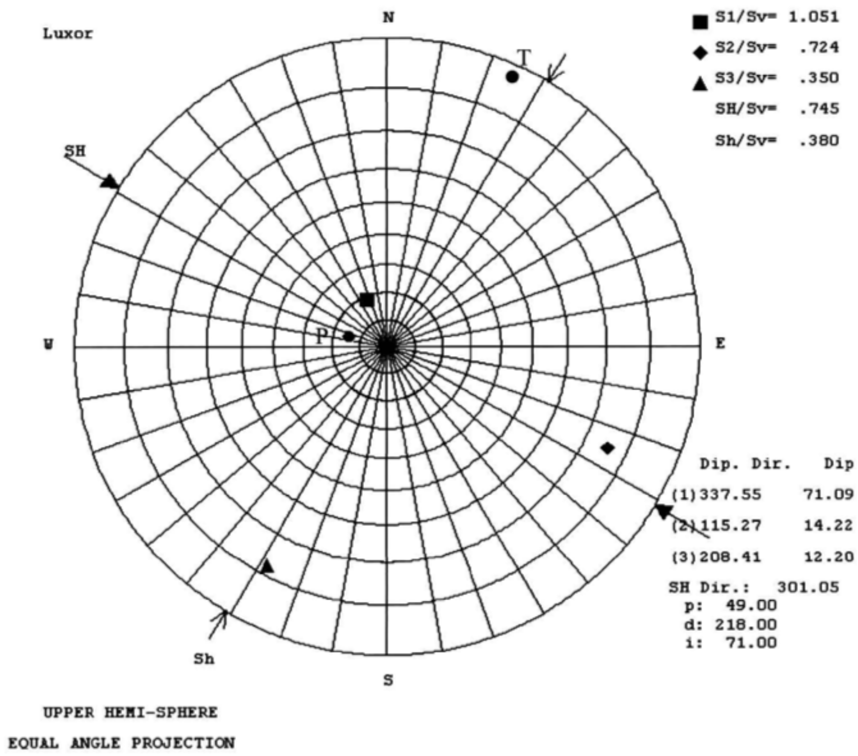


Fig.20 Inferred stress state for the earthquake of July 2, 1984

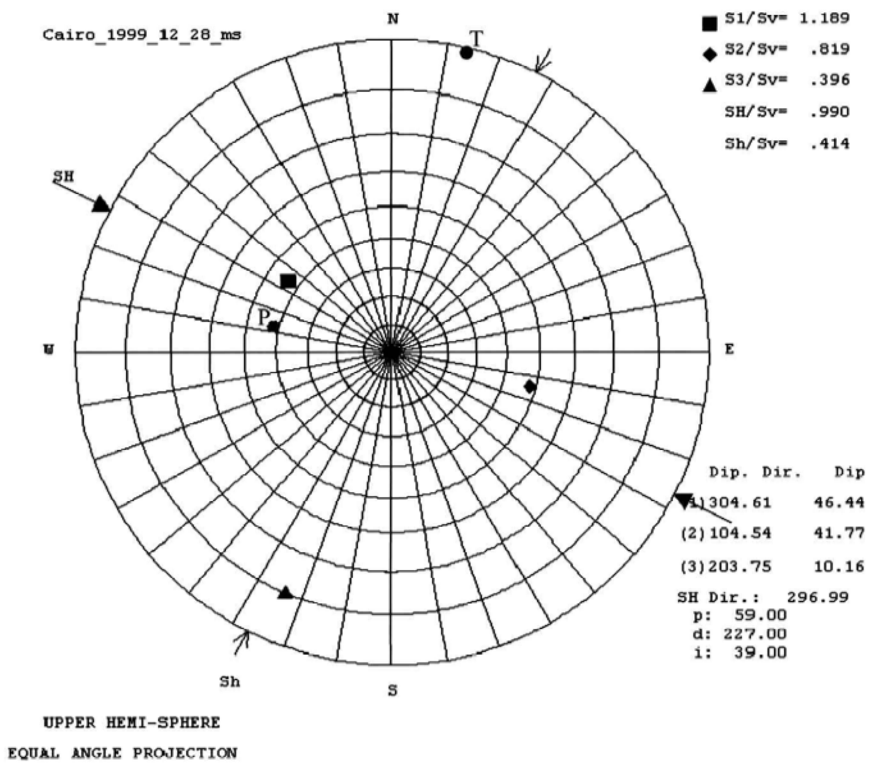


Fig.21 Inferred stress state for the Cairo earthquake of December 28, 1999

6. *In situ* Surveys

(1) Discontinuity survey

Discontinuity surveys were carried out inside the tomb, at the both sides of the Western Valley and the top of the tomb and in the area between the Eastern and Western Valley (Fig.22). Discontinuities were classified as, bedding planes, sub-vertical joints and faults. Fig.23 shows the stereo projections and pole concentration contours of discontinuities.

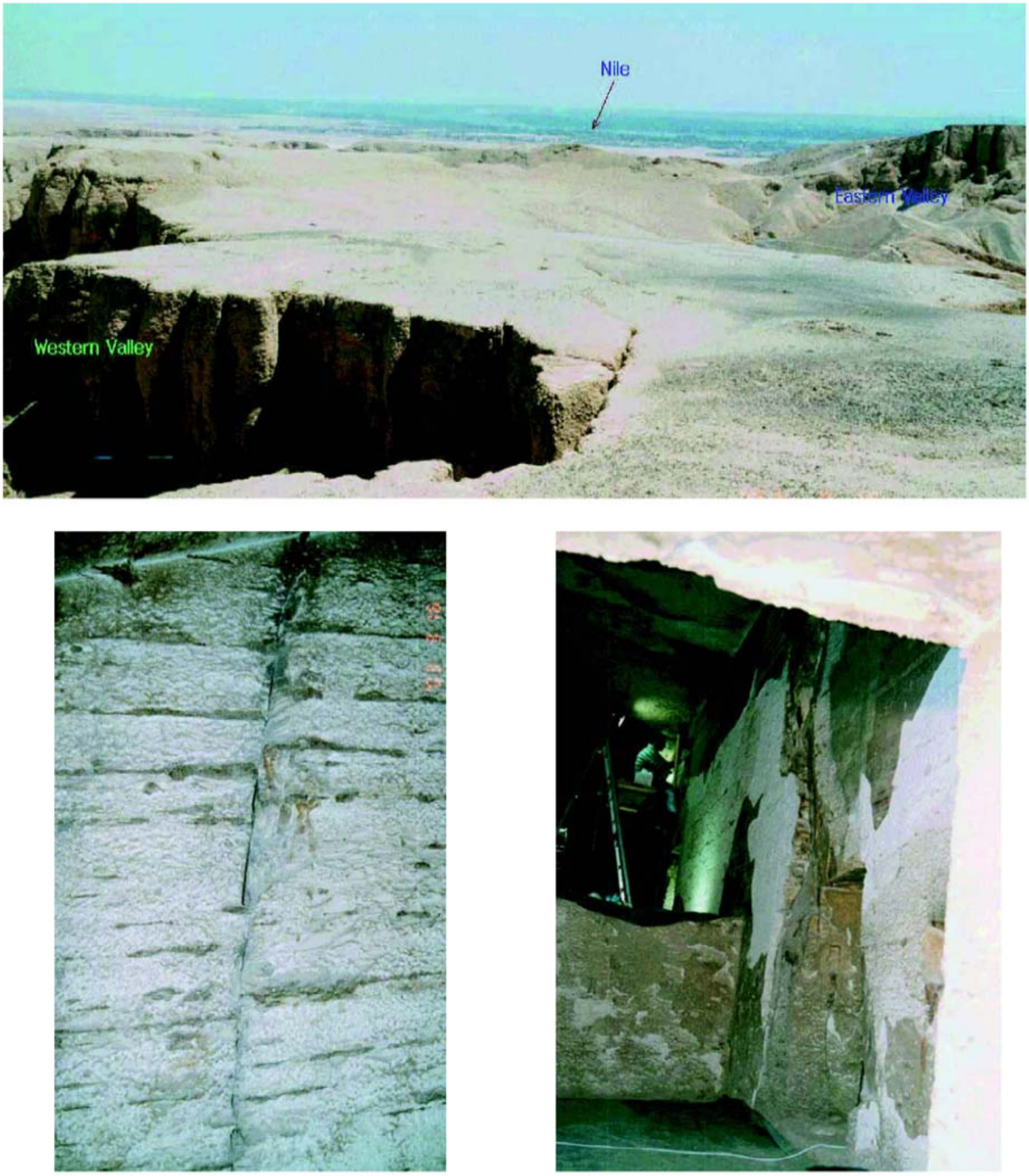
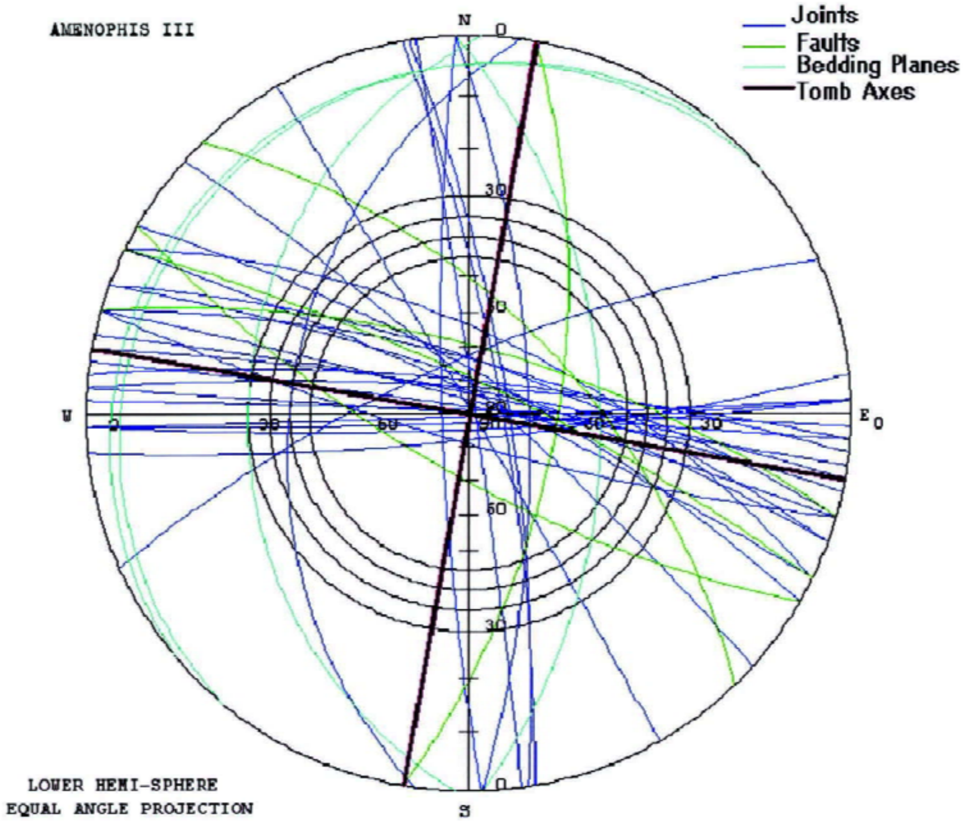


Fig.22 Views of some discontinuity survey sites



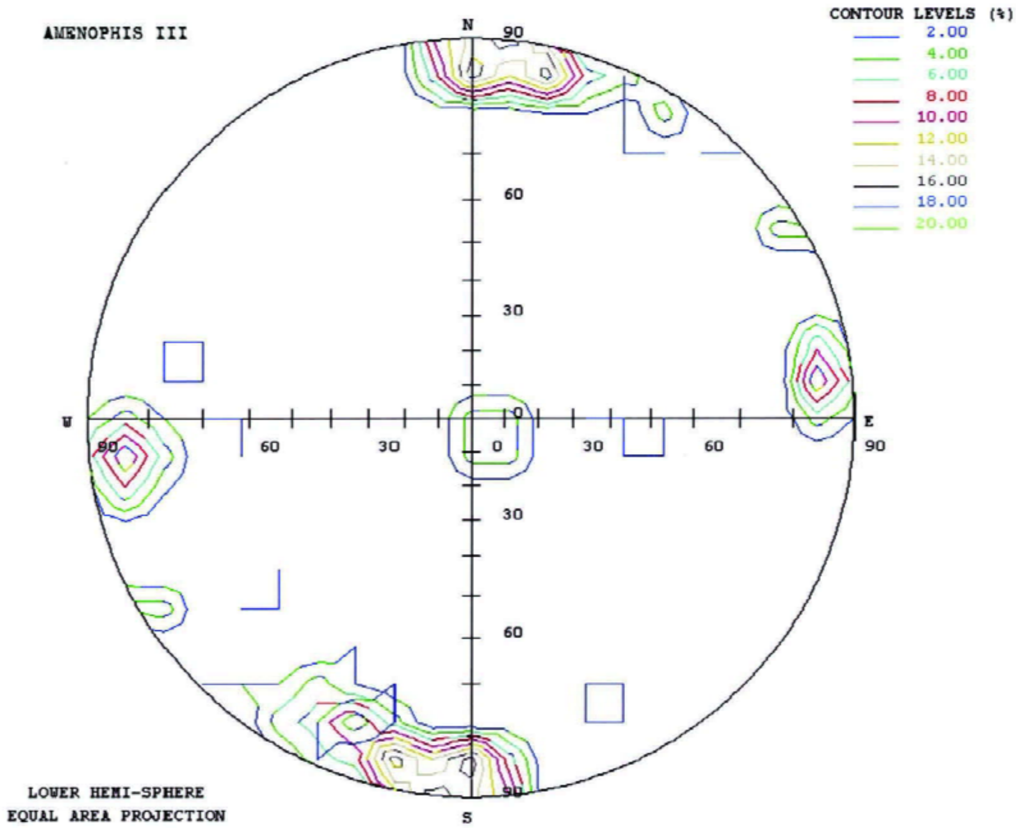
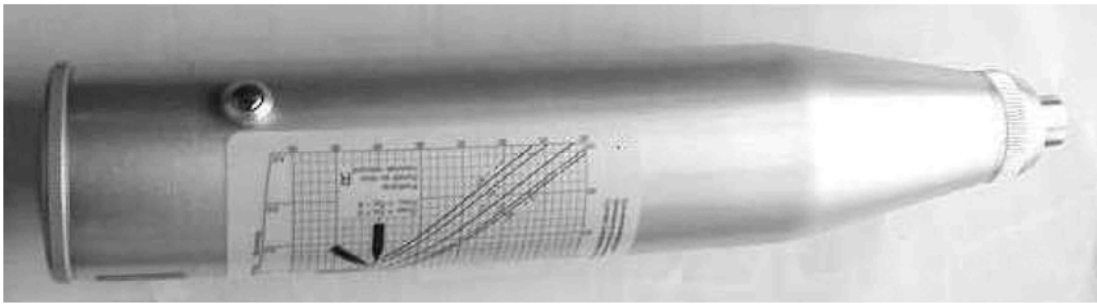


Fig.23 Stereo projections and pole concentration contours of discontinuities

(2) Schmidt hammer survey

Schmidt hammer is commonly used as an index for assessing the state of rock mass as well as inferring the uniaxial strength of rocks. A schmidt hammer survey was carried on rock surfaces accessible in all chambers except room I. Fig.24 shows a view of the Schmidt hammer and its application during the survey. The Schmidt hammer is R-type. Table 3 summarizes the results of measurements.



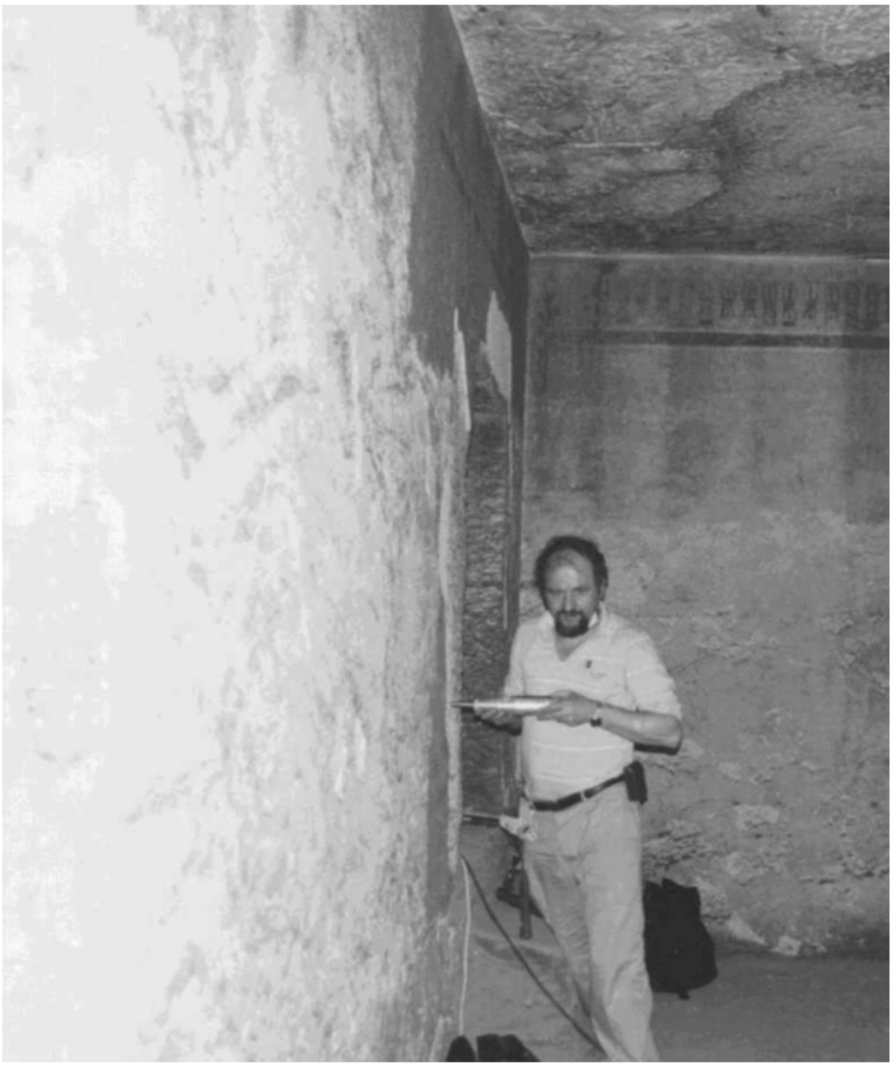


Fig.24 Schmidt hammer and its utilization in room Je

Table 3 Results of Schmidt hammer rebound numbers

Location	North-wall	West-wall	South-wall	East-wall	Roof or Floor
Room Je	42,43,54	34,44,42	35,35,31	37,36,47 27,31,33,36	
Room J	30,40	39,34,38,28	33,34	29,34,36,30	46,44,42
Room Jd	38,44,36,34	37,40,41,46	36,46,33,38	35,42,92	
Room Jd-pillar	40,42,44	41,43,42	40,43,46	34,34,36	
Room Jb	32,34,32	46,40,39	39,44,36	47,34,34 40,32,50,36	
Room Jc	32,32,38	36 25,39,42	40	53,56,50,46	
I-H-gate		38,42,40		39,33,34	
Room G		32,30,43,41		42,37,46,40	
Room F		36,38,33,48	44,38,42	33,31,36	
Room F-pillar1		37	38	34	
Room F-pillar2	34	38	42	44	
Room D	44,48,30,33		36,38,34,32		
C-D-gate	32		34		
Room C	38,37,33,40				
B-C-gate	35	38			
Room B-1	34,38,30		37,34,38		46,40,48
Room B-2	36,42,35		35,37,36		46,48,42
Room A-entrance	46		38		

For R-type Schmidt hammers, the following relations are used for inferring the uniaxial strength σ_c of rocks from Schmidt hammer rebound number R:

$\sigma_c = 10 + 0.6837 * R$ for horizontal direction

$\sigma_c = 10 + 0.6523 * R$ for vertical (upward) direction

$\sigma_c = 12.2 + 0.8333 * R$ for vertical (downward) direction

From these relations, the inferred uniaxial strength of rock will range between 28 and 47 MPa. Since the rock surface was completely dry, the above values should be valid for dry conditions. The Schmidt hammer rebound values were almost uniform throughout the tomb while some small values were observed in fractured zones at room Je, Jd, and J.

At G-room where FI-2 fault was observed, the Schmidt hammer rebound value was 24, while it was 36 and 38 on adjacent rock surfaces. The Schmidt hammer rebound value of flint inclusions ranged between 46 and 52.

(3) Elastic wave velocity measurements

Elastic wave velocity measurements in rock masses are conventionally employed in order to infer the rock mass properties, as well as some yielding or loosening around rock structures. The instrument called Mc SEIS III developed by Oyo Corporation of Japan was used for this purpose (Fig.25). The device has three geophones and one hammer equipped with an accelerometer for triggerring. Fig.25 also shows some views of measurements. Instrumentation layouts are shown in Fig.26. Fig.27 shows some records. The preliminary results of processed data are given in Table 4. The measurements on floor yielded low elastic wave velocities, which imply that some low-velocity zones exist beneath the floors. The pillars, on the other hand, yielded high elastic wave velocities. Furthermore, the wave velocity increases as the elevation increases.

Table 4 Elastic wave velocity measurements

Room	Direction	Lowest Vp (km/s)	Highest Vp (km/s)
Je	N-S	0.862	1.139
Je	E-W	1.200	1.471
J	N-S	1.000	2.090
J	E-W	1.087	1.800
Jd	N-S	1.042	1.139
Jd	E-W	0.980	1.050
I	E-W	1.049	1.220
G	N-S	1.262	1.470
G	E-W	0.971	1.000
F	N-S	0.885	1.471
F	E-W	1.049	2.500
D-1	N-S	1.563	1754
D-2	N-S	1.389	1.818
D-1	E-W	1.087	1.754
D-2	E-W	1.428	1.563
B	N-S	2.000	2.500
B-1	E-W	2.083	2.501
B-2	E-W	1.370	1.613
Jd-pillar-1	Vertical	2.549	3.399
Jd-pillar-2	Vertical	2.195	2.358
Jd-pillar-3	Vertical	1.611	2.712
F-pillar1-1	Vertical	1.857	3.064
F-pillar1-2	Vertical	1.767	2.371
F-pillar2-1	Vertical	1.652	1.867

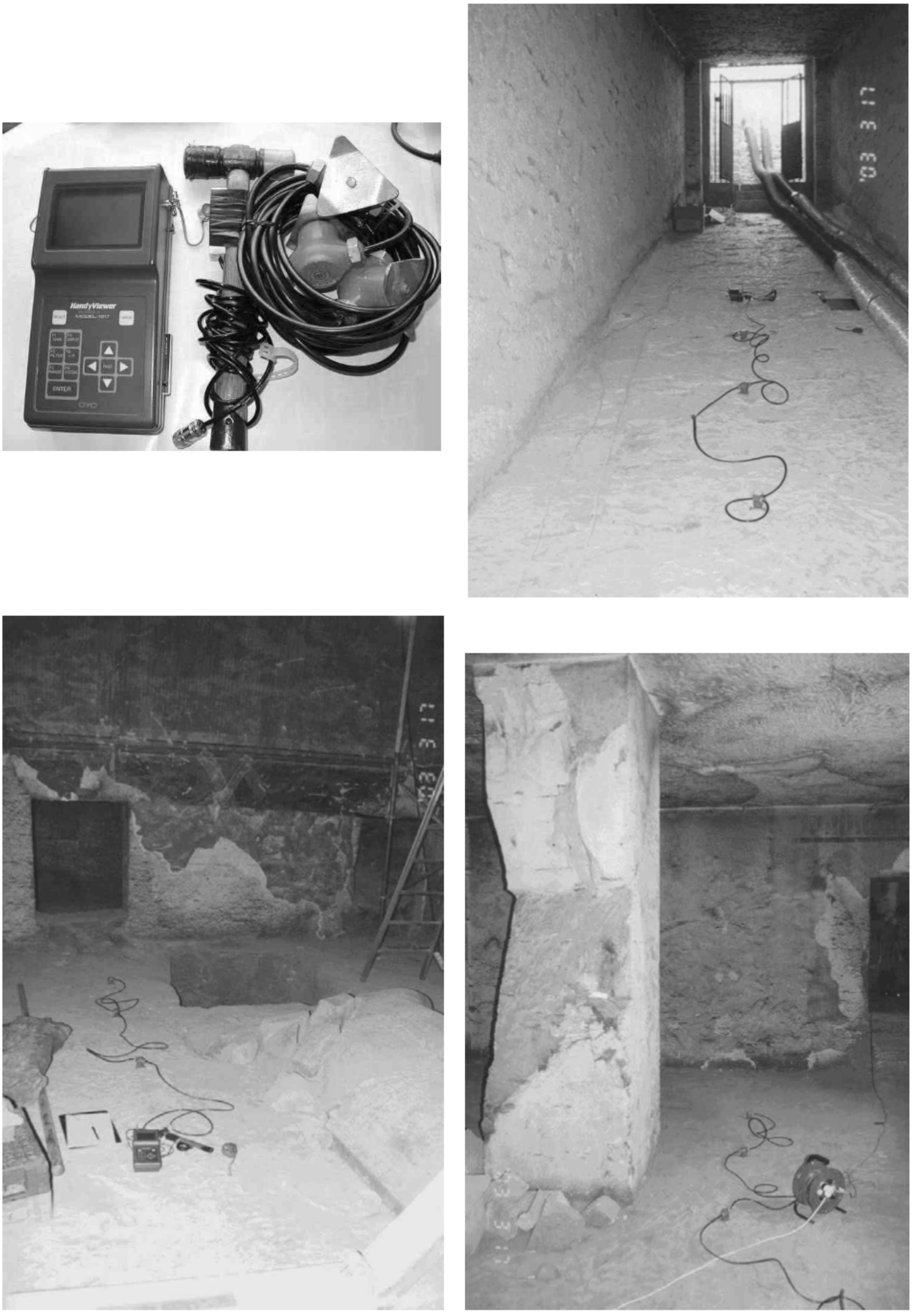


Fig.25 Some views of measurements and instruments

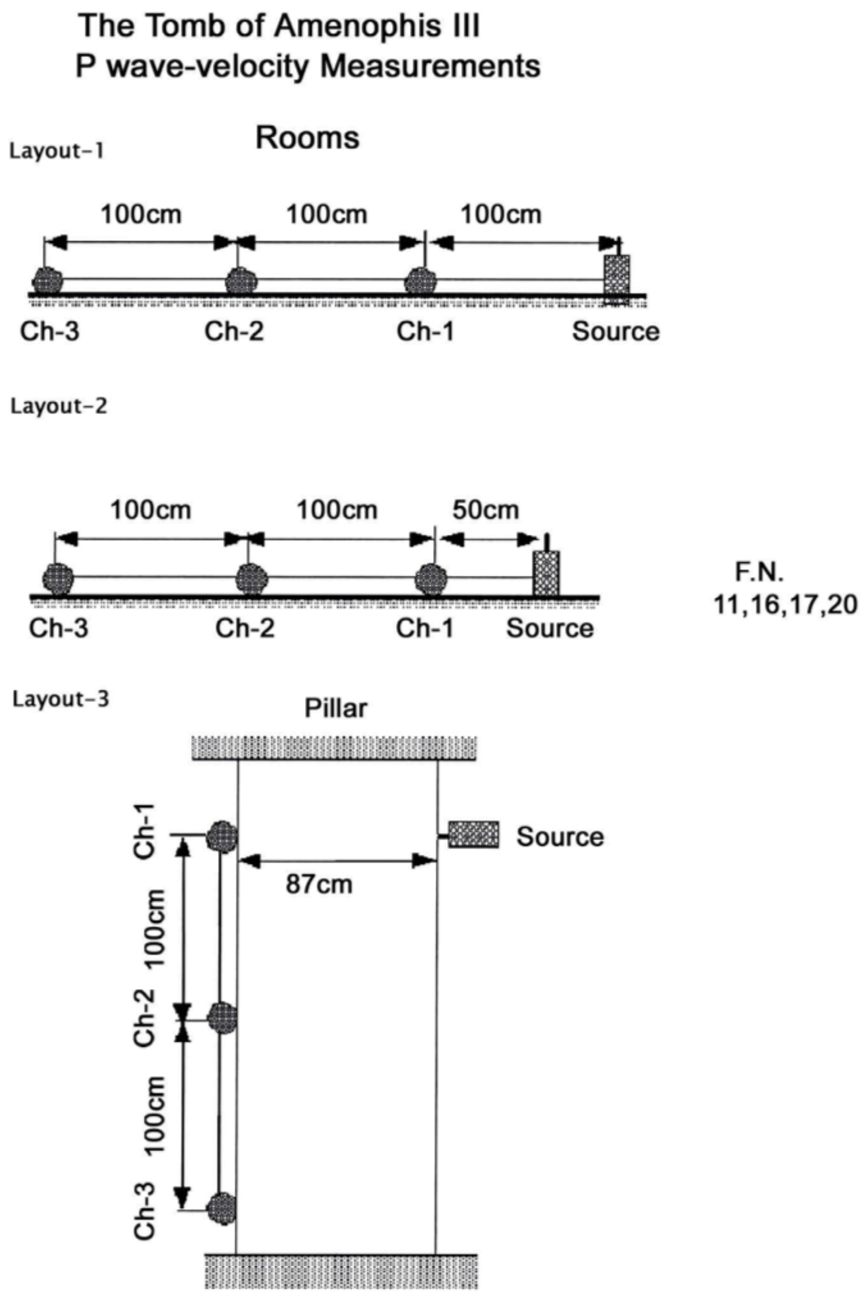


Fig.26 Layouts of geophones and sources

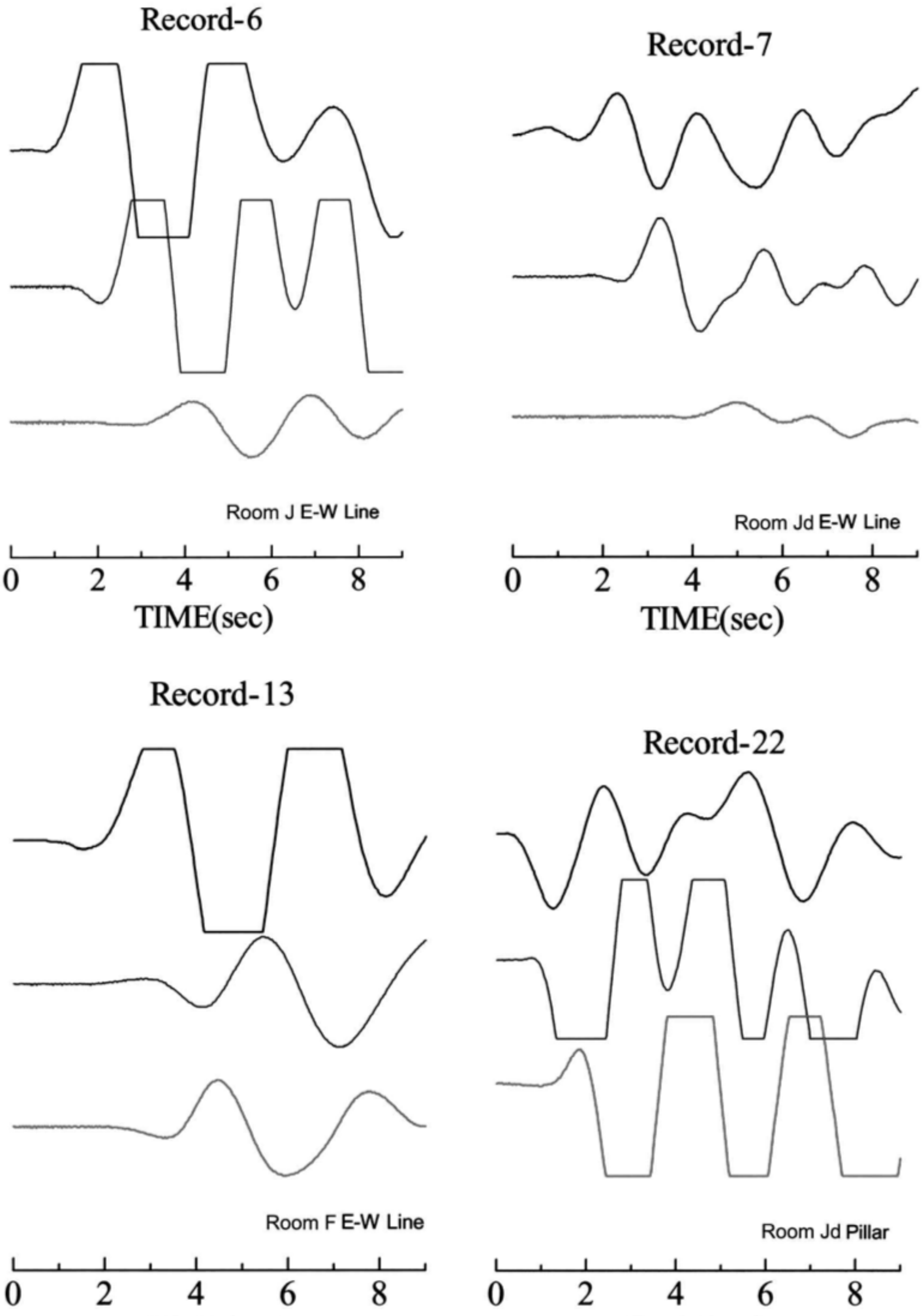


Fig.27 Some examples of velocity records

(4) Weathering assessment

The assessment of weathering of rock is of great concern for evaluating the long-term performance of rock structures. The current underground tomb was excavated approximately 3400 years ago. The tomb was excavated in marly limestone with some flint inclusions. Most weathering assessment procedures in rock mechanics are based on visual inspections and some index tests. When rock weathers, its colour undergoes some variations. Mostly the surface becomes whitish, yellowish or reddish due to alteration of some ferrous minerals contained in rock matrix. Particularly, the variation of colour of rock could be a measure to assess its weathering state. For this purpose a chroma-meter developed by Minolta CR-800 owned by Oyo Corporation and lent to the investigators was used. There are various modes of colour measurements. Takeuchi et al. (1994) reported that *L-a-b* mode is the most suitable mode for characterizing the weathering state of rocks. For this purpose, an orthogonal coordinate system is defined. The axis *L* is a measure of surface darkness. It s value is +100 for white colour and −100 for black colour. The axis *a* is a measure of variation between red (+100) and green (−100) while the axis *b* is a measure between yellow (+100) and blue (−100). Fig.28 shows two views of weathered soft limestone observed outside of the tomb. The weathered soft limestone gives the impression of rock from a thinly layered yellow to brown material.

Fig.29 shows the variation of parameters of *L, a, b* for fresh and weathered soft limestone and hard limestone. Although the variations of hard limestone are very small, very variations occur for soft limestone.

Fig.30 shows the variation of parameters of *L, a, b* from the entrance to the deepest level (Jee) of the tomb. Although some fluctuations are observed, the state of the rock mass throughout the tomb remains nearly the same. In other words, the weathering of rock mass in the tomb is almost negligible for 3400 years compared to that of rock subjected to harsh weather conditions outside.

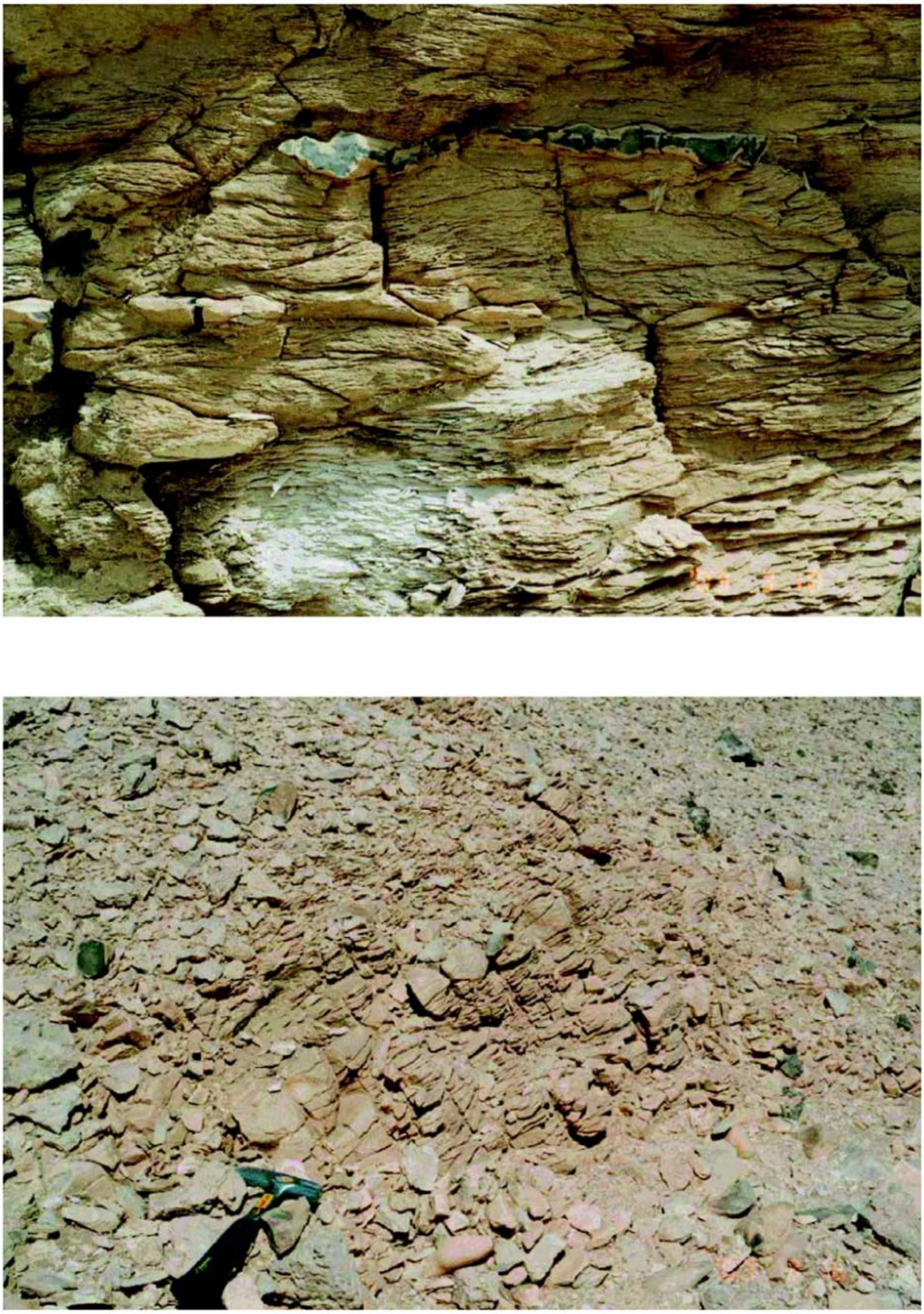


Fig.28 Two views of weathered soft limestone near the entrance of the tomb

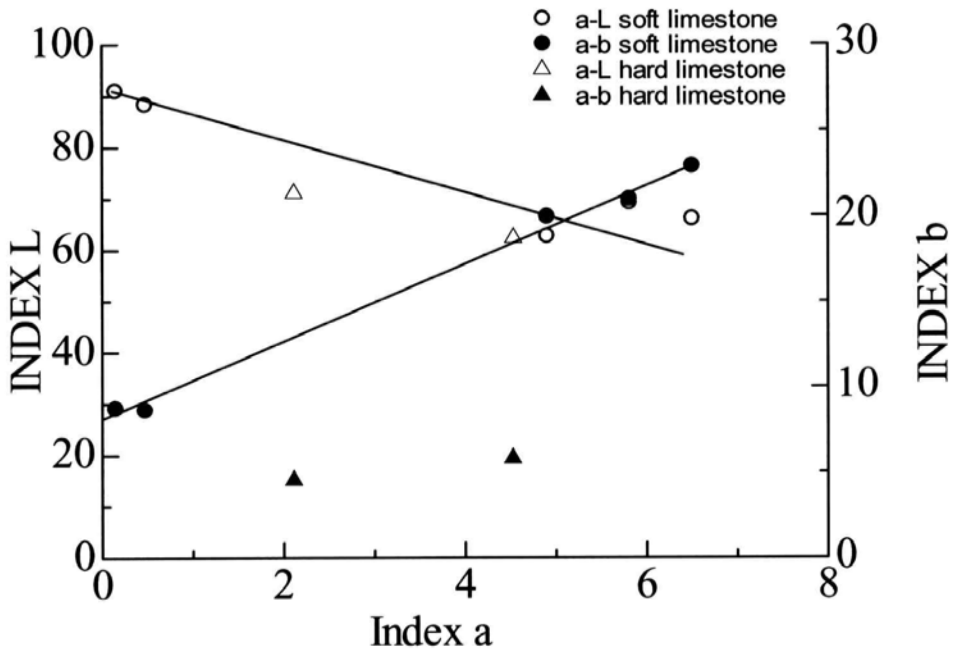


Fig.29 Variation of parameters *L*, *a*, *b* for weathered and non-weathered soft and hard limestones

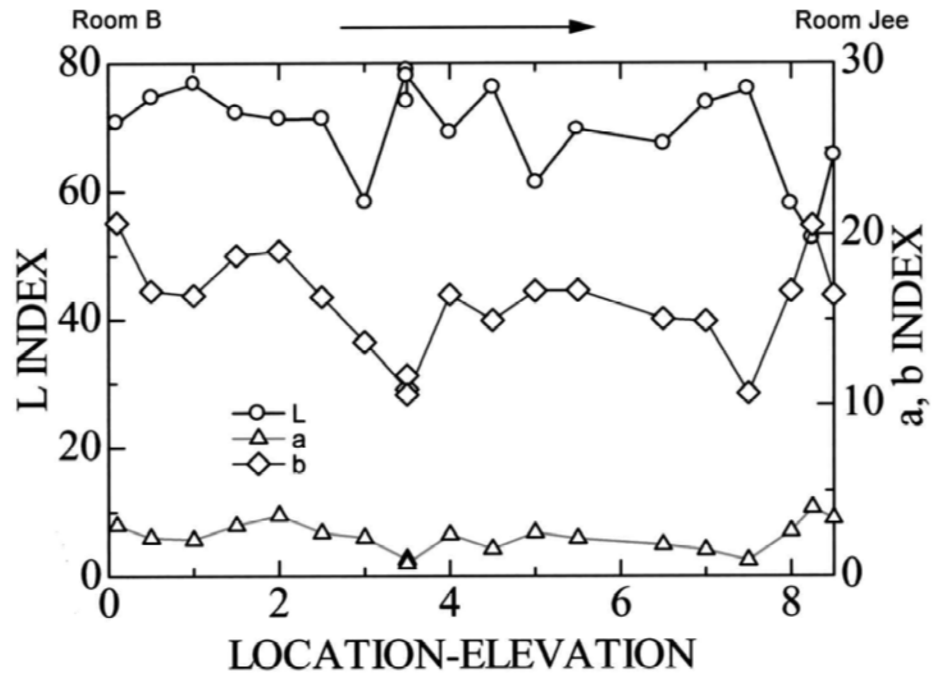


Fig.30 Variation of parameters *L*, *a*, *b* of rock surface from the entrance to room Jee of the tomb

7. Physical and Thermo-Diffusive-Mechanical Properties and Discontinuities

(1) Physical properties

Presently, the unit weight and p-wave velocities of intact soft limestone samples were measured. The dry unit weight of rock ranges between 17 and 21 kN/m³. The elastic wave velocity of dry rocks seems to be anisotropic. The elastic wave velocity is high when parallel to bedding, while it is low in the direction perpendicular to bedding. Fig.31 shows dry unit weight versus elastic wave velocity.

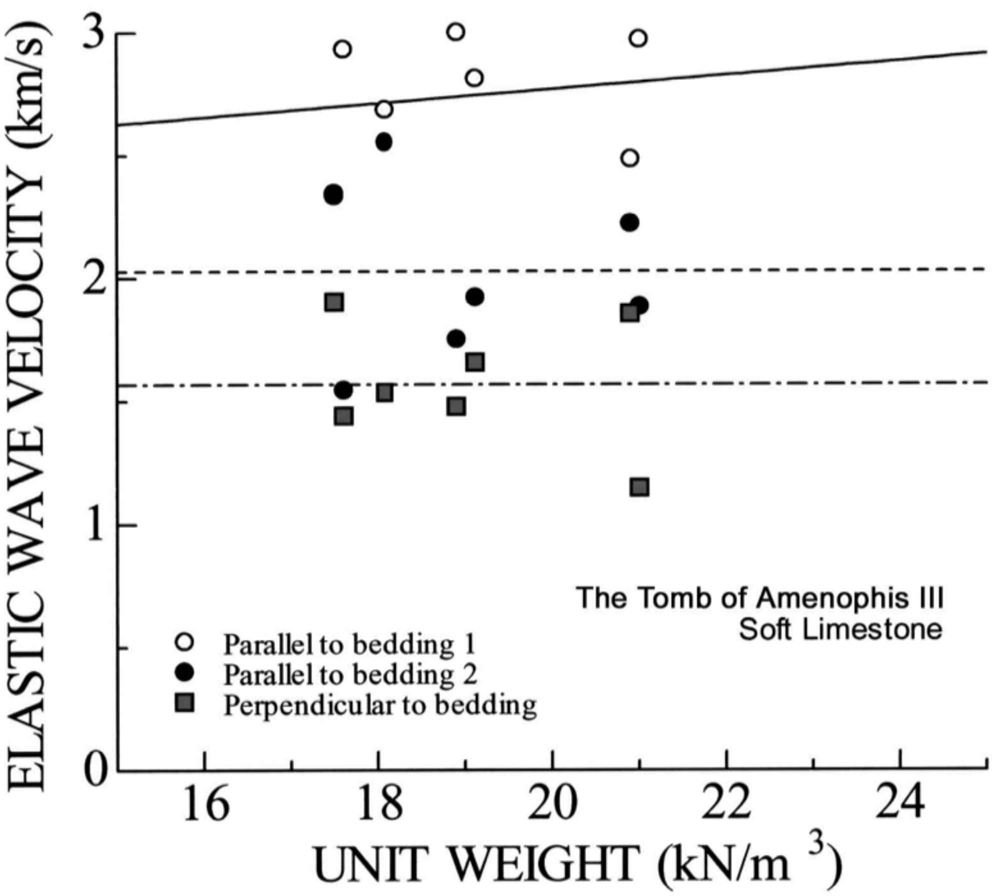


Fig.31 Relation between dry unit weight and elastic wave velocity

(2) Thermal properties of limestones

Limestone samples used in water migration tests were also utilised for thermal property tests. Tests on the samples of soft limestone and hard limestone were carried out by using a new simple thermal property test device. The test set-up consists of temperature sensors, a temperature logger, a thermostat, a liquid with known thermal characteristics and a sample. Fig.32 shows a view of a thermal property test. Fig.33 and Fig.34 show the temperature variations with time during tests on soft limestone and hard limestone samples, respectively. From measured temperature responses and known initial temperature values of liquid and samples and thermal properties of liquid, one can easily obtain specific heat capacity and cooling and thermal conductivity coefficients of rock samples through a method developed by Aydan (2003). Hot water was used for the tests, since its thermal properties are quite stable within a temperature range of 10-90°C.

Fig.32 A view of a thermal property test set-up

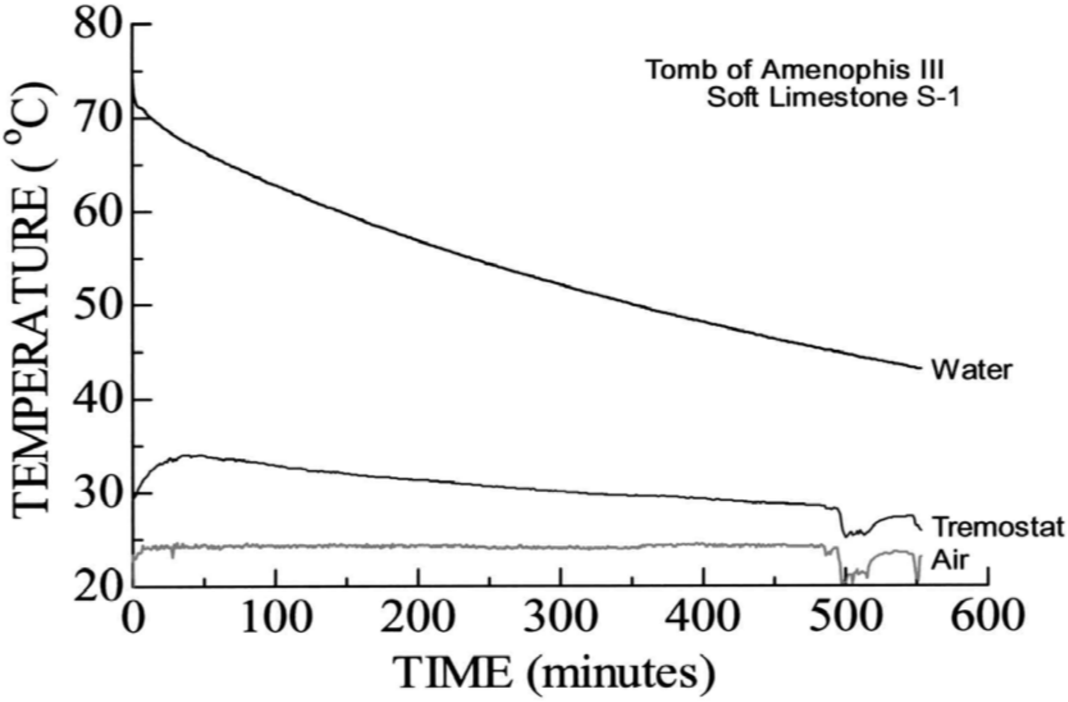


Fig.33 Variations of temperature of liquid, thermostat and air on soft limestone

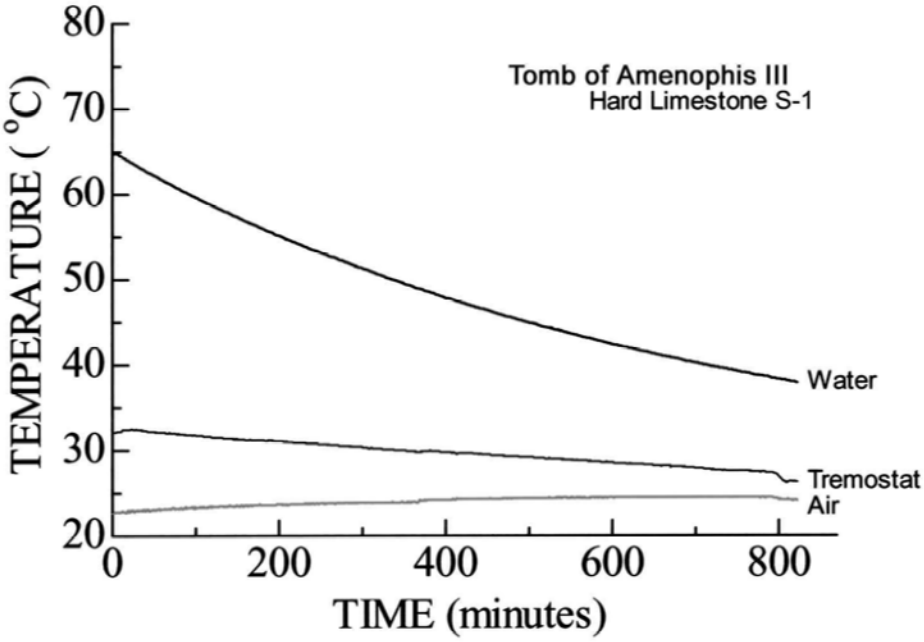


Fig.34 Variations of temperature of liquid, thermostat and air on hard limestone

(3) Water migration characteristics of limestones

Limestones in the vicinity of the tomb are classified into soft limestone and hard limestone. The soft limestone contains clay. It is therefore expected that it will interact with water, and its physical and mechanical characteristics are expected to be greatly influenced by its water content. On the other hand, the effect of water is expected to be negligible on hard limestone, which is almost crystalline. Samples were put into a water container and were submerged in local tap water, whose pH value was 7.00. The samples were kept submerged for more than 48 hours until they were subjected to the drying process in order to investigate their water migration characteristics. When dry samples were submerged in water, it was quite interesting to note that some sounds are audible for a period of about 2 hours. The pH value of water was measured for about 8 hours as shown in Fig.35. As seen in the figure, the pH value increases rapidly and becomes stabilized after 2 hours. However, the pH value had almost returned to its initial value after 48 hours. Additionally, stirring the water could cause some increase in the pH value, which implied that the solved calcium ions had settled on sample surfaces or at the bottom of the container.

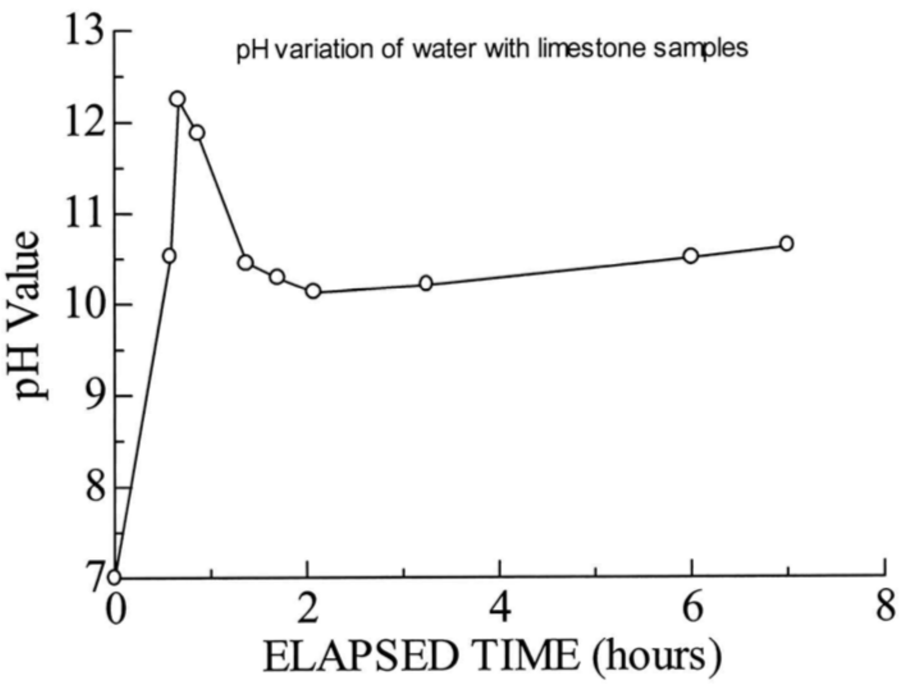


Fig.35 pH value of water in which samples were submerged

A total of 6 samples were tested. One of them was hard limestone while the rest of the samples were soft limestone. Samples were air-dried, as shown in Fig.36. The temperature and humidity of the room in which the samples were tested were recorded automatically at a sampling rate of 1-minute (Fig.37). The temperature and humidity variations were limited to 3°C and 15% throughout the tests. Fig.38 and Fig.39 show the variation of water content of samples of hard limestone and soft limestone. The functions calculated by the respective figures will be used to obtain the water content migration coefficients of rock type using a procedure proposed by Aydan (2003).

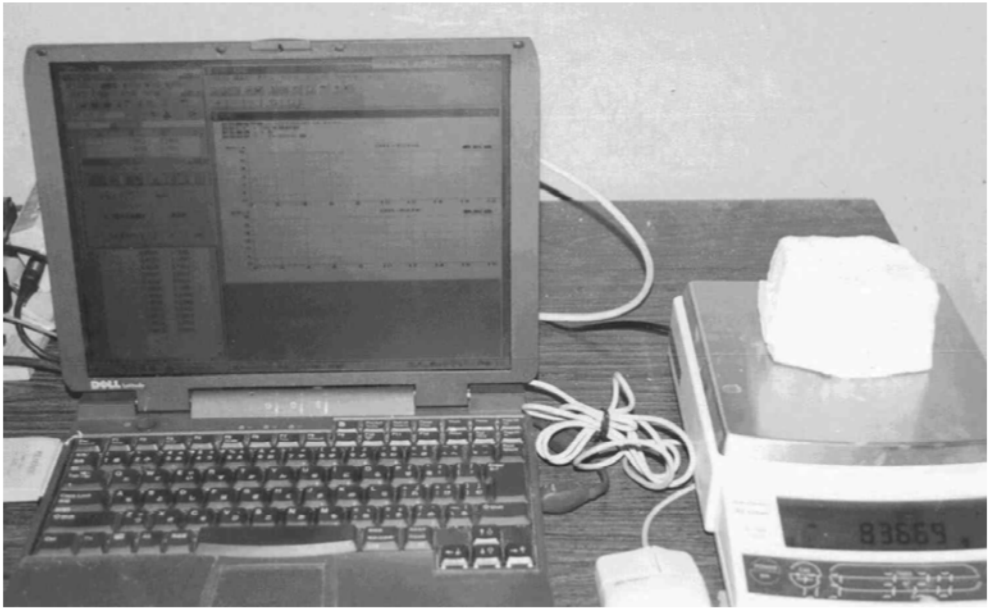


Fig.36 A view of drying test for water content migration characteristics

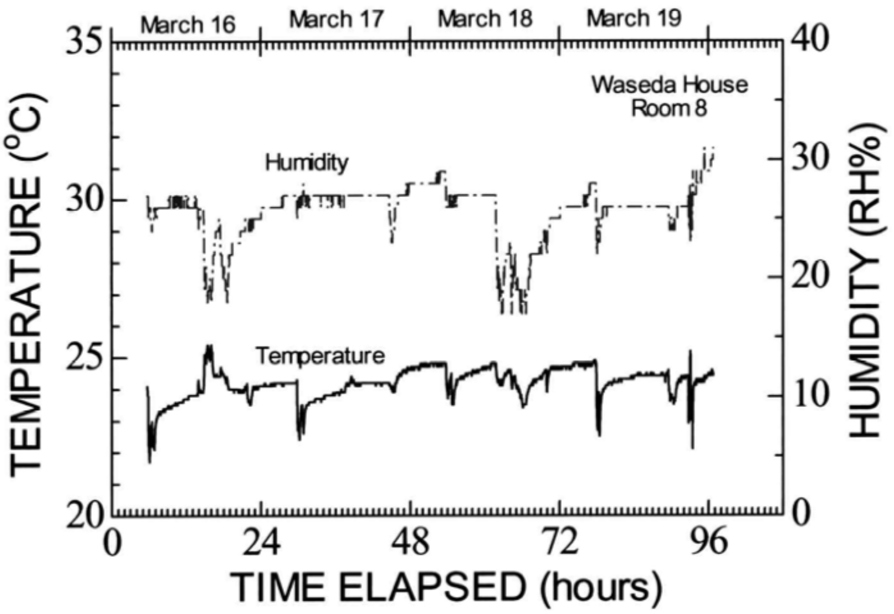


Fig.37 Variation of temperature and humidity of room 8 during drying tests

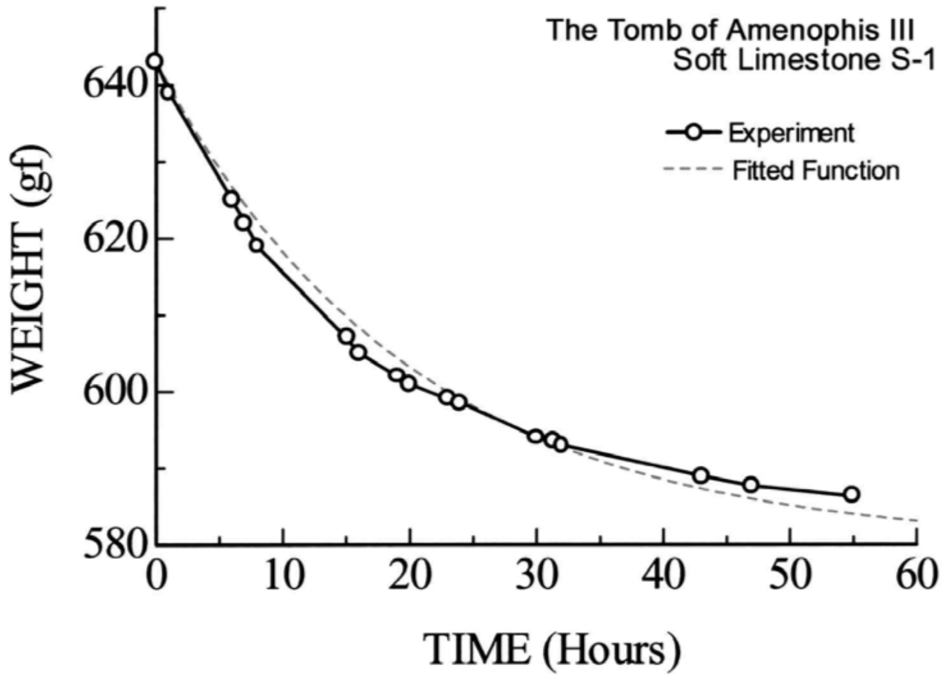


Fig.38 Variation of weight of soft limestone sample 1

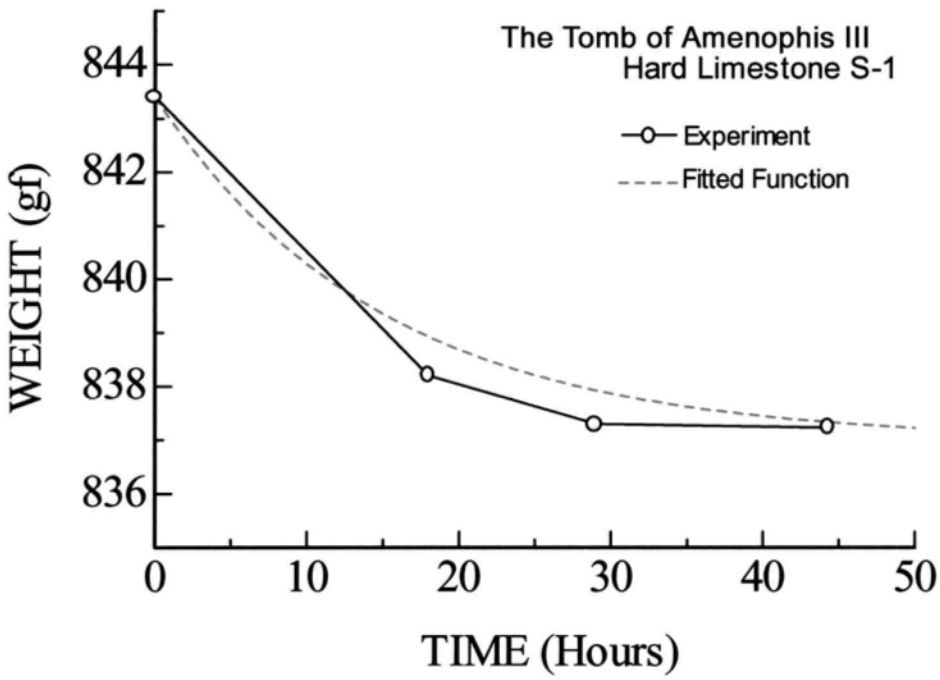


Fig.39 Variation of weight of hard limestone sample 1

(4) Mechanical behaviour of rock discontinuities

The mechanical behaviour of discontinuities existing in rock mass is of great concern when the stability analyses are carried out. For this purpose, some laboratory and *in situ* shear tests were required. Because of the historical value of the tomb, it was extremely difficult to perform such tests. To obtain the frictional characteristics of discontinuities, some tilting tests, which were unlikely to damage the specimens, were carried out on some from fallen rock specimens of non-historical importance and outside outcrops. Fig.40 shows a view of such tests. The portable tilting test device was specially developed for this particular purpose. A laser displacement transducer was mounted to measure the tilting angle and relative displacement of the upper block. In addition, an acoustic emission (AE) sensor was mounted on the tilting device to measure the AE response of discontinuities during the test. Fig.41 shows an example of measured responses during a tilting test. Tests were carried out on several types of rock discontinuities and the results are summarized in Table 5.

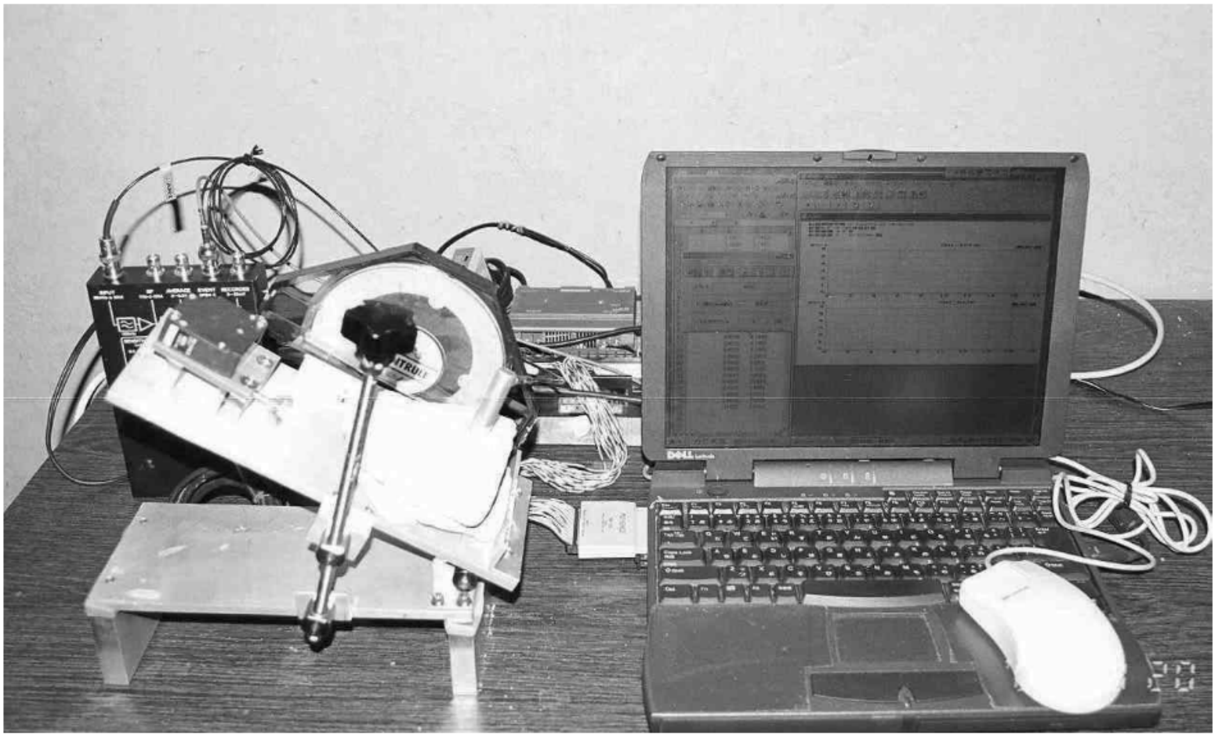


Fig.40 A view of the tilting test

Table 5 Tilting test results

Discontinuity Type	Test Number	Dry	Wet
Tension joint – 1	1	40	37
	2	39	38
	3	38	38
Tension joint – 2	1	44	
	2	46	
	3	46	
Fault to Fault –1(smooth)	1	36	31
	2	34	30
	3	32	31
Fault to Fault –2 (rough) (calcite filling)	1	41	38
	2	39	39
	3	38	41
Fault to Tension Joint	1	34	
	2	31	
	3	31	

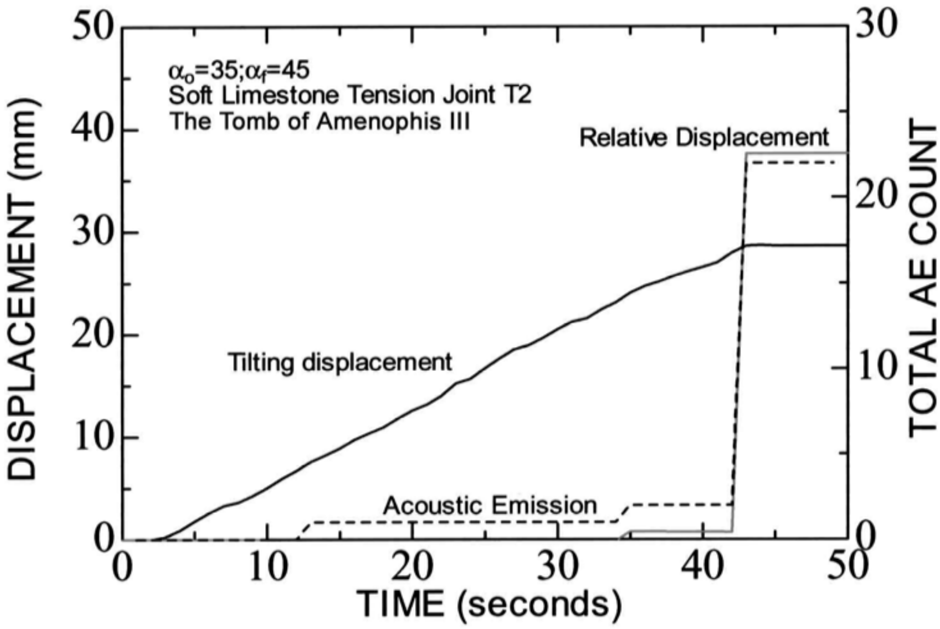


Fig.41 Measured responses during a test on tension joint of soft limestone

8. *In situ* Monitoring

(1) *In situ* monitoring of rock mass behaviour

The investigators were concerned with the *in situ* performance of surrounding rock mass since there are some instability problems in the tomb. The earlier reports (i.e. Tanimoto et al. 1993) claimed that there was a creep-induced failure at the pillar of room Je. The investigators were quite concerned with this pillar regarding its long-term behaviour. However, the investigations on the first day clearly indicated that the pillar was already unstable at the time of excavation of the tomb. After some careful observations, it was identified that the wall between room J and room Jd was in critical condition concerning the overall stability of the tomb in the vicinity of room J and adjacent rooms such as Je, Jc and Jd. Acoustic emission monitoring units consisting of acoustic emission sensors together with their amplifiers and loggers were installed at the wall between room J and room Jd, at the pillar of room Je and at pillar 3 of room J (Fig.42). In addition, a displacement gap gauge was installed at the same wall together with amplifier and logger units. Fig.43 shows some views of the installation locations of acoustic emission measurement units. Fig.44 shows a view of the displacement gap gauge installed at the crack crossing the north wall of room J adjacent to room Jd. During 4 days of observations, no acoustic emission signals were observed except some superficial signals caused by other operations in the tomb. The displacement gap gauge presently seems to be responding to the temperature fluctuations. Temperature and humidity sensor in room J has been re-located nearby the acoustic emission sensors and displacement gap gauge in order to know the variations of temperature and humidity in room J and adjacent rooms Je and Jd.

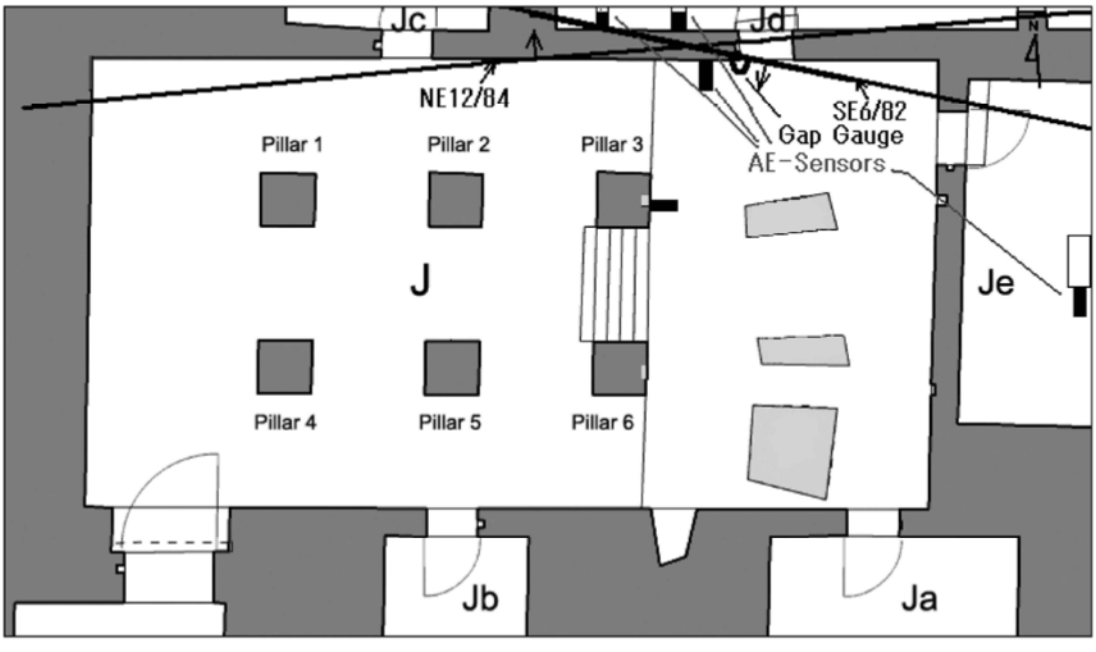


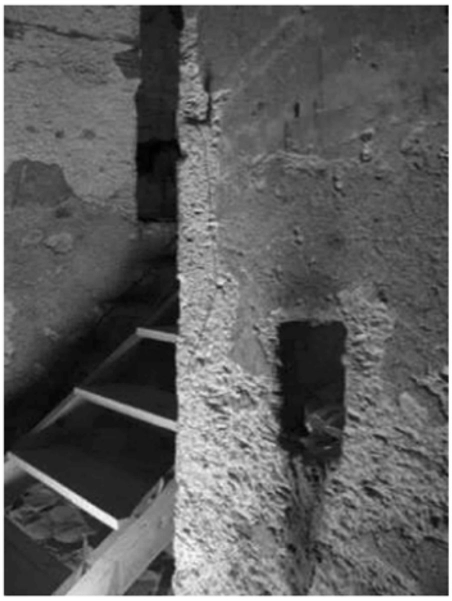
Fig.42 Location of AE sensors and displacement gap gauge

Room J (north wall) (AE1)

Room Jd (south wall) L1 (AE2)

Room Jd (south wall) L2 (AE3)

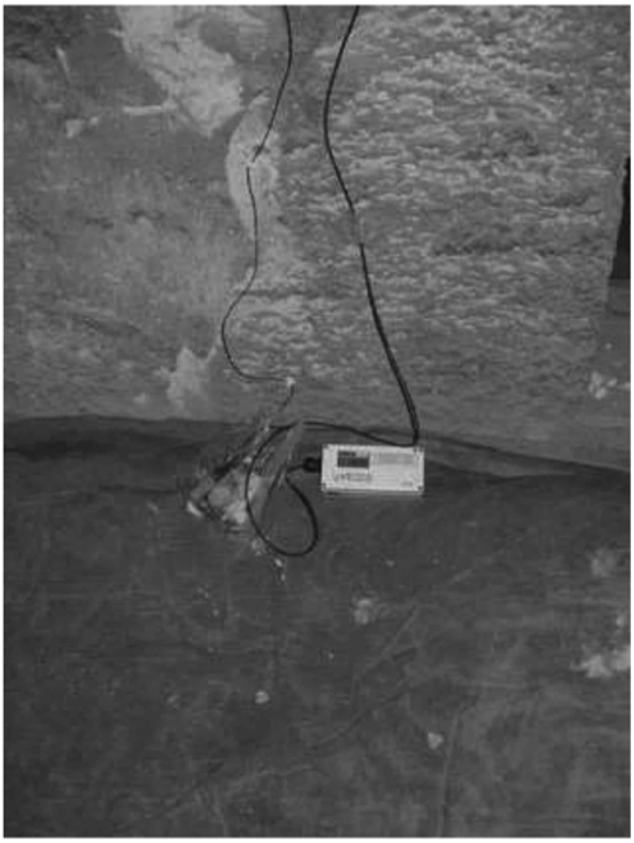
Room Je pillar (AE5)



Room J pillar 3 (AE4)

Fig.43 Views of installation locations of acoustic emission sensors

Displacement gap gauge at the crack on the north wall of room J



Amplifier and logger unit

Fig.44 Views of displacement gap gauge and logger unit

(2) Environmental *in situ* monitoring

An environmental *in situ* measurement system concerning temperature and humidity variations in the tomb has been installed and it is in operation since March 17, 2003. Temperature and humidity sensor and logger units produced by TANDS shown in Fig.45 have been installed at 6 different locations. Fig.46 shows views of some installation locations. The measurements were carried out at a sampling rate of 30 seconds for four days to see if there were rapid variations of temperature and humidity in the tomb. Fig.47 shows the records for the first day and second day. Since the variations were small after the first trials, the sampling rate has now been set to 1 hour and it is expected to record the temperature and humidity until Feb. 16, 2004. Furthermore, a rainfall observer was installed at the roof of Waseda House to monitor the rainfall in the vicinity of the tomb and Luxor. Fig.48 shows a view of the rainfall observer.

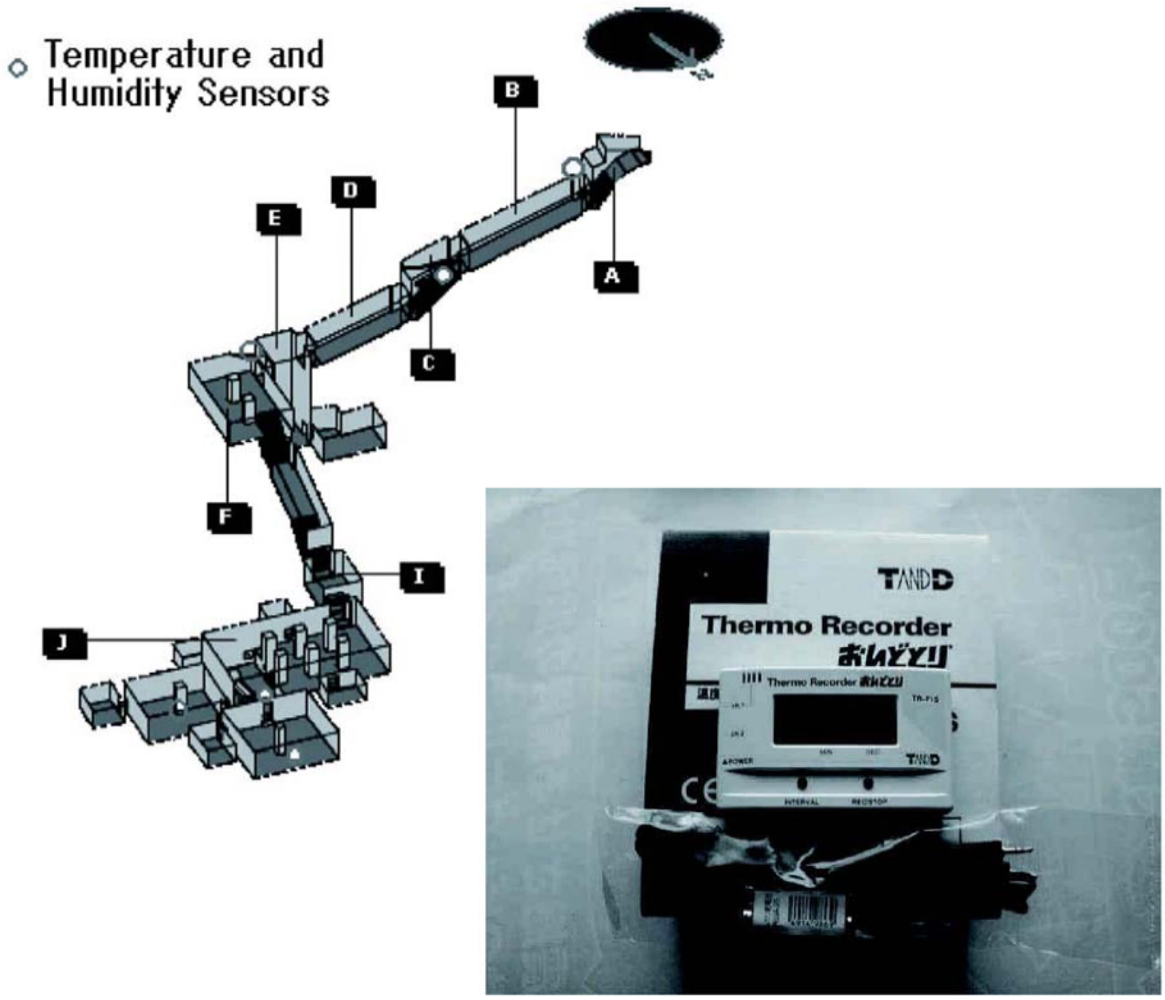
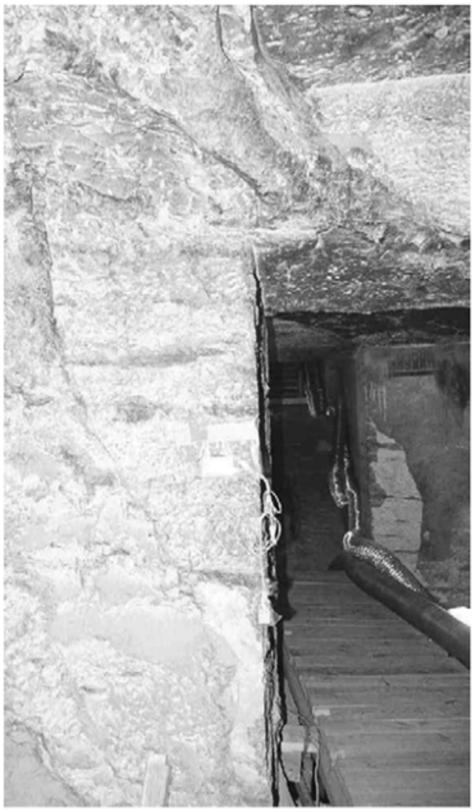


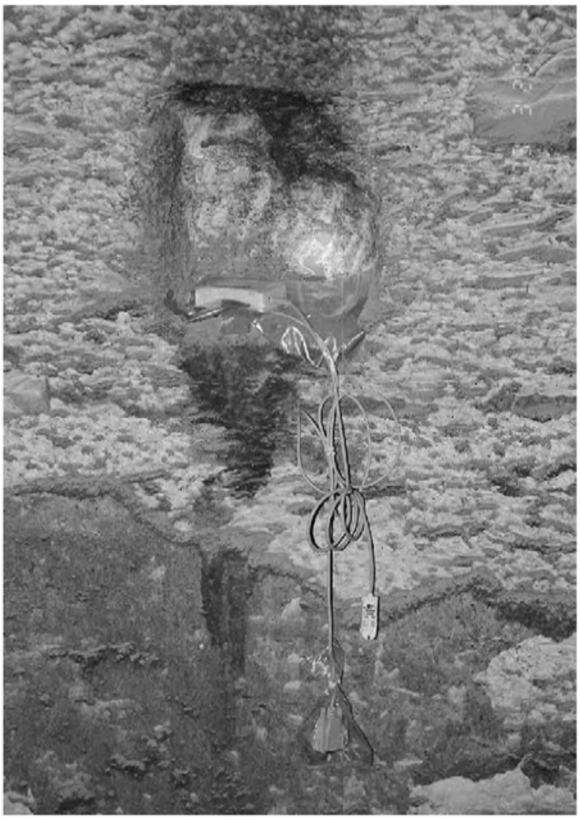
Fig.45 Location and a view of temperature and humidity sensors and logger

Room B



Room F

Room Je



Room J

Fig.46 Views of some temperature and humidity sensor installation locations

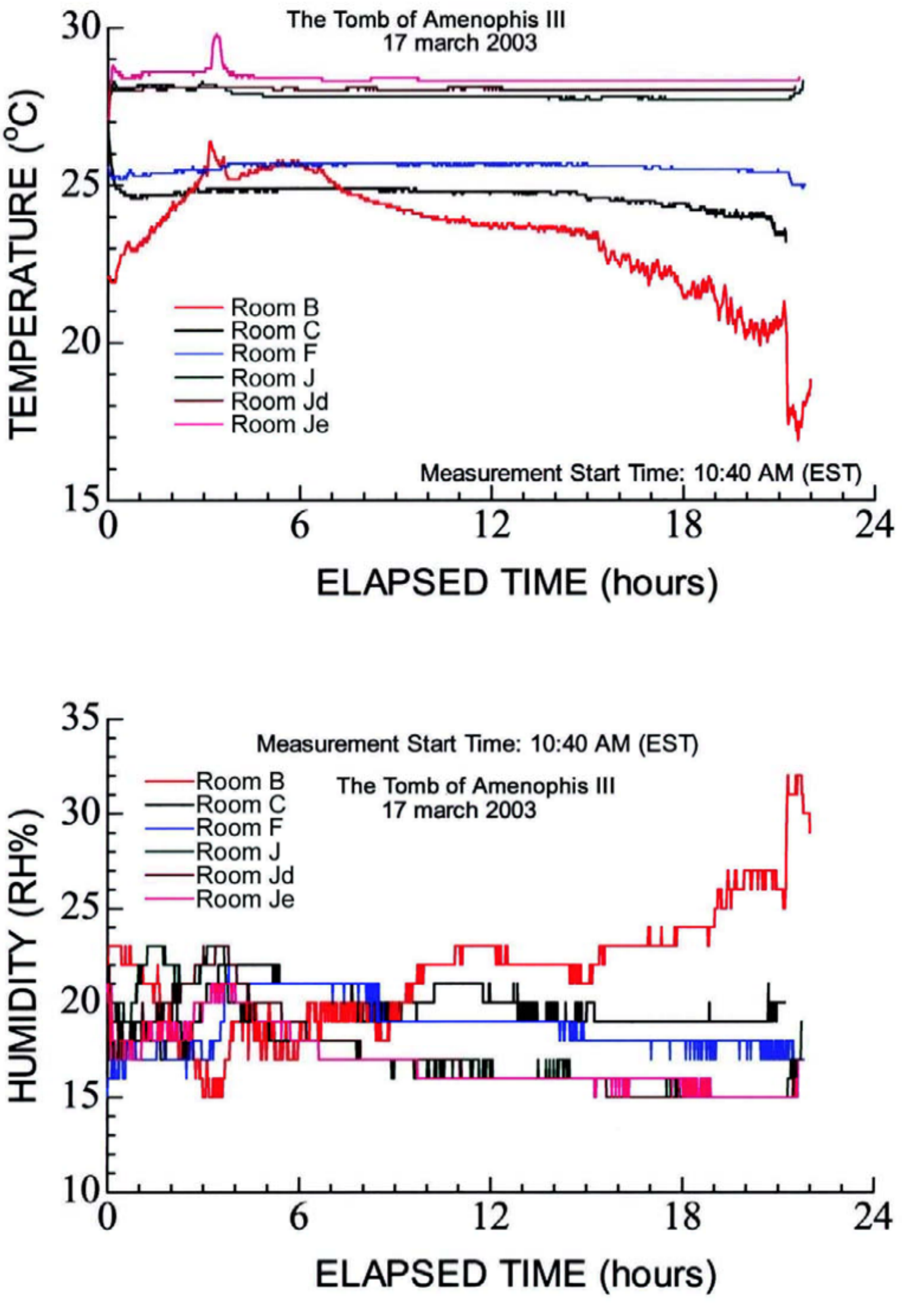


Fig.47 Temperature and humidity variations with time at the tomb of Amenophis III

Fig.48 A view of the rainfall observer installed at the roof of Waseda House

9. Identification of Instability Problems

Several instability problems were observed during the investigation period. These instability problems observed in the tomb are listed in Table 6. Figs.49, 50, 51, 52, and 53 show some actual views of the instability problems in the tomb.

Table 6 Instability problems at the tomb

Location	Problem Type	Possible causes
Room C Room D	Wall collapse	The discontinuities run almost parallel to the longitudinal axis of the opening and the wall collapsed by flexural toppling at the north wall while the slab fall at the south wall. These failures probably took place at the time or soon after the excavation.
Room Je	Pillar Failure	A secondary fault (FI-4) runs diagonally through the pillar and the pillar should had been carrying no load at the time of excavation. The pillar was plastered and further subsidence of the roof caused further deterioration of the pillar
Room Je	Wall fracturing	Many new cracks can be observed particularly in the north, west and east walls. Some open cracks can be observed in the vicinity of the door opening to adjacent room J. The wall adjacent to room J has some deterioration near the NW corner.
Room Jd	Wall fracturing	New cracks and opening of existing discontinuities were observed at the south wall adjacent to room J. Particularly the existing discontinuity (NE16/86) is widely open and presents a critical instability problem. This wall urgently requires some reinforcement measures.
Room J	Wall fracturing	The wall adjacent to room Jd has two pre-existing discontinuities. The discontinuity (NE12/84) was continuous and the discontinuity (SE2/82), which is stepped and sub-parallel to the wall, joined up. The wall is presently splitting and requires urgent reinforcement measures. The wall between room Je has also some new fractures, but its state is better than the wall adjacent to room Jd.
Room J	Pillar splitting fractures	Pillars 1, 2 and 3 have some vertical or sub-vertical splitting fractures. There is a detached piece of split fragment at the SE corner of pillar 3, which is temporarily supported. The east side of pillar 2 split and it had fallen off. Pillar 1 also has split and fallen-off corners. Pillars 4 and 5 have some splitting cracks, while pillar 6 is free of cracks. It is thought that pillars 1, 2 and 3 were subjected to high loads due to failing pillar wall between room J and room Jd.

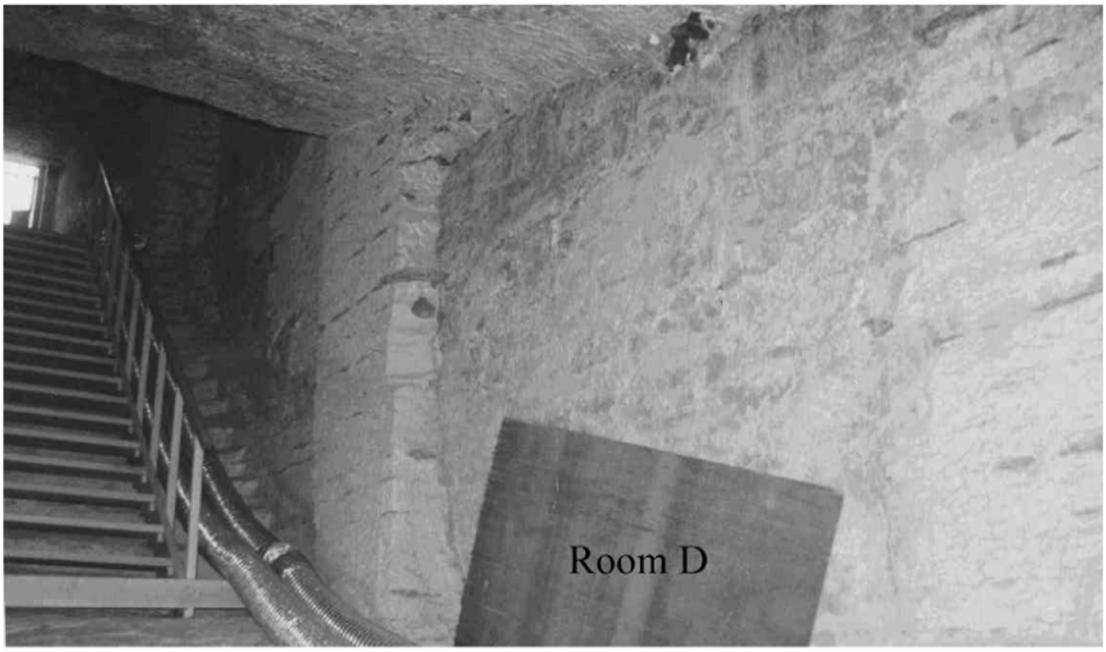
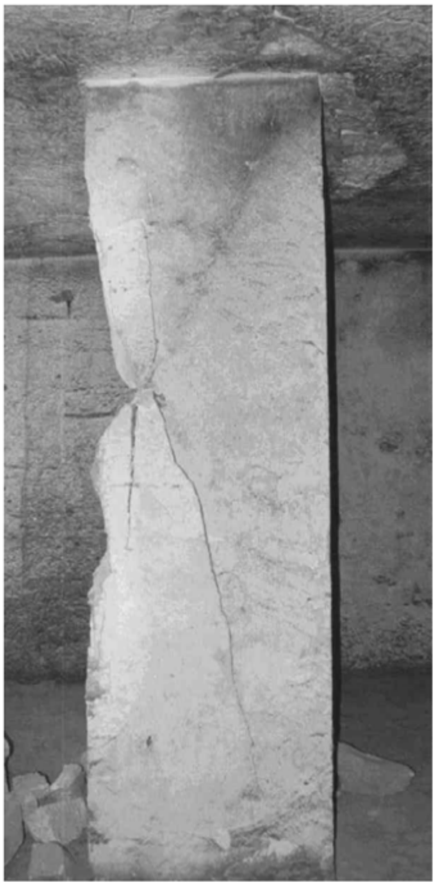


Fig.49 Toppled slabs at room C and room D

East face

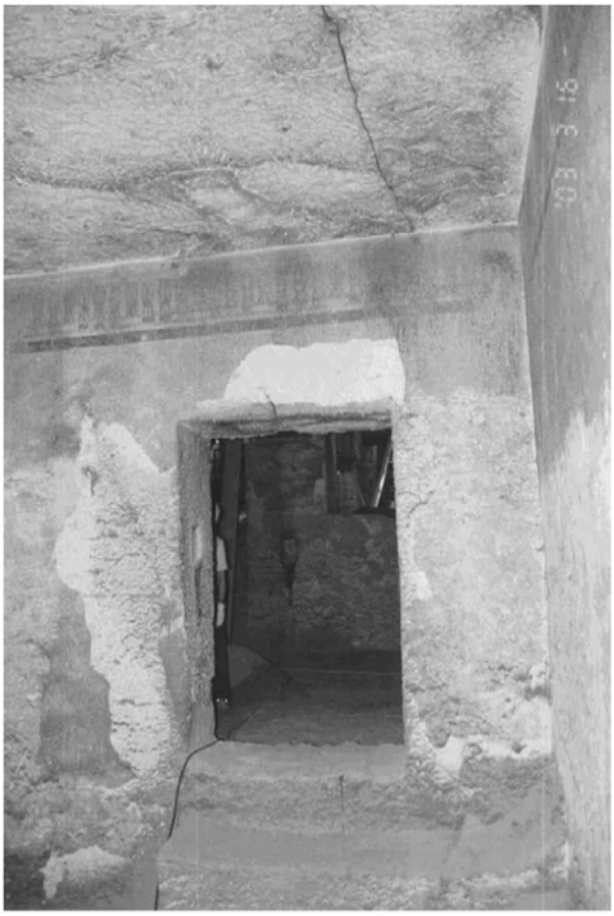


North face

West and south faces

Close-up view of SW corner

Fig.50 Views of fractured pillar of room Je



NW corner of room Je. Plaster tends to fall due to new fracturing and wall deformation

Fractured wall between room Jd and J

Fig.51 Fractured walls between room J and adjacent room Je and Jd

Fig.52 The state of the north wall of room J

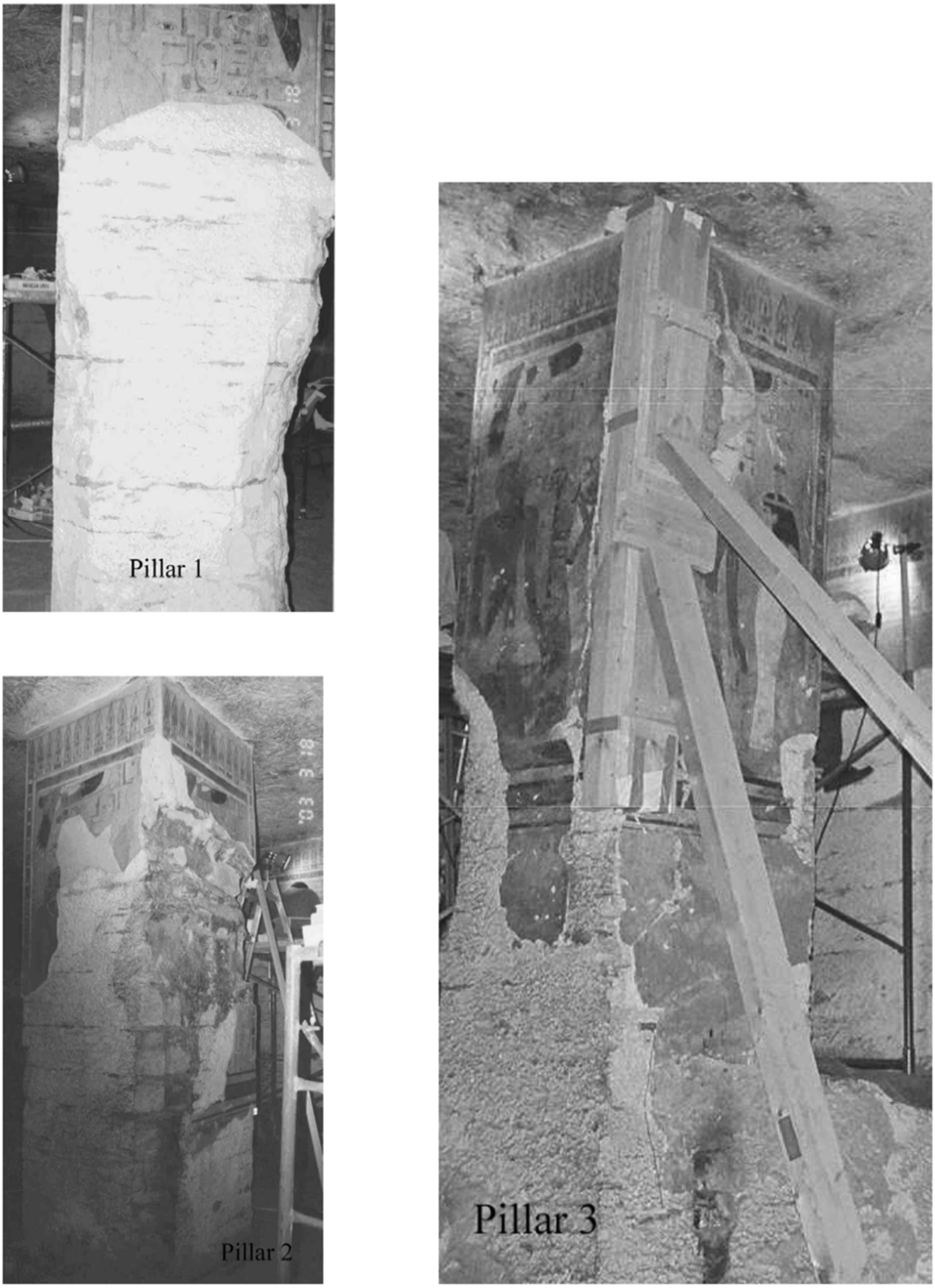


Fig.53 Views of pillars 1, 2 and 3 in room J

In addition to some instability problems in the tomb, the cliff over the entrance of the tomb presents some possible slope stability problems. Fig.54 shows some views of the open cracks observed at the hill over the tomb. These problems can be in the form of rockfalls or block toppling.

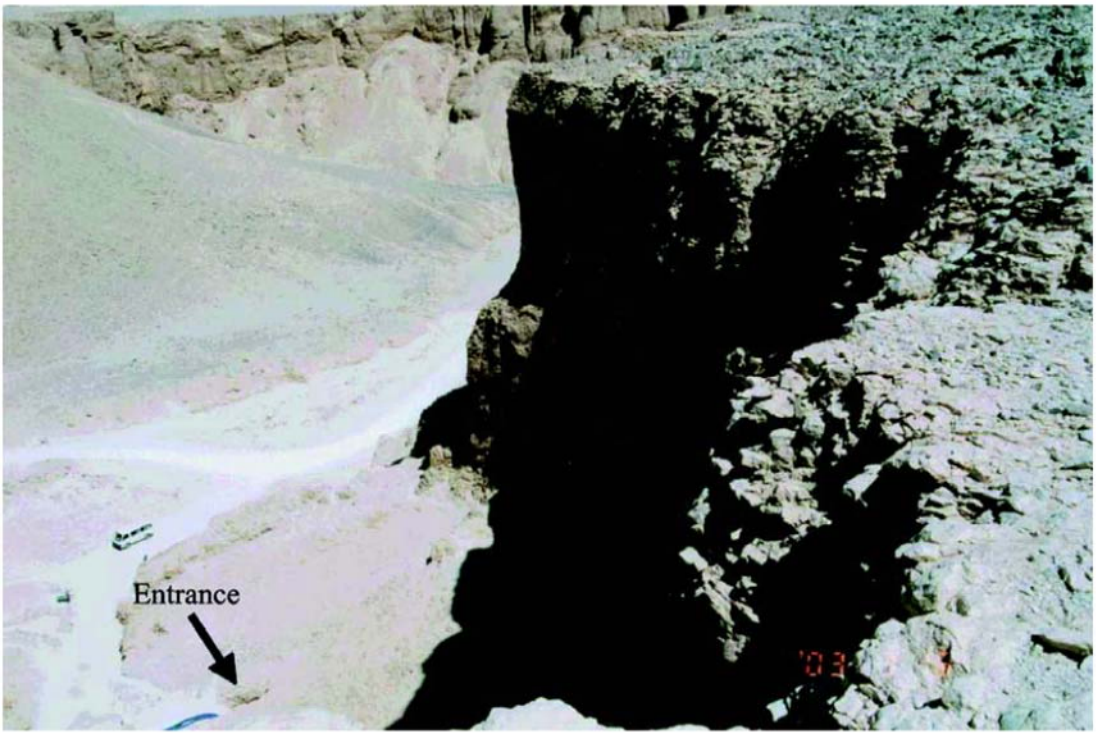


Fig.54 Some slope stability problems nearby the tomb entrance

10. Conclutions and Recommendations

The wall between room J and room Jd is of great concern and it has a great impact on the overall stability of the room J and adjacent rooms Ja, Jc, Jd, and Je. Therefore, the repair and reinforcement of the wall between room J and room Jd must be carried out first. Repair works can then be initiated on pillars in room J and room Je. Some considerations must also be given to the steep cliff next to the entrance of the tomb as a slope stability problem.

(1) The wall between room J and room Jd

The wall between room J and room Jd is in critical condition and must be reinforced in order to prevent the further deterioration of the wall and the pillars of room J. There are two pre-existing discontinuities. One of them goes through the wall, which is 50 cm thick, and connects stepped discontinuities. The views of the present state of the wall from room Jd and room J are seen in Figs.52 and 53. As a result of the geometry of discontinuities of the wall, as well as its position as a load-bearing wall, some splitting failures have been already caused and the wall has been deteriorating. As a result of yielding of the wall, the load imposed on the underground structure has been transferred to other parts of the underground tomb. We suggest the following steps for improving the load bearing capacity of the wall as well as further deterioration of the wall.

1) Grouting and filling the open cracks (required)
2) Installing glass or carbon fiber rockbolts with mesh (required)
3) Constructing a wall in room Jd next the section of the north-wall of room J and attaching the bolt-ends into this wall (optional)

(2) Repairing pillar 3 of room J

The block is detached from Pillar 3 by shearing and splitting, and it is failing in the flexural toppling mode. It does not bear any load from the roof except its own dead weight. The detached block, which is in the shape of triangular prism, is 264 cm high with side lengths of 25-30 cm. It weighs approximately 250 kgf. To be safe, we will presume it to have a dead weight of 300 kgf. The present prop system seems to be sufficient from a view point of structural mechanics. Nevertheless, additional props to the present prop in the direction of NS are felt to be necessary.

The crack must be cleaned of debris and then resin epoxy can be spread over the crack surface. After this procedure, the detached block must be jacked up until it sets. Later, we suggest installing three fiberglass non-pre-stressed fully grouted bolts with a length of 40 cm perpendicular to the crack surface. Since the bottom crack of detached block is almost horizontal, we do not expect a shearing motion and the resistance, therefore, should be against overturning motion. This problem can be easily overcome with the suggested fiberglass bolts.

(3) Repairing the pillar of room Je

A secondary fault (FI-4) runs diagonally through the pillar and the pillar should have been carrying no load at the time of excavation. The pillar was plastered and further subsidence of the roof caused further deterioration of the pillar. The fallen part of the pillar may be put to its original location with some dowels and the surface may be adhered by using non-shrinkage mortar. If the pillar is restored to its original shape, an additional perimetric transparent wall may be put around the repaired pillar. After investigation of all rooms and pillars, we consider that the wall between room J and room Jd is of great concern and it has a great impact on the overall stability of the room J and adjacent rooms Ja, Jc, Jd, and Je. Therefore, the repair and reinforcement of the wall between room J and room Jd must be carried out first. Then repair works can then be initiated on pillars in room J and room Je.

Various tests on the short and long mechanical characteristics of soft limestone in which the tomb is located should be carried out for stability analyses and assessments. Therefore, specimens from the rock unit under consideration are necessary.

Some considerations must also be given to the steep cliff next to the entrance of the tomb as a slope stability problem.

Acknowledgement

The authors sincerely acknowledge Prof. Dr. S. Yoshimura, Ass. Prof. J. Kondo, N. Kawai, K. Seto, and A. Nishisaka and the local staff at Waseda house for arrangements, guidance and many stimulating discussions, as well as information and logistical support during the investigation period.

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6. Egyptological and Art Historical Studies

(1) Egyptological Research

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Introduction

We have continued our Egyptological and archaeological observations of the inscriptions and paintings on the walls of rooms E, I and J in detail as the conservation program went on.

1. Room I

As a result of the cleaning of the walls (north, east, and west walls), we could read the inscriptions on the walls clearly. Having compared the inscriptions on different walls, we noticed some careless mistakes in the text, particularly on the north wall. It seems that they ran out of time in decorating the tomb walls as the eastern part of the north wall was the last part to be decorated when the tomb was made. Also, we were able to read the Horus name in the *serekh* of a royal *ka* figure after the cleaning, and the name was that of Tuthmosis IV, *kꜣ-nḫt twt ḫꜥw*, the father of Amenophis III. It should be noted that the two Horus names observed in room E also have the name of Tuthmosis IV. This fact is noteworthy, for although the north wall of room I was decorated last, it has the name of Tuthmosis IV instead of Amenophis III.

2. Room J

(1) The *Book of Amduat*

In 1959 Eric Hornung visited the tomb in company with Alexander Piankoff to study the *Book of Amduat* inscribed upon the walls of room J (burial chamber); the results of the observation have since been published in his *Das Amduat*. Hornung copied the inscriptions of the texts, but it seems that he could not access good lighting during his work. Even before the conservation work on the walls of room J, we found several variations from his copies. Hornung copied only the inscriptions of the texts of the *Book of Amduat* by comparison with the texts from other royal tombs in the Valley of the Kings, not the style of writing or any vignettes.

During the cleaning work in this project, a number of inscriptions and vignettes of the *Book of Amduat* have been discovered under the dirty surfaces of the walls. By the observation, there are more than three different styles of writing hieroglyphs. It means that more than three scribes were probably engaged in the decoration work in the interior of the tomb. The paleographical studies and full-scale of re-copying of the texts and vignettes will be necessary after finishing the conservation work in room J. The reexamination of the *Book of Amduat* in the royal tomb of Amenophis III will contribute to studies on the funerary texts of the royal tombs in the Valley of the Kings. We should carefully plan the recording, including tracing and photographing on the wall decorations, to make the work comprehensive.

(2) Pillars in room J

There are six square pillars decorated with the figures of the king and a god or goddess on each of four walls in room J. Judging from observations, the decorations on the pillars were painted in the different stages. It is clear from the styles of figures and inscriptions that pillar 3 and pillar 6 were decorated in the later stage. Particularly, the east and south faces of pillar 3, and east and north faces of pillar 6 seem to have been decorated in the very last phase. This is inferred from the fact that all the toes of the left foot of the figure of Western Goddess on the eastern face of pillar 6 were drawn (Fig.1); this is a characteristic feature of the so-called 'Amarna style' art.

However, the four faces of pillar 3 and 6 have not yet been fully cleaned in the present campaign, so it is not possible to give a report in detail.

(3) Black draft lines for construction purpose

We observed black lines under the plaster surfaces of the walls in room J. They seem to have been drawn for the purpose of rock cutting before the decoration was done. If we draw imaginary lines from where the black lines were drawn on the wall, we can find the pillars. They seemed to serve an architectural function for determining the positions of pillars during construction.

They give us knowledge of how the rock cutting was done, so they should be preserved. However, as they will be hidden under the plaster and decoration, we should keep their traces somehow in the conservation work.

3. Room E

The conservation work of room E has not been started, but we have observed and recorded the inscriptions and decorations of the walls. As the catwalk has been built, we could observe the walls from close distance; as a result, we observed one figure of goddess Nut whose right foot was drawn with all the toes. Though the cleaning has not been done yet, we cannot make any conclusions, but this provides important data for the chronology of the tomb.

Fig.1 Left foot of Western Goddess on the east face of pillar 6.
All the toes were drawn for the figure of the goddess

(2) Egyptological Remarks for the Conservation of the Wall Paintings in the Royal Tomb of Amenophis III

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UNESCO Counterpart of the Project

Introduction

Waseda University Egyptian Expedition initiated its work in the tomb of Amenophis III in 1989. Since then, we have conducted documentation of the tomb paintings and inscriptions in addition to excavation, mapping, and survey. The wall paintings have been damaged and have deteriorated from natural cracks, bat guano, and bacteria. Thanks to the conservation work in this season managed by UNESCO, we discovered new evidence concerning the original iconography and texts of the wall paintings. In this report, I will discuss the new discoveries and insights from an art historical and epigraphic point of view. Also, I will mention the Egyptological contribution by means of the conservation work in this project.

1. Art Historical Observations

The art during the reign of Amenophis III has been regarded as the apex of the Egyptian art, which shows elaborate and mature statue of art work. This has also been seen as the precursor of Amarna Period. The conservation work on the wall paintings of the tomb of Amenophis III, therefore, will contribute towards our understanding the Egyptian art of the highest quality.

We had a great opportunity to examine the wall paintings during and after the conservation work. I will discribe here some new discoveries and offer tentative thoughts on the technique of the wall paintings in the tomb of Amenophis III.

(1) Room E

The three walls of room E (shaft chamber) (north, east, and south) are decorated with the scenes of the king being received by several different gods. Stylistically, they are depicted more naturalistic manner than those depicted in room I (antechamber). The physical feature of the king that are stressed are young face, fat belly and masculine masculature, which is characterized as the style after year 30 in his reign (Fig.1)[1]. Particularly, the face of the king is now more youthful looking, with an exaggerated, overlarge eye that dominates the face. His body is often bent forward slightly at the waist. His belt is thicker than before. W. Raymond Johnson suggested that the painted figures found on the walls of Amenophis III's royal tomb display stylistic characteristics that date them late in his reign[2]. The unexpectedly plump figures of the king, with their thick waists and youthful faces, are graced with wide belts, sporrans, and kilts covered with elaborate falcon-feather patterns.

In room E, we had an opportunity to carry out the X-ray florescence and diffraction analysis of the pigments. Here I would like to describe some observations on the pigments and on the painting methods in comparison with room I where also the X-ray analysis was conducted.

On the south wall of room E, the colors of Horus name of the *ka* figure, the cartouche of the king depicted in western most, the skin of the goddess Nut, kilt of the king and his *ka* were painted pink (Fig.2). This pink color is seen on the background of orpiment, but it is not clear that the orpiment was applied above it because there are no remains of this color in this room. However, the X-ray analysis of this color attested arsenic which is the component of orpiment and realgar.

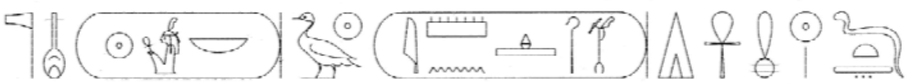
The color of the skin and sun-disk of godess Hathor on the north edge of the east wall are orange color, which is the same color as those of Hathor depicted near the entrance way on the north wall of room I. It is probable that the same painter drew those figures because they were supposed to be painted after the burial of the king.

The background color of room E is slightly darker than that of room I (Figs.1, 2). It is probable that the background color in room E survived better than that of room I.

The blue color applied on the wall of room E is also darker than that of room I. It seems that the black color (manganese) is mixed with Egyptian blue. For instance, the color of the beard of the king and stripes of *nemes* headdress of the kings look darker. It was probably due to the work of different artist and a different time.

The painting method of the wings of Nekhbet vulture is different on the south and north wall respectively (Figs.3, 4). On the south wall, black color is applied on the entire wing and white color in painted to make differentiate each feather. On the contrary, on the north wall white color is painted near the edge of the wing as background, and black color is applied over it to draw each feather. These wings are more degraded due to the nature of white pigment (huntite), which easily detaches from the wall plaster.

It should be noted that the shoulder bands of goddess Hathor on the east and north wall are painted with the inscription of Amenophis III vertically as follows.



"Perfect god, Nebmatre, Son of Re, Amenophis-ruler-of-Thebes, given life like Re, forever." It is unusual to have the inscription with the name of king on the dress of deities.

(2) Room I

In this campaign, conservation of the wall paintings of room I were mostly completed. It was beneficial for Egyptologist to see the detail of the painting works hidden below the bat guano. Here I would like to describe new insights from the paintings of room I.

The paintings on the walls of room I are depicted with the king being received by different gods as is shown on the walls of room E (Fig.5). In room I, the king and gods are depicted in a more idealized style, which shows close similarity to the style of Tuthmosis IV. These are characterized with the idealized Tuthmoside eyes, thin body with flat belly, and thin belt. Johnson suggested that this style represents the first decade style of Amenophis III[3]. However, it is also possible that the king is depicted with a more divine image as he prepares to go into the realm of the gods and death, while the kings are depicted as more naturalistic style in room E, which is located close to the entrance and the world of living. I believe that this expresses the transformation and rejuvenation in the underworld as he is being received by the deities of the underworld. This iconographic peculiarity cannot be explained satisfactory at this moment, but it will be necessary to give a reasonable explanation in the near future.

The cleaning work by conservators makes us to see even the grid lines before applying the painting layer on plaster. In room I, the human figures on the west wall are defined by the line of the top of the head. On the contrary, top of the heads of the human figures on the western half of the north wall is not corresponded with the grid line. A different grid line, higher on the wall than that on the west wall , is found here. However, the height of the figures seems to be the same as those on the west wall. On the eastern half of the north wall where the gate to room J (burial chamber) is located, the grid line is higher than that of the western half of the same wall. Thus, the human images look higher than those on other walls in room I. This may be due to the fact that that part of the wall were decorated after the burial of Amenophis III, which means that the work was done at the very beginning of the reign of Amenophis Ⅳ.

Now I would like to focus on the painting procedure on the walls of room I. In the course of conservation work, we are able to see the process of the painting procedure on the wall. For example, the inscription near the south corner of the west wall shows the abbreviation of the hieroglyphics probably due to the shortage of pigment or lack of time. The inscription has to be written as *di ʿnḫ mi Rʿ ḏt* "given life like Re, forever," but *ḏt* sign is missing. After the careful examination of that part of the wall, it was found that the *ḏt* sign was drew in the initial drawing. The block border at the south corner of the same wall is also unfinished. This is again probably due to the lack of pigment or time. Thus, it is most likely that the paintings were completed from the north to the south. The same phenomena can be seen on the east wall. The block border at the south corner here is also unfinished. The sky sign just below the *khekher* frieze was originally drawn to extend the edge of the wall, but it was corrected as a mistake and adjusted to the edge of the block border's initial outline. These phenomena indicate that the painting work was begun from the northern parts on both east and west walls.

As for the color used in room I, the background blue color is lighter than that of room E (Fig.5). There is a distinctive yellow color used in this room, which is called orpiment (arsenic sulphide) (Fig.6). Orpiment is a kind of rare pigment which can only be provided in Kharga Oasis and St. John's Island in the Red Sea. It should be noted that orpiment is drawn over the layer of whitish pink color. Orpiment is applied skin of the goddesses, solar disks, stripes of nemes headdress, cartouche, crown of Osiris, collars, uraei, where gold color is used in other artifact. Thus, it is most probable that orpiment was used as substitute for gold.

On the eastern half of the north wall, the solar disk of Hathor is painted in red instead of yellow orpiment color (Fig.7). X-ray analysis revealed that the pigment used here is realgar, an arsenic sulphide. This pigment is also rare like orpiment. It has been suggested that realgar originates at St. John's Island in the Red Sea or Asia Minor in Turkey. The color of the cartouche on the same area of the north wall is also painted in realgar. It may be that there is a symbolical meaning for the color on this particular part of the wall, which was decorated after the burial of the king. It should be noted that the same color may have been applied on the figure of Hathor depicted on the east wall of room E, which is partially missing because the figure is located at the gate to room F. This part was supposed to be decorated after the burial of the king as well.

On the southern edge of the east wall, the head of the king is represented as molded Nubian wig in Egyptian blue (Fig.8). It is notable that the molded wig is always located at the beginning of the theme on the wall. The same type of wig is worn on the head of the first king who is protected by his *ka* on the north wall of room E. The king on the west face of the pillar 4 is also wearing molded Nubian wig. This part is located closely to the entrance to room J from room I. It is most probable that the king is depicted as normal living image such as wearing Nubian wig at first, so that the rest of the figure manifest the transformation of the king into the realm of the underworld.

Finally, we found some fragments of gold leaf between the legs of the second king from the right on the west wall (Fig.9). It seems that gold leaf was a remnant from something scratching against the wall. It is probable that gilded funerary furniture was scratched against the wall either when someone installed it or when someone tried to take it. These scraches are the evidence that gilded furniture were stored in room I (antechamber) as was the case in the tomb of Tutankhamun.

(3) Room J

There are six pillars in the upper area of room J (burial chamber). Each pillar depicts the king being received by gods or goddess. The preservation of the color and the quality of the work is less elaborate than the walls in room E and room I. Most of the background color is missing. We believe that the quality of the plaster is different from that of room E and room I. Remarkably, there are four faces of the pillar 3 and 6 respectively, which have three layers of plaster (Fig.10). On the same four faces which are located near the sarcophagus of the king, the quality of the decoration is much higher than that of other faces of the pillars, and the paintings are more preserved (Fig.11). As fine white layer of plaster is applied to those faces for the painting plaster. On the contrary, coarser layer of plaster was used on other faces of the pillars. In comparison, in the tomb of Amenophis II, the paintings on the pillars are rather unskilled compare to the wall of its burial chamber where the *Book of Amduat* is elaborately painted. In Amenophis III's tomb, it seems that ancient painters did not make great effort to decorate the wall of the pillars in room J (burial chamber). The background color of the most of the pillars has been defaced, possibly when the Eighteenth or Nineteenth century traveler made squeeze to make copy of the wall paintings of the pillar like they had done in the tomb of Seti I[4)]. We found some traces of wax and bitumen, which was possibly used to copy the wall scenes on the walls.

The poor preservation of the background color on the walls of the pillars gives us the opportunity to observe the method of drawing, especially after the cleaning by conservators. Each face shows the original square grid lines on the wall. The four faces aforementioned has bigger square grid than others. For instance, the height of the king on the east face of the pillar 6 is 119 cm while others normally measure 114-5 cm. The height of the king on the south face of the pillar 3 measures 120 cm and each square grid varies from 6 to 6.5 cm. Even in room I, the height of the king is normally 115 cm. It is note worthy that the Western Goddess depicted on the east face of the pillar 6 represents differentiated tow, which became more popular during the Amarna period. When a conservator was cleaning on that face, it was recognized that the wall was drawn completely than the other faces on the pillars. It is probable that those faces are decorated by skilled artist at the different time probably towards the end of the reign of Amenophis III or just before his burial.

The walls of room J are decorated with the *Book of Amduat*, a story of the journey of the solar boat through the twelve hours at night. They are depicted as if it is drawn on papyrus (Figs.12, 13). Thus, the human figures are mostly abbreviated. The background color is totally different from that was used on other walls in room E, room I, and the pillars. In room J, the background is muddy gray. There is no consistency on the tonality of the color. On these walls, only four different colors are used except the border and frieze. They are black, red, yellow, and blue. It is notable that the grid system was not applied on these walls, but painters and scribes drew the images and inscriptions with high quality.

2. Epigraphic Observations

(1) Room I

Having been cleaned by conservators, some previously unreadable texts have become visible. On the north wall of room I, there is an image of *serekh*, representing the Horus name of the king on the head of the *ka* of the king. In room E, the *ka* figure of the king bears the Horus name of Tuthmosis IV instead of Amenophis III (Fig.2). Betsy Bryan suggested that Amenophis III considered his father's involvement in the tomb to have continued throughout the son's reign due to the presence of the foundation deposits of Tuthmosis IV in front of the tomb of Amenophis III[5]. However, before cleaning it was not clear that the same Horus name of the father of Amenophis III was inscribed on the image of *serekh* of the *ka* figure on the north wall of room I since this part was supposed to be decorated after the burial of the king. It was thought that the Hours name of either Amenophis III himself or his son Amenophis IV is inscribed. Now it has become clear that the Horus name on this part also mentions the Hours name of Tuthmosis IV. This means, as Bryan assumed, Amenophis III regarded his father's involvement in his tomb to have continued even after his death.

On the same part of the north wall it was found that some mistake was made in the inscription. For example, the description of the act of goddess Nut receiving the king described as follows: *ỉr.s nyny ms.s.n Nwt nbt pt ḥnwt nṯrw* instead of *ỉr.s nyny ms.n.s Nwt nbt pt ḥnwt nṯrw* "May she make welcome to the one whom she bore, Nut, Lord of the Heaven, Mistress of the gods." It is likely that the scribe or painter drew the inscription very hastily after the burial of the king.

It should be noted that a hieratic graffito was found on the east wall of room I after the cleaning, but there are only few words written and it is impossible to understand its meaning.

(2) Room J

The cleaning work on the walls of room J allowed us to read the inscription hidden under guano. During the first season, a number of unreadable inscriptions have become visible especially in the ninth to eleventh hours of the *Book of Amduat*. The revised version of the text is expected to be published after completing the conservation project. In the course of this campaign, I also tried to relocate a number of the wall fragments from the walls of room J. Some of the fragments can be attached to their original places. It is hoped that our conservator will fix these fragments to the original position.

3. Egyptological Contribution to the Conservation Work: Concluding Remarks

It is true that Egyptologist will benefit a lot from the conservation work by having a better understanding of what is written or drawn behind the dirt on the wall. On the other hand, Egyptologist can contribute to the conservation work to achieve a better result. In the course of the first campaign, we have noticed that it is difficult for someone who is not familiar with Egyptian art to identify the iconography and inscriptions on the wall paintings. For instance, there is a kind of ambiguity in a line of hieroglyphs when a conservator is cleaning the wall. As I am an Egyptologist, I could provide the conservators the data and give them advices on the basis of certain patterns of religious texts. It is hoped that more discussion and evaluation will be made between conservators and Egyptologists including Egyptian and other foreign experts to conserve these 3400 old paintings in the future seasons.

1) W.R. Johnson, "Monuments and Monumental Art under Amenhotep III," in D. O'Connor and E. Cline (eds.), *Amenhotep III: Perspectives on His Reign*, Michigan, 1998, 82-84.
2) *Ibid.*, 85.
3) *Ibid.*, 81-82.
4) M. Jones, "The Work of the American Research Center in Egypt in the tomb of Sety I in the Valley of the Kings, 1998-1999," in Z. Hawass (ed.), *Egyptology at the Dawn of the Twenty-First Century: Proceedings of the Eighth International Congress of Egyptologists*, Cairo, 2000, Vol. 1: Archaeology, Cairo, 2003, 258-259.
5) B. M. Bryan, *The Reign of Thutmose IV*, Baltimore, 1992, 195.

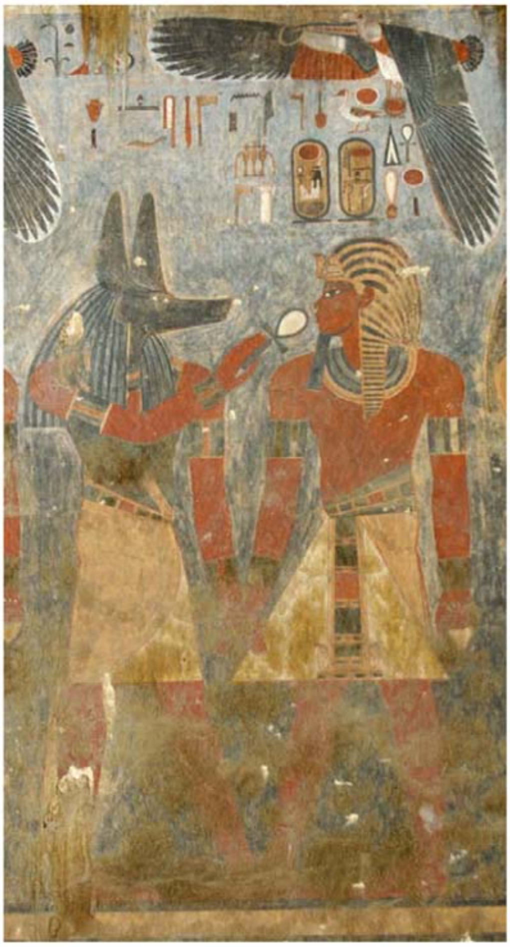


Fig.1 King and Anubis on the south wall in room E

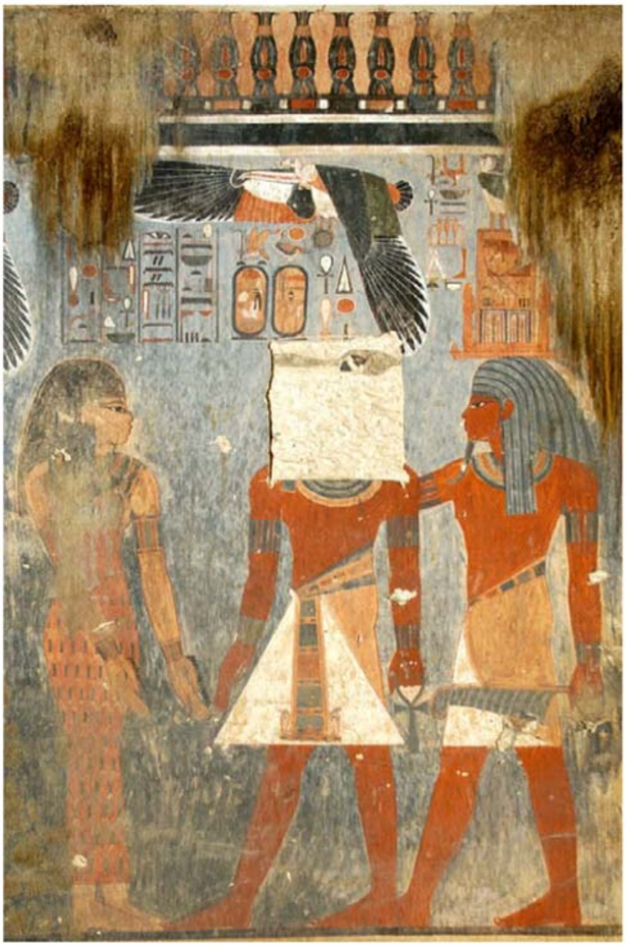


Fig.2 King, *ka* and Nut on the south wall in room E

Fig.3 Nekhbet on the south wall in room E

Fig.4 Nekhbet on the north wall in room E

Fig.5 Room I west wall after conservation

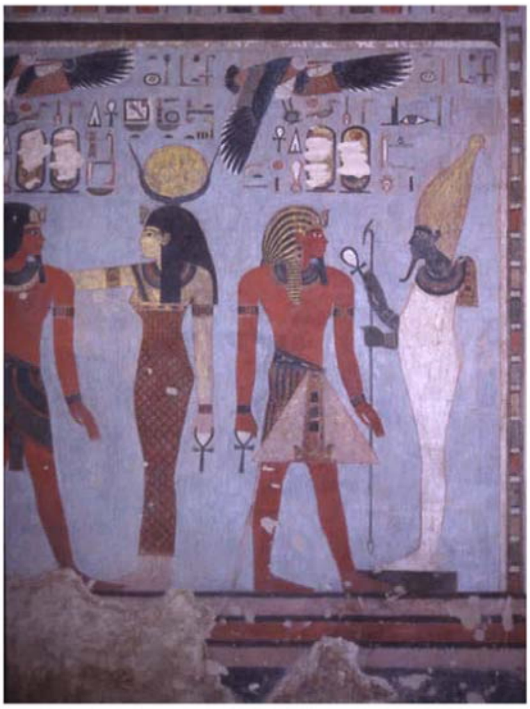


Fig.6 Images painted in orpiment in room I

Fig.7 Images painted in realgar in room I

Fig.8 The king wearing molded Nubian wig

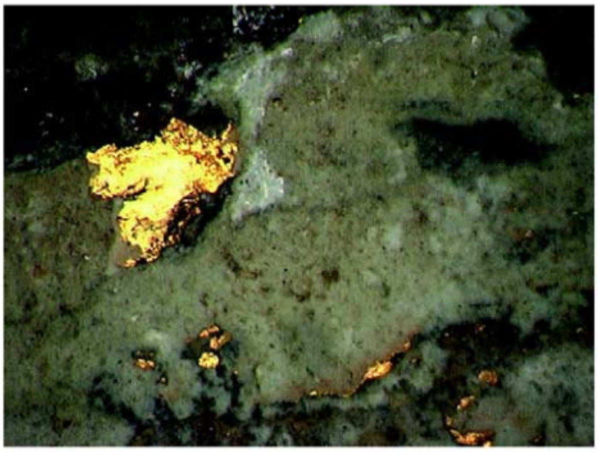


Fig.9 Gold leaf found on the west wall (Microscope)

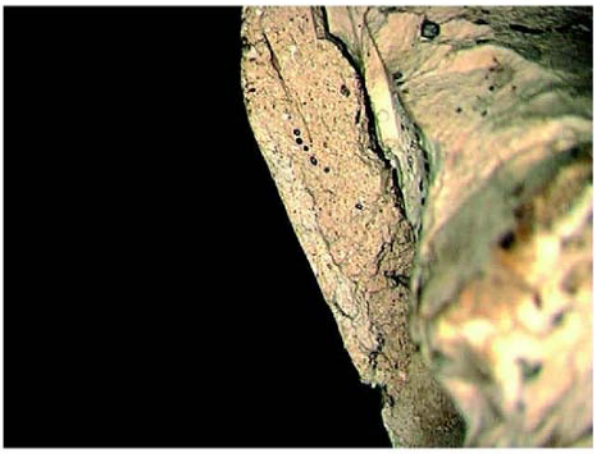


Fig.10 Three layers of plasters on the face of pillar 6 (Microscope)

Fig.11 Room J pillar 6 east face

Fig.12 Room J south wall (third hour of the *Book of Amduat*) after conservation

Fig.13 Room J north wall (eleventh hour of the *Book of Amduat*) after conservation

(3) On the Reconstruction of Wall Painting Techniques and Processes in the Royal Tomb of Amenophis III

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1. On the Substrate of the Egyptian Wall Paintings

The following is quoted from Mora, P., Mora, L. and Philippot, P., in *La Conservation des peintures murales* (1977) :

"In Egypt, mud from the River Nile provided the material for walls. The basic format for the substrate of wall paintings in the Old Kingdom consisted of sun-dried bricks made by mixing Nile mud with chaff (chopped straw), or flat-cut stones as the structural body, with wall painting material applied on top of them. This material was most commonly gypsum plaster. The gypsum used in this case was obtained by baking at about 130°C, and contained natural calcium carbonate. In the New Kingdom, however, the supporting body was made of rough-hewn stone, and so a foundation layer was applied over this using mud and chaff. In the New Kingdom (from 1570 B.C.), or the Ptolemaic era, the method of applying a top layer based on lime appeared. In some cases, the use of a gypsum-lime mixture is seen. It is unclear, however, whether the gypsum and lime were purposely mixed together or whether the process was natural.

The foundation layer consisted of clay and chaff, with a lime-based top layer applied on top of this. Between them, these two layers formed a thickness of about 2 mm. In some cases, gypsum was applied over the foundation layer of clay and chaff.

The pigments are thought to have fixed using a binder. As Egyptian paintings are highly sensitive to water (the pigments dissolve in water), it is possible that the binder used was arabia gum or gelatine. It is also thought that different binders were used for different colours."

2. Creation of Egyptian Wall Paintings

The process of creating wall paintings can be seen in unfinished tombs. After plastering the wall, a chequered pattern of horizontal and vertical lines would be drawn on the finished surface, either with a stylus or by striking the surface with a line of string soaked in red dye. This was used to determine the shape of picture and the proportions of the hieroglyphs. The pigments used in the paintings included yellow ocher, green and blue (Egyptian blue). Since several wooden sticks with their tips crushed to fibres have been found next to trowels, pestles and mortars, it is thought they were sometimes used to create shallow relief. This is thought to have been partially illuminated with beeswax or by applying paint. In many places, deterioration of the paint has caused it to peel off.

- Basics of Egyptian wall painting materials
  Nile mud*+chaff: Raw material used for intonaco (top layer of wall)
  * Nile mud is clay containing sand+small amounts of calcium carbonate and gypsum; the higher quality material Nile mud called "*hib*" contains limestone.

3. The Wall Surface as a Supporting Body and Observations on Wall Materials

Irregularities on the rock wall surface reveal compression in a vertical direction, with tabulate grain running horizontally. Although the ceiling shows chisel marks from the time of excavation, these are not seen on the vertical surfaces. The depth of the irregularities on the wall surface is normally 2 to 3 cm. The foundation layer materials are thought to have adhered better on the walls than on the ceiling. Rock that looks particularly white in places appears with a width of tens of centimeters at vertical intervals of between 10 and 30 cm horizontally along the tabulate rock. This section is particularly rigid, and protrudes somewhat. When this appears in the corner of the burial chamber, it is impossible to reduce with a chisel. Here, therefore, foundation layer materials were applied as if to hide this part, producing a warped surface. Meanwhile, in places with particularly deep hollows, foundation layer materials are thought to have been applied specially in advance, to bring the surface up to the same level as the rest of the wall.

While further analysis is required to specify the actual wall materials, the results of X-ray analyses so far suggest it is difficult to judge whether this was calcium hydroxide at the time of creation, even when calcium carbonate has been discovered. However, conjecturing from the fact that the method of creating wall paintings in ancient Egypt required plenty of time, it is thought unlikely that pigments were fixed via carbonation of lime. On observing the site of a wall painting in mid-creation in the tomb of Amenophis III, the creation is not thought to have proceeded within the time of initial hardening (from 10 to 20 hours), as in *buon fresco*.

This means that a method not dependent on lime was used for hardening the wall and fixing the pigments. In this respect, if a wall has been made with earth as its main material, sufficient hardening can be obtained if the earth is a good clay soil and sufficient pressure is applied when preparing the wall. In the tomb of Amenophis III, the rock face was roughly hewn, and this was relatively even, and this is thought to explain why peeling has occurred in so many places there.

To prepare the surface for the wall paintings, two layers were usually applied. The first of these was a coarse material mainly consisting of sand, and the second a finer material applied with a trowel. Layers were applied after moistening the wall. It is thought that the interval between the first and second layers was decided by observation after the water gypsum, calcium carbonate or lime were mixed in with the substrate, as these are thought to have assisted the hardening process. As seen in the wall paintings at Pompeii in Italy, materials mixed from lime and earth are observed to have extremely strong hardening capacity and durability.

On some walls, preparation in three layers has been observed (p.150: Fig.10), although the reasons for this are unclear. Also, since the soil contains kaolin, varying degrees of whiteness can be observed. Moreover, when it was difficult to make the surfaces uniform when excavating the wall surface, it is possible that three or more layers were applied to even out irregularities.

According to Giorgio Capriotti, chief conservator of our project who also had worked in the tomb of Queen Nefertari, the admixture of fibres was observed in layers applied over the substrate layer there in the tomb of Nefertari. However, no vegetable fibres could be seen in the substrate of walls in the tomb of Amenophis III.

4. On the Fixing of Pigments

No grid fixing (such as by carbonation of lime) can be seen. Arabia gum has been cited as a fixative for pigments. It is also thought possible that different binders were used for different colours. In the royal tombs, where humidity was low and temperature variation small, there is thought to have been little deterioration of these binders.

In the tomb of Amenophis III, a tutorial on the partial reconstruction of wall paintings was given to me by our chief conservator, Dr. Giorgio Capriotti. Part of this is reported here.
The substrate material used in this tomb was:
Calcareous sand+natural clay (lime: *hib*) + gypsum dehydrate.
This was prepared as a material for the conservation work on the wall paintings.

5. Steps in the Reconstruction Work

For the supporting body, veneer board of about 1 cm in thickness was used.

(1) Applying the first layer (Fig.1)
The first foundation layer was applied on top of this to replicate the rock wall. The material used was an experimental mixture of foundation material used when actually restoring walls, mixed with acrylic bonding agent and primal stock solution.

Calcareous sand is light brown in colour and similar to Japanese silicate sand. Coarse sand about the size of Japanese No.6 silicate sand was used. Sand: 3, Gypsum: 0.5, Natural clay: 1, and Primal: Acrylic 33 (Emulsione Acrilica Acquasa) water-soluble acrylic emulsion were used for the first layer. This foundation layer was thoroughly dried.

(2) A second layer was then applied as the top layer, and a wall for painting was prepared (Fig.2). The proportions used in mixing the material were the same as in the first layer, but a finer grain of sand was used. No emulsion was added in this process, which relied on the soil hardening capacity and a small amount of gypsum.

(3) The preparation was dried in the sun. When some of the moisture had evaporated, the surface was pressed flat with a spatula, and the material was compressed and smoothly finished.

(4) Making the cord
A cord was prepared using a method thought to have been practiced when the wall paintings were first created (Fig.3). In this case, cheesecloth was unraveled into several lengths of cord and knotted

at interval of about 2 centimetres.

(5) Framing
White-coloured water containing white powder from calcium carbonate was prepared. The cord was soaked in this, and lines were made at the top and the bottom, right and left to mark out the area of the picture (Fig.4). To do this, the moistened cord was fastened at two datum points. Then one point in the centre was lifted up, pulled and allowed to spring back, leaving a line on the wall. This was basically the same procedure as a Japanese carpenter would use to ink a line with inking string.

(6) Drawing a grid (Fig.5)
Next, points were set at equal distances along the white line, and thin lines drawn in bright red (red iron oxide: hematite) between them, without using the cord, to form a grid.

(7) The original painting was copied onto film (Fig.6)
Transparent film was placed over the actual wall painting, and the shape was traced with a permanent maker.

(8) A grid of the same size as the prepared panel was drawn, and the lines of the sketch were transferred onto the panel in light red (Fig.7).

(9) Corrections were made on the sketch in black, and the shape perfected (Fig.8).

(10) Colouring (Fig.9)
Light red, yellow ocher, and ivory black were used for colouring. The yellow ocher parts were those in which orpiment had actually been used.

(11) As a substitute for Egyptian blue, indigo powder and sand with a high silica content were passed through a fine sieve and mixed (Fig.10). For the background, calcium carbonate was added to make a pale blue. For the blue on the head, ivory black was added to make a darker colour. Calcium carbonate was used for the white parts. Finally, lines were drawn in ivory black to complete the picture. The binder was acrylic emulsion, the same as with the foundation layer.

(12) Aging
The edge of the top layer on the finished panel were scraped off with a knife, then sand was sprinkled and rubbed onto the surface (Figs.11, 12). This removed the shine from the surface, making the painting look old. The picture was given cut marks with a knife.

(13) Substrate material was again applied to the parts of the edge that had been scraped off, and the level made uniform (Fig.13). Then the foundation layer was scraped to lift the actual picture about 1mm above the surround, whereupon the reconstruction was complete (Fig.14).

Fig.1

Fig.2

Fig.3

Fig.4

Fig.5

Fig.6

Fig.7

Fig.8

Fig.9

Fig.10

Fig.11

Fig.12

Fig.13

Fig.14

Fig.15

7. Social Environmental Research

Social Environmental Research on the Site

So HASEGAWA

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Introduction

In this report, I will describe the environmental changes in the archaeological sites in Luxor. Luxor is the largest city in Upper Egypt and is located approximately 600 kilometers south of Cairo. The city is in the Qena Province (Fig.1). The Luxor sites spread both towards the east and west areas of the Nile. In the east area of the Nile, the city starts at the entrance between Karnak and the Temple of Luxor as its axis. The west area of the Nile is composed of sites groups which are concentrated around Qurna Village and dotted throughout the areas to the south. In this research, I have decided to focus on six areas in Luxor (Area A to F, Fig.2) considering the expansion of the city after the bridge that connects the east and west sides of the Nile was constructed in 1997.

1. Population Growth and Environment

As we can see in the results of the census which is conducted once every ten years since 1966, Luxor has much changed and is now the largest city in Upper Egypt with its present population of 360,000 (Table 1)[1]. It surpassed Asyut which had been the city with the largest population. When we look at the changes in the population of the city of Luxor in the past thirty years, the increase in the population between 1986 and 1996 has the greatest increase rate of 187.3%. We tend to think of Cairo as a city which suffers from serious environmental pollution from such things as exhaust fumes and factory smoke[2]. Other cities in Upper Egypt, such as Luxor, have been facing environmental destruction from salt water. However, we need to be aware that the environmental problems which have been developing at Luxor sites are not mundane. Since Luxor is a city in which Waseda mission started a general survey in 1966, I would like to trace the development of the city making use of the photos we took of the general survey as visual materials for our research[3].

2. Development and Historical Monuments

The east area of the Nile in Luxor has a long history in which only the areas around Karnak and the Temple of Luxor had been developed. Before 1922, the places which spread east and south of the Temple of Luxor were especially developed. Furthermore, the areas northeast of the Temple of Luxor were developed intensively during some thirty years between 1922 and 1953 and the areas in both the north and south of the east area of the Nile in Luxor were partially developed during this period as well. During the period between 1953 and 1980, the areas up to Karnak in the northeast of the Temple of Luxor, the east side of Luxor station, and the south side of the Temple of Luxor were developed (Fig.3). After 1980, the developed places extended more towards the north and south sides of Luxor[4]. Therefore, the observation point of this research, the south area of the Temple of Luxor (Area A) is the newest developed area with five-star hotels (Fig.4), shopping malls with souvenir shops, Chinese restaurants (Fig.5), and Pubs which have tourists as their main customers. The bridge which connects the east and west area of the Nile in the city of Luxor was constructed approximately 3 kilometers south of the middle of the city, taking into account the traditional views of the city (Area B).

3. The Locality of the Tomb of Amenophis III

Regarding the west area of the Nile in Luxor, we focused on the surrounded areas of the places where sites are concentrated in Qurna Village. The west area of the Nile across the bridge used to be an area where only small villages such as Aqalta Village and Dab'aiya Village once stood[5]. However, the west area of the Nile was connected to the wharf area of Luxor by a paved road and became an intersection of the main road which runs between the two major cities, Naqada and Armant. In addition, the entrance from the desert side now has a newly constructed bridge (Fig.6). The area that covers Deir al-Shalwit at south of Malqata, which used to be called an abbey. This was an isolated place by the sites in the New Kingdom Period in the desert, Kom al-'Abd. In this area (Area C), a new village and a five-star hotel were constructed, which provides a very comfortable environment[6] (Fig.7). This hotel was built although the area around the village doesn't have places for shopping. At the edge of the desert, a paved road which connects the areas of Armant to Deir al-Shalwit was constructed. Then, the road was connected to other roads which run through the desert in the Malqata Area, and was extended further to the ruins concentrated in the Qurna Village. In the area (Area D) to Naqada across from the Qurna Village where the sites are concentrated, a new village was constructed. The people who live in the site area were asked to move to this village, is called the "Tarif Housing Project" (Fig.8). Furthermore, a paved asphalt road in the desert from a junction in the Valley of the Kings to the new village was constructed[7]. The scenes at the ferry wharf (Area E) in the east area of Luxor changed drastically in the past thirty years. The area (Fig.9) at the wharf, which was used for barges in 1966, has been modified because of land reclamation, and the piers there have been covered completely with concrete. A paved road which runs from a low level of the present wharf was constructed (Fig.10). A parking lot for taxi cabs was also constructed here at the higher level. Compared to the areas which have seen drastic changes, Qurna Village (Area F) doesn't have many noticeable changes during the past thirty years (Figs.11, 12). The government planned to designate Qurna as a place of historic importance, and to move its residential areas. In fact, we can see houses which are no longer used between Shaikh 'Abd al-Qurna and Dira' Abu al-Naga because the people living around the ruins have moved to the new village. In this area, there are some nobles' tombs, as well as the tomb of Nefertari which has recently been opened to the public after preservation and restoration by the Getty Institute[8]. Such sites as the Temple of Merenptah have recently been opened to the public as part of an open museum project[9]. The Valley of the Kings is located at the most secluded part of the concentrated sites area. The Main Valley attracts tourists to the sites which are located west of the Nile. Since all the ruins there are rock-cut tombs, there are problems such as: how to restore the wall paintings that have been damaged by salt water, bat excrement, carbon dioxide vapor from humans, and how to prevent the paintings from further damage. The undesirable effects caused by the drainage of kitchens and the degradation of the wall paintings caused by vibrations and exhaust fumes from sightseeing buses have also been serious issues. To solve these problems, the rest houses that stood in the 1960's (Fig.13) have been removed from the area. There was a gate for cars to enter the ruins in front of the tomb of Ramesses IX. However, the gate was removed and a new gate was constructed in front of the tomb of Ramesses IV, which is located further down in the valley. The closest place to the site for cars is located further away at an area near the junction between the Main (Eastern) Valley and the Western Valley. To prevent vibration and pollution, trolley buses have been introduced to take tourists to the main gate (Fig.14). On the other hand, in the Western Valley, the tomb of Ay is the only one which has been opened to the public, and trolley bus service is not available at the present time. The Western Valley is still isolated from the environmental problem (Fig.15).

4. Conclusion

In the research we conducted this time, it renewed our understanding of the drastic changes in the city of Luxor due to the rapid increase of its population, especially after 1986. We could confirm that the most noticeable changes were in such places as the southern part of the Temple of Luxor (Area A) in the east area of the Nile, and the areas around the Luxor Bridge (Area B), and the adjoining lands to the north and south of Qurna Village (Area C and D), and the areas around the wharf (Area E). In these areas we could confirm the most noticeable changes are mainly located outside the area where the sites are concentrated. The Luxor Bridge is one of the symbols of noticeable changes to the area, as is the new construction of the roads entering the ruins. We estimated that a housing project was built around 1995; it seems that all the noticeable changes were made in the past ten years. The government has been taking the initiative in protecting the areas where the sites are concentrated from any damage caused by the changes in the environment. However, there is the possibility that the changes in the areas outside have somehow affected the sites, considering the case at Greater Cairo[10]. Therefore, we would like to research the relationship between the changes in the outside areas and the effects it has on the ruins, as the theme of our future research.

1) CAPMAS 1996. Here I cited the date from the article by Hirofumi Tanada, "Population and Urbanization in Egypt, 1966-1996" (in Japanese), in *The Contemporary Middle East*, Institute of Developing Economies, no.27, 1999, pp.78-87.
2) Hopkins, N.S., Mehanna, S.R., and Saleh el-Haggar, *People and Pollution -Cultural Constructions and Social Action in Egypt-*, Cairo, 2001.
3) I express my gratitude to Prof. Dr. Sakuji Yoshimura for giving me a facility to use following old photos stored in the Institute of Egyptology, Waseda University.
4) Mājida Muḥammad Juma', *jughrāfīya miṣr al-siyāḥīya*, al-munūf, 2000, pp.524-535.
5) Muḥammad Ramzī, *al-qāmūs al-jughrāfī lil-bilād al-miṣrīya*, al-qāhira, vol.4, 1993, pp.160-167.
6) "Royal Grounds –al-Moudira Hotel in Luxor combines comfort with enchantment for the perfect gateway-" , Spotlight : Travel, *Egypt Today*, vol.23, no.4, April 2002, pp.67-70.
7) Three Housing projects ware promoted at New Thebes, Tarif, and New Luxor, to disperse at the reach of 360,000 population. Tarif Project was intended as a solution for the age-old problem of Qurna Village, and for the first phase of this project was expected to absorb approximately 8,500 persons, while the final project should house 15,000. *al-Ahram Weekly (AW)*, no.376, 1998. On the other hand, New Luxor project was launched for people on low income by Mrs Suzanne Mubarak at the total of another eight cities of Cairo, Beni Suef, Miniya and Asyut, *AW*, no.386, 1998.
8) Miguel, A.C. and Mahasti, A.A.E. eds., *Art and Eternity -The Nefertari wall paintings conservation project, 1986-1992-*, Singapore, 1993. The tomb has been temporary closed for these two years.
9) Jaritz, H., "The Museum of the Mortuary Temple of Merenptah", *Egyptian Archaeology* 19, 2001, pp.20-24.
10) Yoshimura, S. and S. Hasegawa, "The Remarks on the Preservation of Historical Monuments in Egypt, As exemplified by the case of Greater Cairo" (in Japanese with English summary), *Annuals of Japan Association for Middle East Studies*, vol.18-1, 2003, pp.215-226.

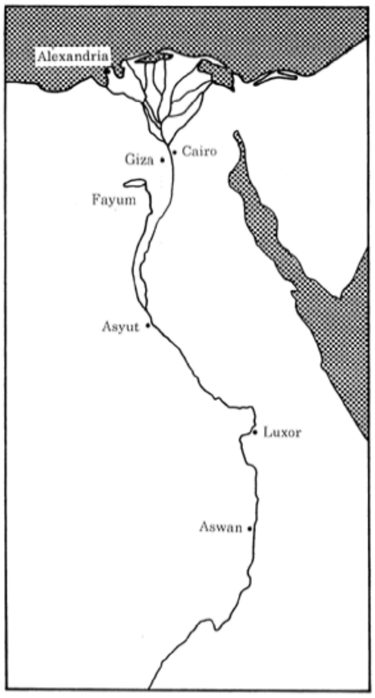


Fig.1 Map of Egypt

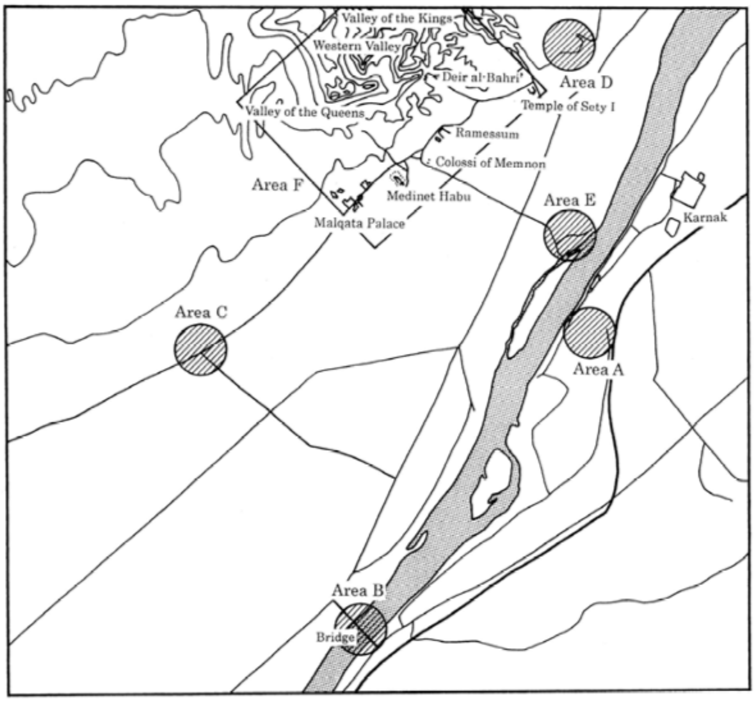


Fig.2 Map of Luxor

Table 1 Population of Principal Cities in Egypt since 1966 (CAPMAS 1996)

City	Abb. of (Muhafza)	Population				Increase grade of duration (%)		
		1966	1976	1986	1996	1996～76	1976～86	1986～96
Cairo	(CA)	4,219,853	5,084,463	6,052,836	6,789,479	20.5	19.3	12.2
Alexandria	(AL)	1,801,056	2,318,655	2,917,327	3,328,196	28.7	25.9	14.1
Giza	(GZ)	571,249	1,232,654	1,870,508	2,221,868	115.8	52.0	18.8
Port Said	(PS)	282,977	262,620	399,793	469,553	-7.2	52.2	17.4
Ismailiya	(IS)	144,163	145,978	212,567	254,477	1.3	45.7	19.7
Suez	(SZ)	264,098	194,001	326,820	417,610	-26.5	68.5	27.8
Damietta	(DM)	86,327	93,546	89,498	111,111	8.4	-4.3	24.1
Mansura	ĎH)	191,459	257,866	316,870	369,631	34.7	22.2	16.7
Mit Ghamr	ĎH)	43,665	72,206	93,253	101,801	65.4	29.2	9.2
Zagazig	(SQ)	151,186	202,637	245,496	267,351	34	21.2	8.9
Bilbais	(SQ)	58,070	69,290	96,540	113,608	19.3	39.7	17.7
Banha	(QL)	63,849	88,992	115,571	145,792	39.4	30.1	26.1
Shubra al-Khaima	(QL)	172,902	393,700	710,794	870,716	111.7	80.3	22.5
Kafr al-Shaikh	(KS)	51,544	77,537	102,910	124,819	50.4	32.8	21.3
Mahalla	ǴB)	225,323	292,853	358,844	395,452	30	22.8	10.2
Tanta	ǴB)	229,978	284,636	334,505	371,010	23.8	18.1	10.9
Shibin al-Kom	(MF)	66,290	102,844	132,751	159,909	55.1	29.1	20.5
Kafr Dawwar	BH)	41,560	160,554	195,102	231,978	286.3	33.4	18.9
Damanfur	B́H)	146,079	188,927	190,840	212,203	29.3	11.8	11.2
Fayyum	(FY)	133,616	167,081	212,523	260,964	25.0	27.3	22.8
Beni Suef	(BS)	90,425	118,148	151,813	172,032	30.7	28.8	13.3
Minya	(MN)	112,580	146,423	179,136	201,360	30.1	22.4	12.4
Mallawi	(MN)	59,938	74,256	99,062	119,283	23.9	33.5	20.4
Asyut	(AS)	153,956	213,983	273,191	343,498	39	27.8	25.7
Suhag	(SG)	74,753	101,758	132,965	170,125	36.1	29.2	27.9
Qena	(QN)	68,536	93,787	119,794	137,244	36.8	27.9	14.6
Luxor	(QN)	77,578	92,748	125,494	360,503	19.6	33.7	187.3
Aswan	(AW)	127,594	144,377	191,461	219,517	13.2	32.4	14.7
Total 1		9,710,604	12,676,520	16,248,264	18,941,070	30.5	28.2	16.6
Total 2		12,032,743	16,036,403	21,173,436	25,479,325	33.3	32.0	20.3

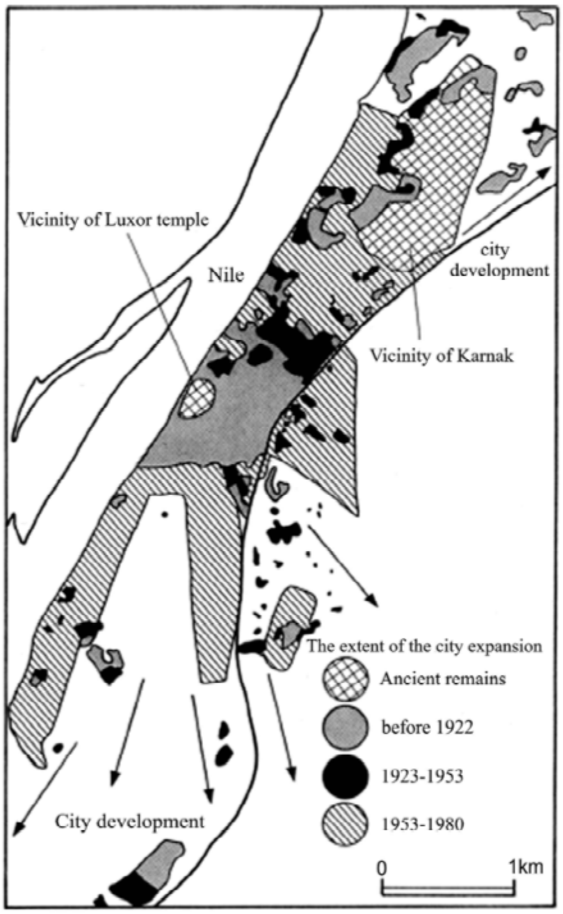


Fig.3 City development of Luxor
(Mājida Muḥammad 2000, fig.211)

Fig.4 Five-star hotel at Area A

Fig.5 Chinese restaurant at Area A

Fig.7 Five-star hotel at Area C

Fig.6 Newly constructed bridge at Area B

Fig.8 New village at Area D

Fig.9 Ferry port in 1966 (Area E)

Fig.10 Ferry port in February 2003 (Area E)

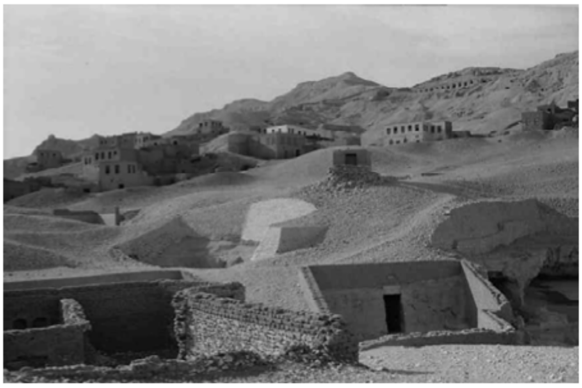


Fig.11 Qurna Village in 1966 (Area F)

Fig.12 Qurna Village in February 2003 (Area F)

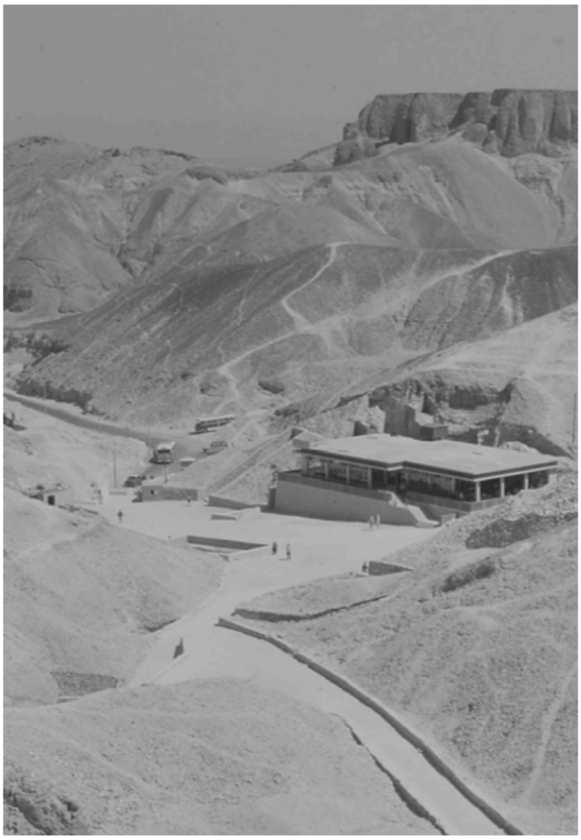


Fig.13 Valley of the Kings in 1966 (Area F)

Fig.14 Trolly buses in February 2003 (Area F)

Fig.15 Approach route to the Western Valley in February 2003 (Area F)

8. Conservation of the Wall Paintings

(1) Conservation of the Wall Paintings in the Royal Tomb of Amenophis III

Giorgio CAPRIOTTI

Conservator, Rome

Introduction

One of my most exciting sensations was visiting the tomb of Amenophis III for the first time, in February 2001. In addition to my admiration of the place and the very high quality of the paintings, it was impressive to observe -as a conservator- the morphology of decay, which appeared extremely complex.

Almost all the surfaces have been damaged and severely offended by the consequences of ancient bat colonizations. Even before its rediscovery, during the Napoleonic campaign, thousands of animals must have used for centuries the Royal hypogeum as den, soiling all over the painting, scraping and detaching plaster.

1. Condition Survey

When we started work it was necessary to organize a rational scheme of reading the surfaces through their alterations, recognizing all the phenomena of different agents of degradation, resumed in a specific "Condition Survey". In order to compile this synthesis it was necessary to have direct knowledge of the constituent materials and the execution techniques, supported by a parallel scientific analyses campaign.

The unusually complex phenomenology of the decay in the tomb of Amenophis III requires four different levels of reading, each one of them subdivided in a number of specific points.

A) Condition of the support (Fig.1-A):

- Cracks (fissures or fractures in the rock structure or in the stratification of the plaster)
- Lacunae of depth (loss of the entire stratification)
- Lack of adhesion (reduction of the adhesion of the plaster, of various types at different levels)
- Lack of cohesion (trend to the desegregation of the preparatory strata of plaster)

B) Alteration of the painted layer (Fig.1-B):

- Loss of the pictorial layer
- Lack of cohesion (trend to pigment pulverization)
- Abrasion (direct mechanical damage, wear)
- Macular chromatic alteration (evident smear of the colour tone of the painted surface, by supposed chemical origin

C) Typology and consequence of biological attacks (bat guano) (Fig.1-C):
- Nest (evidence of bat hanging point, on the ceiling and along the edges and corners)
- Concretion (compact strata created by drying of urine, excrement and mud content into the plaster)
- Residua of excrement (evidence of local smear, in point shape)
- Urine drip (evidence of sprinkled liquid substance)
- Bacteria (black spots trail, supposed metabolic agent of organic residua)

D) Previous interventions (before 2001) (Fig.1-D):
- Facing (gauze or sheets of Japanese paper applied to block endangered areas)
- Filling (plaster applied to block deadhesion along the edges of loss of depth)
- Consolidation (injection of synthetic resin, for most dangerous part)

To compile the survey scheme we have adopted drawings by the Waseda University archaeological mission during the last few years, reducing only the internal details and choosing a single scale (1:10), to sufficiently allow accurate analytical reading of the decay.

On every drawing (about 60), four transparent acetate sheets were superimposed for the four levels of reading as indicated above, relative to the state of conservation of the paintings. For each item of the scheme graphic symbols have been added with coloured markers, showing the localization of the phenomena of degradation (Fig.2).

The punctual and analytical survey of these phenomena was done manually with the aid of cold lights in direct and raking light and with stereoscopic lenses in the entire surface of the tomb.

2. Interventions

At the beginning of this first operative campaign the selection of the areas was based upon the gravity of damage. Priority was given to parts in imminent danger, following the recommendations contained in the preliminary condition survey.

(1) Facings

The first treatment was to remove the existing facing with Japanese paper with starch paste. Both materials, based on organic-vegetal compounds, were in fact already attacked by insects (silverfish).

After checking the real risk of collapse (along the lower edges of the painting, because of the complete deadhesion between bedrock and plaster), the paper facings were substituted with strips of polyamide tissue and gauze, to ensure temporary stability, using an acrylic resin in solution.

Flakes which had collected between the facing layer and the painted plaster were removed and reattached where possible.

In some cases, painted fragments were found in the cracks, still intact from subsequent decay, providing us with precious information about the real chromatic value of pigments' tonality, before their alteration. These were later repositioned and consolidated *in situ*.

(2) Plaster consolidation

All the areas of detachment, already indicated in the condition survey, were carefully checked by tapping the plaster surface, to individualize the extension and depth of the detachment. Consolidation was usually executed by injections of mortar similar to the original formula used by the ancient Egyptians, used as fluid grouting:

a): 1 gypsum : 1 fine sand : water : plus few drops of acetic acid as retardant, (quick setting useful for ceilings)

b): 1 acrylic resin : 1 fine sand : water, (slow setting useful for vertical empty vacuums)

c): acrylic resin emulsion, pure or in various dilution in water (narrow space useful for contiguous dehadesions)

All of these above described formulae have to be preceded by a preparatory injection of ethanol and water 1:1.

The inclusion of acrylic emulsion, more than simply increasing the adhesion power in the mortar, slowed the drying rate, thereby preventing too-rapid absorption of moisture into the sensitive, painted plaster.

Nevertheless, after the injection of fluid mortar, because of the dryness of the plaster, sometimes the water content in the moisture let dark stains rise, corresponding to the consolidated areas. It seems to be a physical consequence of index-refraction changes of the inner layers of the plaster. The disturbing reaction is removable with the application of a poultice of sepiolite trough Japanese paper, capable of completely absorbing the dark stains.

(3) Rock-support consolidation

In the case of fragmented rock-support, the cracks have been cleaned of the debris and then epoxy resin was spread over the crack surface. The epoxy was charged with calcium carbonate powder, to increase the sticking-power of moisture.

(4) Reattachment of flakes

Raised or detached paint flakes with some plaster adhering to the back were reattached with infiltrations of acrylic resin in emulsion, applied behind loose flakes with a pipette or syringe. The flakes were then gently pressed back in to place using silicon paper and a steel spatula.

(5) Strengthening of the cohesion of the pictorial surface

In case of weakness of the original binding medium, a powdering phenomena of the paint layer has been observed. This weakening of the cohesion of the pictorial layer was treated with impregnation of acrylic resin in solution, of a low percentage. Only in some cases of extreme powdering of pigment (Egyptian blue and green), extremely sensitive to brushing, a more rapid and efficient consolidate as a low solution of acrylic resin in emulsion, highly solute in water, was used.

(6) Detachment and reattachment

All detached and askew fragments were faced with synthetic polyamide tissue and a 10 to 20 % solution of acrylic resin, to temporarily protect the surfaces during the operations for reattachment and realignment. With special, long metal chisels, the fragments were slowly removed from the wall completely and placed face down on wooden supports stuffed with cotton and covered with a layer of soft polyurethane.

With lightweight hammers and chisels, accumulated dirt, guano, pebbles were mechanically removed from the walls and the reverse side of the fragments. The thickness of the plaster was reduced by1/3 to facilitate the replacement *in situ*.

The reverse of plaster was prepared with impregnation by acrylic emulsion and water, to reinforce the powdering plaster. Then the losses and cracks on the reverse side were filled in level with a mortar similar to the original plaster. Finally, on the reverse side a layer of gauze with pure acrylic emulsion was applied, to give a new internal unity to the detached piece, fragmentised like a piece of a puzzle.

The presence of this new functional support applied on the reverse side allowed the removal of all facings from the surface, which is much more convenient in terms of readability during the replacement of the fragment. Only carefully checking the correspondences of the painting lines will guarantee the correct realignment of the pieces. So, the facings were removed from the surface with thinner, by wetting and brushing. The residua of resin were absorbed through a sheet of paper.

These operations are completed and the rock has been smoothed. The fragments need to be reattached, in the next campaign, by means of epoxy bridges connected to the rock support. The correct position during the setting of the resin will be guaranteed by means of a temporary gypsum belt, which will be plastered along the lower part of the fragment.

After placement, the fragment will be held in place by a tension press until completely set by the resin (24 hours). Then a more fluid mixture of the original mortar compounds will be injected to fill all the internal vacuums, giving new stability and adhesion to the replaced pieces.

(7) Removal and repair of fills

All the fillings, especially along the edges of the lacunae, applied during previous interventions were mechanically removed, sometimes totally, sometimes only reducing their presence to the simple function of reinforcement of the borders.

First, the original plaster on the borders of lacunae was consolidated acrylic resin in emulsion. To prevent a later deterioration of the painted plaster some lacunae have been filled with a plaster similar to that used by the ancient Egyptians:

a): 3 sand (original limestone sand medium sieved) : 1 kaolin : 0.5 gypsum (for depth layer)

b): 3 sand (fine sieved) : 1 sand (medium sieved) : 1 Nile brown clay : 1 gypsum (for superficial layer)

The material used as new mortar has to be as compatible to the original to avoid differential tensions in the structure. The new fillings were installed under the level of the surrounding original plaster, so as to imitate the surface wear of the original mortar, using a special method of applying by spatula and final dry-brushing.

(8) Cleaning

An initial visual inspection of the surfaces was made, supplemented by information that had been gathered on the material history of the wall paintings, including previous interventions, graffiti, spoliations, decay, physical conditions of exposure since their creation, as well as other factors. Subsequently, those foreign substances needing removal were exposed to specific cleaning agents and solvents in order to study their reactions and thereby gauging or suitably modifying the cleaning treatment accordingly. At this stage, laboratory analyses of pigments, binding media, plaster, and rock were made to ensure precise treatment and confirm hypotheses based on visual examination.

The choice of cleaning agents and use was based on:

- nature and entity of substance to be removed
- resistance of the original material constituent with the paint layer

In order to respect the correct balance between these two items a range of cleaning agents has been selected, as follows (the parts are expressed in volumes):

a): 1 acetone : 1 ethanol : 1 distilled water

b): 2 lacquer thinner : 2 ethanol : 1 distilled water

c): 1 acetone : 1 distilled water

d): 2 distilled water : 1 ethanol : 1 acetone : 0.2 ammonia

e): Solution of biocide agent in distilled water 3% (antibacterial)

f): Peroxide water (30 vol. concentration), for eterotrophies micro-organisms colonies

g): Poultice of distilled water in sepiolite, through paper sheet, to absorb deep stains from the inner layers of the plaster

The most efficient application recommended is by absorption through Japanese tissue paper in three different and subsequent phases, to let the greasy guano react, until swelling. Among the phases of treatment it is necessary to provide precise mechanical cleaning by scalpel to remove thicker layer of guano.

(9) Final presentation

To help the readability of the paintings, in the context of such complex situation of decay, where decorated surfaces coexist with wide losses and evidence of rock support, special attention has been applied to the research of a balanced perception of the tonality of the parts.

On this subject, all the whitish abrasions of the surfaces have been veiled with tonality suggesting the same value of the surrounding patina of the ancient paintings. The glazes were obtained by pre-washed heart powder (brown Nile clay), diluted in water and exactly applied by fine brush over the whitish abrasions.

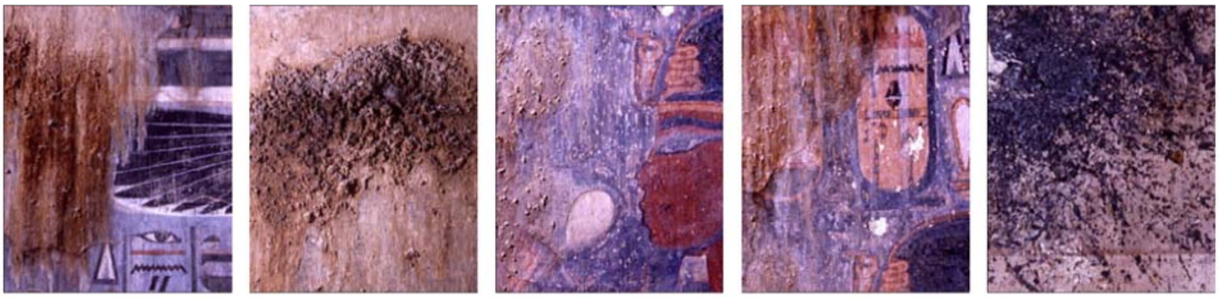
A) Condition of Support:

Crack | Lacunae of depth | Lack of adhesion | Lack of cohesion

B) Alteration of the painted layer:

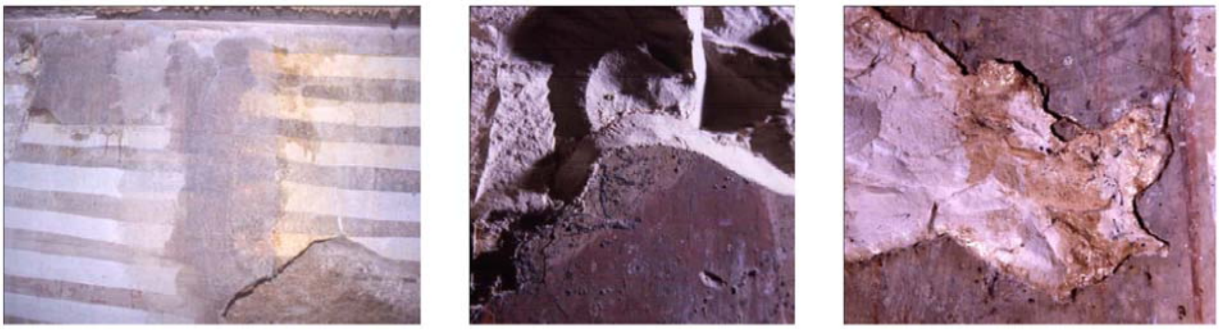
Loss of the paint layer | Lack of cohesion | Abrasion | Chromatic alteration

C) Typology and consequence of biological attacks (bat guano):



Nest | Concretion | Excrement | Urine drip | Bacteria

D) Previous interventions (before 2001):



Facing | Filling | Consolidation

Fig.1 Examples of the conditions

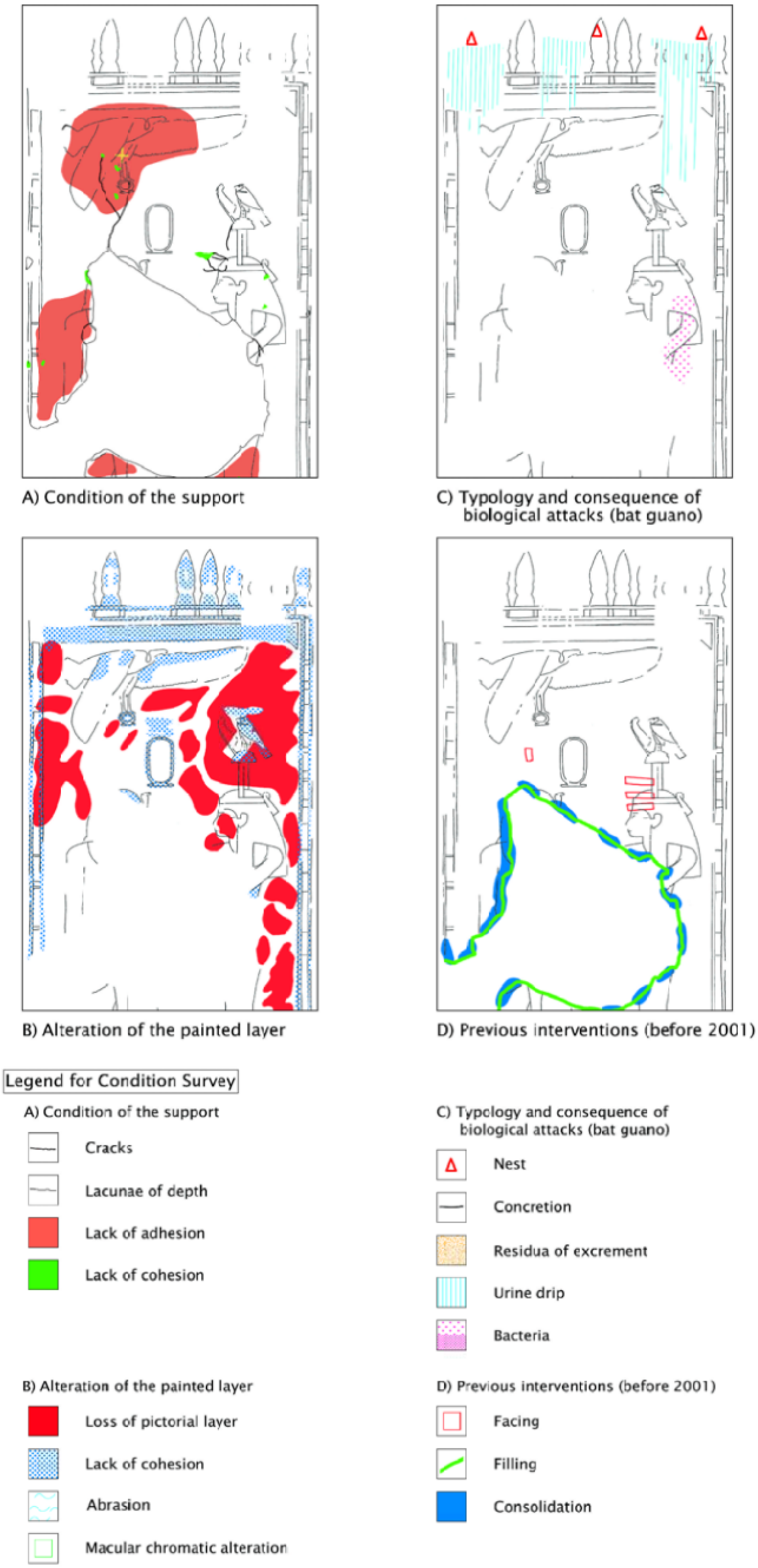


Fig.2 A example of sheets of the condition survey (not to scale)

(2) A Report on the Conservation Work on the Wall Paintings in the Royal Tomb of Amenophis III

Eriko NAKAU

Conservator, Tokyo

1. Observation of the Painting Techniques and Materials

The pigments used in the tomb of Amenophis III are blue, green, yellow, red, black, and white, as already mentioned in this volume by Prof. Dr. M. Uda.

In room I and room J, where the yellow pigment of orpiment was used, the rose color under the painting was observed. The color scheme and the proportions of figures in room E seems to be different from room I and room J. The background color and the blue areas in room E appear to be darker.

2. Observations on the State of Conservation

Observation on the state of conservation work in room E, I and J was made in reference to the following four aspects: (1) Support, (2) Paint layer, (3) Biological attacks, (4) Previous interventions. The blue, green and yellow pigments were used, and the white pigment was peeling from the plaster. The red and black pigments were resistant to damage.

3. Conservation Work

The period of my participation in the conservation work was April 8 to May 11, 2003, and the work included the consolidation and cleaning of the south wall in room J (burial chamber).

(1) Consolidation of the plaster layer

First, the edge of the detachment of the plaster layer was filled with *muna*. Areas of detachment not visible to the eye were identified by tapping the plaster surface. When a hollow sound resulted, consolidation was executed by injections of acrylic emulsion (Primal AC33).

Where the detachment of a large space between the rock and the plaster, pure acrylic emulsion or filling (gypsum, very fine grains were added in acrylic emulsion diluted with water) was injected. For the small detachment, a solution of 50% acrylic emulsion was applied. Usually drops of 50% ethanol and 50% water were applied for help in penetration of adhesives.

Finally, the lacuna of plaster layer was filled with *muna*, and it was shaved 2-3 mm in low thickness from the paint layer.

(2) Cleaning of the paint layer

The surfaces of paint layer were covered by dense layer of bat excrement, and a kind of bacteria of a black aspect. The cleaning of the paint area was executed very carefully, especially the pigments of blue and green, which are powdering. The choice of cleaning materials and methods was based on the test cleanings tried by chief conservator, Dr. Giorgio Capriotti, in the preliminary season.

The basic steps for cleaning the background of the *Book of Amduat* is as follows:

1) Application of cleaning solution (2000cc water, 500cc ethanol, 100cc acetone, 80cc ammonia) by absorption through tissue paper, to allow the greasy dirt (organic residua of bat excrement) to react.
2) Cleaning by scalpel, to remove thicker layers of residua.
3) Cleaning by brush, remaining residua with 50% ethanol and 50% water. (For areas of hieroglyphic inscription, cleaning by cotton instead)
4) Application of anti-bacterial solvents through tissue paper. Let it dry until it's completely dried.

For painted areas, the cleaning steps were taken as follows:

1) Application of cleaning solution (2000cc water, 500cc ethanol, 100cc acetone, 80cc ammonia) by absorption through tissue paper, to allow the greasy dirt (organic residua of bat excrement) to react.
2) Cleaning by scalpel, to remove thicker layers of residua.

Above process (1 and 2) were continued until dirt was completely removed.

3) Application of anti-bacterial solvents through tissue paper. Let it dry until it's completely dried.

After cleaning, for the presence of whitish material which was caused by the residue of dirt, or where color was consumed, the dirty water (pre-washed heart powder of brown Nile clay, diluted in water) was applied with brush.

(3) Consolidation of pigments

Where the pigments of blue and green are present, application of 3-4% acrylic emulsion (Primal AC 33) in water was executed for cohesion of pigments which are powdering.

The 3-6% Paraloid B72 in thinner was applied on the pigments of blue, green and some weak pigments.

(3) A Report on the Conservation Work on the Wall Paintings during the First Phase

Kunihiro SETO[1] and Akiko NISHISAKA[2]

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Introduction

This season our work was concentrated on consolidation and cleaning of the wall paintings on the pillars and walls in room J. In room J, there are 6 pillars decorated with the figure of the king coupled with a god or goddess on each of four faces. In this season, we have cleaned all four faces of pillar 1, and the north and west faces of pillar 3. After finishing the work on the pillars, we were assigned to move to a part of the south wall of room J, which is decorated with the second and third hours of the *Book of Amduat*. The duration of our work for this project in this season was from January 6 to May 15, 2003.

1. Observation of the Condition of Each Wall before Intervention

Pillar 1 west face: A bat's nest remained at the upper-left part, and there was thick concretion around the nest. The middle and lower part of this face was already lost (Fig.1).

Pillar 1 south face: There was a thick concretion of bat excrement on the upper-left side of the face, and a concentration of bacteria on the right side of this face. A previous intervention with Japanese paper had been attempted where the crack was running on the right side of the pillar. The middle and lower portions of this face were already lost (Fig.2).

Pillar 1 east face: There was a thick layer of bat excrement on the upper-left side of the face. The middle and lower portions of this face were already lost (Fig.3).

Pillar 1 north face: There was a thick concretion of bat excrement on the upper-right section of the face. The middle and lower portions were already lost (Fig.4).

Pillar 3 west face: There was a thick layer of bat excrement at the upper-left corner of the wall. Middle and lower portions of this face were already lost (p.25: Fig.11).

Pillar 3 north face: A big crack and previous intervention with Japanese paper was found on this wall. The detachment of the plaster layer along this crack was very critical. There was also a thick layer of bat excrement on the upper left corner of this face. The middle part of this face was already lost, but the lower part of the painting was preserved (p.25: Fig.12).

Room J south wall: The place we were assigned on the south wall was decorated with the second and third hours of the *Book of Amduat*. The condition was similar to that of pillars, and the main problems of deterioration were detachments of the plaster layer and biological damages from bat excrement and bacteria (Figs.5, 6).

2. Method of Conservation

(1) Consolidation

Conservation work was directed by our chief conservator Dr. Giorgio Capriotti, who has been training us since the preliminary season (March to April, 2002). At first, according to the condition survey that we did for all faces of walls in the preliminary season, we have to fix the detachments of plaster layer to the bedrock by acrylic resin and *muna* made by fine grains of sand from near our site before cleaning. We used some different percentages of acrylic resin and *muna,* balancing the percentages depending on the wall conditions. Further, when there were even larger spaces between plaster and bedrock, we also used gypsum and lime, adding to the mixture of acrylic resin and *muna.* These injections were made by different sizes of syringe through the cracks or lacunae, and sometimes through small injection holes that allowed us to inject consolidant to fix large detachment areas. Finally lacunae were filled with *muna*. This filling was lowered below the level of the paint layer and brushed to give a natural appearance.

(2) Cleaning

The main problems of disturbance and damage to the paintings were bat excrement and bacteria. For cleaning bat excrement on the walls, a special solvent called *cleaning solution* was very efficient. This is a mixture of four solvents (acetone, ethanol, ammonia and water) chosen by our chief conservator. To remove bacteria, especially where the concentration is very heavy, we used a small amount of peroxide water. When we apply the *cleaning solution* to the wall, it was applied through tissue. The tissue absorbed a lot of bat excrement from the wall. After removing the tissue, softened residua of dirt could be removed using a scalpel or cotton with bamboo stick. As the last step of the cleaning, in order to suppress the re-activation of the bacteria, we applied the *anti bacterial solution* also through tissue. This consisted of the *cleaning solution* and a few drops of germicides (NEODES and DETTOL). After cleaning, on abrasions and whitish areas which were caused by the residue of dirt, dirty water was applied by brush. Finally, Paraloid B72 (3-6%) in thinner and acrylic emulsion were used to fix the specific pigments (for example blue and green and, to a lessser degree, black and red) where the pigments were flaking or losing cohesion.

3. Conclusion

Dealing with different situations on those pillars and walls in room J, we have gained more knowledge and experience on the conservation of ancient Egyptian paintings in the course of about five months of work. Close observations during the execution of the conservation work brought about some new considerations on the painting techniques and work organization of those ancient painters who worked in this royal tomb. This should be intensively studied after conservation to help understand the art historical significance of these royal paintings. This tomb should be preserved as one of the most important cultural heritages in Egypt.

Fig.1 Pillar 1 west face before and after conservation

Fig.2 Pillar 1 south face before and after conservation

Fig.3 Pillar 1 east face before and after conservation

Fig.4 Pillar 1 north face before and after conservation

Fig.5 Room J south wall (second hour of the *Book of Amduat*) before conservation

Fig.6 Room J south wall (second hour of the *Book of Amduat*) after conservation

9. Photographic Documentation

A Report on the Photographic Documentation during the First Phase

Tsuyoshi SASAOKA

Photographer, Sasaoka Photo Laboratory, Tokyo

Introduction

I participated in the project of conservation of the wall paintings in the royal tomb of Amenophis III by taking photographs. I had two campaigns during this season:

The 1st time: from February 4 to February 20, 2003.

The 2nd time: from April 29 to May 14, 2003.

The following gives the purpose and the method of the photographic recording.

1. Purpose

The purpose of taking pictures is to record the condition of the wall paintings before and after conservation. The condition of the wall paintings has been badly deteriorated by bat droppings, and plaster on the walls has flaked off and cracked in patches, in spite of the fact that the paintings are of high quality even among the Eighteenth Dynasty royal tombs. Therefore I took pictures to record the dangerous conditions before conservation in order to compare the results after conservation. The result of conservation shows that the wall paintings originally had a vivid and beautiful color, on which figures and hieroglyphs were also clear, and it will be fruitful data for Egyptology.

2. Method

The cameras I used were a medium format camera (6×7)[1] and a SLR camera (135)[2]. I took pictures of the wall paintings in rooms E, I and J. Because the paintings were wide, photographs had to be taken in several separated shots so that they could be composed to become one even picture, and I always set a level on the camera to keep the horizontality.

The first time I participated in this project, I concentrated on taking pictures in room J, which has largest wall paintings (15×8 m) among the rooms in the tomb. Since it was impossible to take such large paintings as one shot, I took several pictures in each portion, and they were composed to be one picture in a laboratory in Japan.

In room J, there were six pillars, all faces of which have wall paintings. I recorded the paintings of these pillars from the ceiling to the floor. In rooms E and I, paintings are still visible on the ceilings. I also took pictures of these.

Moreover, I took close shots of important parts separately, for example, figures of pharaoh and gods. The badly damaged portions and the portions of the plaster cracked and separated from the walls were also recorded in detail.

The second time I participated, I again took pictures in each room. Especially in room I, where conservation was almost finished, the wall paintings had become clear and showed beautiful figures.

I took close shots of the figures on the pillars of room J, as the conservation work has progressed. In some cases, a figure on the pillars was divided top and bottom, and because the plaster has flaked off in the lower edges, these figures were taken separately. For other walls in rooms E and J, I took pictures to record the works at the end of this season.

Care was taken that the picture could be developed with the correct color. For this concern, I used Photo bulbs[3)] (Photographic Color Temperature is 3200K), 2 or 4 lamps and color reversal films[4)] that fitted for a photo bulb. Considering a decline of the voltage and color temperature by the reflected light from the wall, I measured the light illumination of the wall paintings by a colormeter[5)]. If it showed low color temperature, I attached a light-balancing filter to the lenses for controlling color temperature. And then I put a Kodak Color Separation Guide inside of a picture per shot in order to reproduce the correct color in printing.

3. Problems and Prospects

I often used a wide-angle lens[6)] because I had to avoid an obstacle such as a pillar while shooting the large paintings. But in this case, pictures showed a distortion in circumference. For correcting this distortion, I think it is better to use a long-focus lens, keep an exact distance between the camera and the wall and take pictures by dividing the wall paintings into small portions. This takes a lot of time and expense to execute. The solution is to take pictures with a digital camera. Next season I would like to use an analog camera as well as a high performance SLR digital camera.

4. Conclusion

In the next season, I am going to take pictures of the wall paintings that will be conserved. I am pleased if these photographs can aid future research.

Lastly, I would like to express my thanks to Prof. Dr. Sakuji Yoshimura and UNESCO for giving me a chance to participate in this project, I also thank Mr. Nozomu Kawai, field director, who gave me many instructions, also Dr. Giorgio Capriotti, chief conservator, Mr. Kunihiro Seto and Ms. Akiko Nishisaka.

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1) Mamiya RZ67 Camera
2) Nikon F100 Camera
3) Photo Bulb 300w
4) Kodak Ektachrome 160T(EPT) film
5) Minolta Color Meter 2
6) Focal Lengh is 18mm

10. Conclusion

Sakuji YOSHIMURA[1] and Nozomu KAWAI[2]

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UNESCO Counterpart of the Project

As preceding reports present, the first long term campaign saw enormous progress and fine results in all aspects of the conservation work, through international cooperation. In additon, it is notable that some conservation techniques were being passed to Egyptian and Japanese conservators by our Italian chief conservator. Here, we would like to comment on some necessary issues for the next campaign as our concluding remarks.

The working environment of the tomb has to be revised in the next campaign. Since we always use chemical solvents such as ammonia, acetone, thinner, and ethanol, which cause harm to humans, it is necessary to reconsider the working environment. The ventilation system has to be revised and it is expected that fresh air will be brought from the outside by the power of ventilation motors. The absence of an electricity line makes our work very difficult in terms of supplying light and a ventilation system. It will be necessary to provide another electric generator in order to have an additional duct pipe for sending fresh air to the inside of the tomb.

The prohibition of sampling material outside of Egypt was enacted by the SCA in 2002. Therefore, we still have not conducted microscopic analysis, cross section analysis of pigment and plaster, or gas chromatographic analysis of binding media on the wall paintings. It is hoped that these analyses will be conducted in the scientific laboratory of the SCA.

During the photographic campaign, the efficiency and advantages of a 4×5 medium-sized camera and digital camera were also realized for the coming season.

Our civil engineering experts have examined the stability of the tomb from a rock mechanical point of view. As they suggested in their report, it would be necessary to stabilize the crack between rooms J and Jd. The method of the fixation of the pillar 3 is also proposed. As we had several discussions with Egyptian authorities in the tomb, the method should be selected from several ideas carefully. However, the budgets for these interventions were not included in our original plan. It is expected that UNESCO and the Japanese government will facilitate the matter to save this precious world monument.

Finally, we would like to propose the plan for the next campaign. The next campaign needs to be started in October or November 2003 and should run until the end of March 2004, because the best season for working in Luxor is from October to the end of March. Most foreign archaeological missions work this time of the year. This year we suffered severe heat in April and May.

We intend to continue our conservation work in room J (burial chamber) where the conservators will be working for cleaning and consolidation of the walls of the room. We plan to stabilize the crack between rooms J and Jd and the crack on pillar 3. This will be carried out by both wall painting conservators and civil engineers. In room E (shaft chamber), we will conduct cleaning and consolidation on the walls. We also plan to clean and consolidate the walls of room Je and the ceiling plaster in rooms E, I, J, and Je. In addition to the conservation of the wall paintings, we plan to restore the lid of sarcophagus in room J. The time schedule will depend on the skill and number of conservators, and budget. After the conservation of the entire wall, we shall conduct the photographic campaign to document the results of the project for publication. It is hoped that the results of this very important project will be greatly appreciated by many people in the world.

IV. THE SCIENTIFIC REPORT

Part 2 THE SECOND PHASE

1. Introduction

Sakuji YOSHIMURA[1] and Akiko NISHISAKA[2]

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Last season, January to May 2003, the first long-term comprehensive conservation work was finally inaugurated. The campaign included the following conservation work and scientific researches: (1) Preparatory works, such as setting up staircases, cleaning and building scaffolding in the shaft room, covering floor with sheets, (2) Photographic campaign, (3) Wall paintings conservation work: cleaning and consolidation, (4) Working environment evaluation, (5) Biological investigation, (6) X-ray analyses on pigment and plaster, (7) Rock mechanical analyses, (8) Observation and documentation of the wall paintings, such as color measurement, study of painting technique, and epigraphic study.

We resumed our work in the Western Valley of the Kings for the second long-term season from December 3, 2003 (Figs.1, 2). Although, this campaign was intended to emphasize the intensified wall paintings conservation work, several items of other works were conducted. Items of research and activities included: (1) Preparatory work for the conservation and setting up needed facilities, (2) Wall paintings conservation work: cleaning and consolidation, (3) Study and documentation of the wall decoration of the tomb, (4) Continuation of the rock mechanical monitoring to protect the walls and pillars in the tomb, (5) Conducting the analyses and assessment of short-term and long-term stability of the tomb, (6) Continuation of environmental monitoring in the tomb, (7) Analyses of pigments binding media and plaster by taking samples to the laboratory of the SCA, (8) Study of the environment in the tomb, (9) Photographic documentation of the wall during and after conservation. Following is the brief description of the items done during the period of the second phase: December 3, 2003 to March 13, 2004.

1. Preparatory Work and Setting Up Needed Facilities

All the anti-dust sheets prepared at the beginning of the last season were taken out of the tomb to be cleaned and re-installed to cover the floor. Then scaffoldings were set up again in room J to start the conservation on the north, east, and south walls. The red-granite sarcophagus lid was covered by a plastic sheet as temporary protection.

It was suggested during the last mission that we should plan a new air condition system to reduce the danger to humans caused by the evaporation of chemical solvents used during conservation. This year the number of aspirator machines was increased to three, and an additional portable wind fan and 130 m vinyl duct (this set was kindly donated by Mr. Tsugunori Muramatsu, President, Fumitech Co., Ltd., Tokyo) which will send in fresh air was introduced (Fig.3). Also, additional stand-fans were installed at different locations inside the tomb to exhaust the polluted air.

This season, we also installed wooden sledges in rooms B, C, and G and a staircase at room A (entrance) of the tomb in order to cover the original limestone surface. The modification of the iron door to widen the entrance was also made. The old stairs of cement in room A (entrance) were in bad condition and concealed the original surface, so the cement was dismantled to receive the new wooden staircase. These facilities were fixed without causing damage to the original masonry and could be removed easily when necessary. It will not only facilitate our way, but will also protect the original structure.

2. Wall Paintings Conservation Work: Cleaning and Consolidation

The wall paintings conservation work was resumed on December 6, and it has progressed well during the three and half months of this season (Fig.1). It was particularly appreciated that the SCA had sent the same conservators who had already learned the method and techniques in the first phase. The tomb benefited greatly from the participation of these conservators. The staffs are: Dr. Giorgio Cappriotti (chief conservator), Ms. Caterina Tocci, Ms. Akiko Nishisaka, Dr. Eriko Nakau, Mr. Kunihiro Seto, Mr. Ahmed Ali, Mr. Mohammad Assas, Mr. Ahmad Shwaib, Mr. Mohammad Mahmoud, Mr. Mohammad Salama. This season we were joined by conservator Ms. Cristina Caldi and another assistant conservator, Mr. Kazumitsu Takahashi, as well as two conservation trainees, Mr. Mohammad al-Azam and Ms. Afaf Mohammad.

(1) Assignments

The Italian conservators and one Egyptian conservator have been working in room E (shaft chamber) (Fig.4). Japanese conservators were assigned to work on the south wall in room J, which is a continuation from last season (Fig.5). Egyptian conservators was assigned to finalize the work on the north wall in room J, then, they were assigned to move to the east wall (Figs.6, 7).

(2) Training

This year the project received two local young wall paintings conservators from the SCA to be trained during the project (Figs.8, 9). By the end of the season they have learnt all the different procedures used in this tomb and it is hoped that such training by foreign experts will improve the skills and understanding of the conservation of wall paintings. Such work seems to be needed very much in the Luxor area.

(3) Progress of the work

(a) Room E

The consolidation and cleaning of the wall paintings in room E was started and almost completed this season. Reattachment of a small fragment, discovered last year during the clearance of the shaft, was also conducted on the east wall (Figs.10, 11). This room is decorated with wall paintings of the figures of the king and gods and goddesses on its north, east, and south walls, and after cleaning, bright polychrome colors were revealed (Figs.12, 13). The typical style of the art during the late reign of Amenophis III is recognized and is now available for further studies. The nature of the deterioration and alteration of the compounds of dirt seemed to be different from the other parts of the tomb. For this reason, the cleaning process consumed more time than other rooms. A sample of the white powdery compound was gathered during the work and was sent to the laboratory of the SCA to be analyzed.

(b) Room J

The conservation work on the north, south and east walls has been completed this season. The walls in this room are decorated with the *Book of Amduat* describing the journey of the solar boat through the twelve hours of the night. On the north wall, some finalization process took place, including Dr. Capriotti's reattachment of two painted plaster pieces which were detached along the huge crack (Figs.14, 15). On the south wall, about 20% of the wall had been finished last season and the other 80% of wall was completed in this season. Work has been also done on the east wall, which is decorated with the eleventh and twelfth hours of the *Book of Amduat* (Figs.16, 17). The east face of pillar 6 was also completed this season. Three faces of pillars near the sarcophagus, including pillar 3, the pillar with the huge crack, have not been completed yet. The other areas which were not finished in this season was the west wall and a small section of the frieze around the doorway to room I, and it is necessary to complete this work in the next phase.

During the execution of the cleaning, some important archaeological discoveries were made. On the east face of pillar 6 in room J, a gold leaf was found which is similar to the one uncovered in room I during the first phase. It seems that the gold leaf is a remnant of gilded funerary equipment. Near the corner of the north and west walls in room J, more gold leaf with white, yellow, and red faience beads was found beneath the concretion of dirt, after execution of the cleaning. These items seemed to be a part of ornaments buried with the king.

(c) Cleaning of the rock surface

When the painted surface is cleaned, the appearance of the undecorated rock contaminated with excrement and bacteria seemed to be articulated. To avoid the disturbance to the admiration of the paintings and also for the sanitation of the place, the necessity of the cleaning the rock surface was conceived. The trial cleaning of rock surface was executed in room J by selected workers under the instruction of the conservators. As a result, some of the ancient construction marks and guidelines in red and black inks became more discernible after cleaning.

(4) Method and materials

The procedure used for the cleaning of the painted surfaces in general is:
(a) Application of *cleaning solution* (2000 cc distilled water, 500cc ethanol, 100cc acetone, 80cc ammonia). Absorption through tissue is efficient to allow reaction of the organic residua of excrement. (b) Cleaning by scalpel, to remove thicker layers of residua. (c) Cleaning with brush of remaining residua with lacquer thinner or 1 acetone and 1 distilled water. (d) Application of *sepiolite* in distilled water, to absorb deep spots from the inner layers. (e) Application of *anti bacterial solution* (few drops of anti bacterial detergent in cleaning solution) through tissue paper. (f) Application of 3-6% Paraloid B72 in thinner for the paint layer, which is seriously powdering. (g) Application of *dirty water* on the part of abrasion.

For the consolidation of the detached plaster layer, acrylic resin (Primal AC33) or gypsum mixed with fine grains of sand, *muna,* was injected between the bedrock and the plaster layer to reattach the separated layers. The periphery of the loss was also consolidated with gypsum mixed with fine and coarse grains of sand. To enhance its appearance, lacunas were filled with the same mixture, and the surfaces of the filling were lowered to the level just below the paint layer and brushed to give a more natural appearance.

For the cleaning of the rock surface different solvents are employed: (1) Application of cleaning solvents (80cc ammonia and 2000cc distilled water) through tissue. (2) Application of anti bacterial solvents (few drops of anti bacterial detergent in cleaning solvent) and cleaning by brush.

3. Studying and Documentation of the Wall Decoration

After the conservation work, especially on the part covered by bat excrement, archaeological and Egyptological studies were made on the walls and pillars by Ass. Prof. Jiro Kondo and Mr. Takao Kikuchi.

In room E, the study was concentrated on copying and interpreting the previously unrecorded inscriptions which were uncovered after cleaning the nests and thick concretion of bat guano. Above all, the most important inscription recorded was the legend of the *ka* Figure of Tuthmosis IV on the south and north walls of this room. Now, the whole epithet could be read as *kȝ nswt ʿnḫ nb tȝwy ḫnt ḏbȝt pr dwȝt* “the living royal *ka*, lord of the Two lands, foremost of the Robing room and the chamber of morning” (Fig.18). Such scene is very peculiar in the decoration of the royal tombs and the historical significance of this inscription deserves to be studied.

In room I, close observations were made on the cleaned wall paintings, and now the painting sequence could be roughly reconstructed. An interesting feature could be studied on the upper part of the south-east corner of the east wall, which was covered by a heavy concentration of bat guano before.

In room J, the wall was decorated with one of the most important religious texts, which is the *Book of Amduat*. Since many parts on the wall were covered by guano, some of the inscriptions were totally illegible during the campaigns conducted before this conservation project. After cleaning, not only do we have access to every inscription surviving on the wall, but there are even some previously unattested remains of ancient drafts.

4. Continuation of the Rock Mechanical Monitoring to Protect the Walls and Pillars in the Tomb

To monitor the rock mechanical movement, two kinds of instruments (KADEC-displacement gap gouge and RF-3 acoustic emission monitoring unit) with data logger were setup by the experts during the first phase. They continued to operate through the year. The maintenance and collection of the data from the logger using a computer was done during the season by Japanese assistant conservator Mr. Seto under the instructions of the rock mechanical specialist.

5. Conducting the Analyses and Assessment of Short-term and Long-term Stability of the Tomb

The collected data described above was sent to the rock mechanical experts, Prof. Dr. Masanori Hamada, Prof. Dr. Ömer Aydan, and Prof. Dr. Hisataka Tano, in Japan for analyses and assessment of short-term and long-term stability of the tomb. The stabilization of the cracks in walls and pillars in rooms F, J, and Je, must be planned in accordance with the results of these surveys. A final proposal will be drawn to advise effective stabilization methods and their execution after the discussion between the rock mechanical specialist, civil engineer, architectural specialists, wall paintings conservator and Egyptian authorities.

6. Continuation of Environmental Monitoring in the Tomb

The long-term observation of microclimate of the tomb has been continued. The thermometer data loggers were set by the Japanese experts in the first phase. SATO temperature and humidity measure at 2 locations and TANDS temperature and humidity sensor and logger at 6 locations are continuously operating throughout the year. The maintenance and collecting records were made during the second phase. The collected data is presented in this volume by the environment specialists, Ms. Harue Igarashi and Mr. Muramatsu.

7. Analyses of Pigments Binding Media and Plaster

Samples Nos.1-8 were chosen from the fragments which we found during our excavations or conservation work and were taken to the laboratory of the SCA for the following scientific analyses: (1) Analysis to determine the components and proportion of each element in the plaster (qualitative and quantitative). (2) Analysis to determine the material used for the binding media in each pigment presented in the sample. (3) Analysis to determine the material of the whitish powdery dirt accumulated on the surface of the wall.

8. Study of the Environment of the Tomb

Monitoring and scientific research were conducted to investigate the microenvironment of the tomb by Prof. Dr. Shin-ichi Tanabe. In addition to the temperature and relative humidity inside the tomb, the chemical density of carbon monoxide, carbon dioxide, nitric oxide, ammonia, benzene, ethanol, aromatic hydrocarbons, acetone, formaldehyde, was tested in different rooms by using GASTEC Corporation, Air Sampler Kit GV-100S and Gas Tubes. Wind velocity was also measured by using KANOMAX Corporation Climomaster 6511 to evaluate the present ventilation system. The collected data will be analyzed and will serve as the fundamental data for implementation of appropriate environment controls on the site. Comparative observation for the future protection and utilization were also made by Prof. Dr. Takeshi Nakagawa.

9. Photographic Documentation

Photographic documentation of the wall after conservation in room E and J was done by our photographer Mr. Tsuyoshi Sasaoka at the end of the season. The method employed for this photographic documentation was the same as last season (using medium format camera and SLR camera including a Kodak Color Separation Guide and a 1 meter scale inside each shot), except for the introduction of a high resolution digital camera (Nikon D100 Digital Camera), so that comparable photographs of before and after the conservation work will be available.

10. Tripartite Meeting

The tripartite meeting was held on March 6, 2004 to discuss the matters regarding this project. The meeting was attended by Mr. Gadi Mgomezulu, Ms. Mouira Baccar, representing UNESCO Cultural Heritage Division, Mr. Sabri Abd al-Aziz, Dr. Holeil Ghaly, Dr. Ahmad Shwaib, Mr. Ali Asfar, representing the Supreme Council of Antiquities, Prof. Dr. Sakuji Yoshimura, Ass. Prof. Kondo, representing the Institute of Egyptology, Waseda University, Dr. Capriotti, Ms. Nishisaka, representing the conservators in the field, Mr. Tatsundo Yoshimura, representing the administrative office of the project. At first, the tomb was visited by the delegation to inspect the work. Then, the meeting was held at Mercure Hotel on the east bank. Review and evaluation of the second phase was first on the agenda. Following this, recommendations for next season were presented. At last, future cooperation among this tripartite organization was discussed.

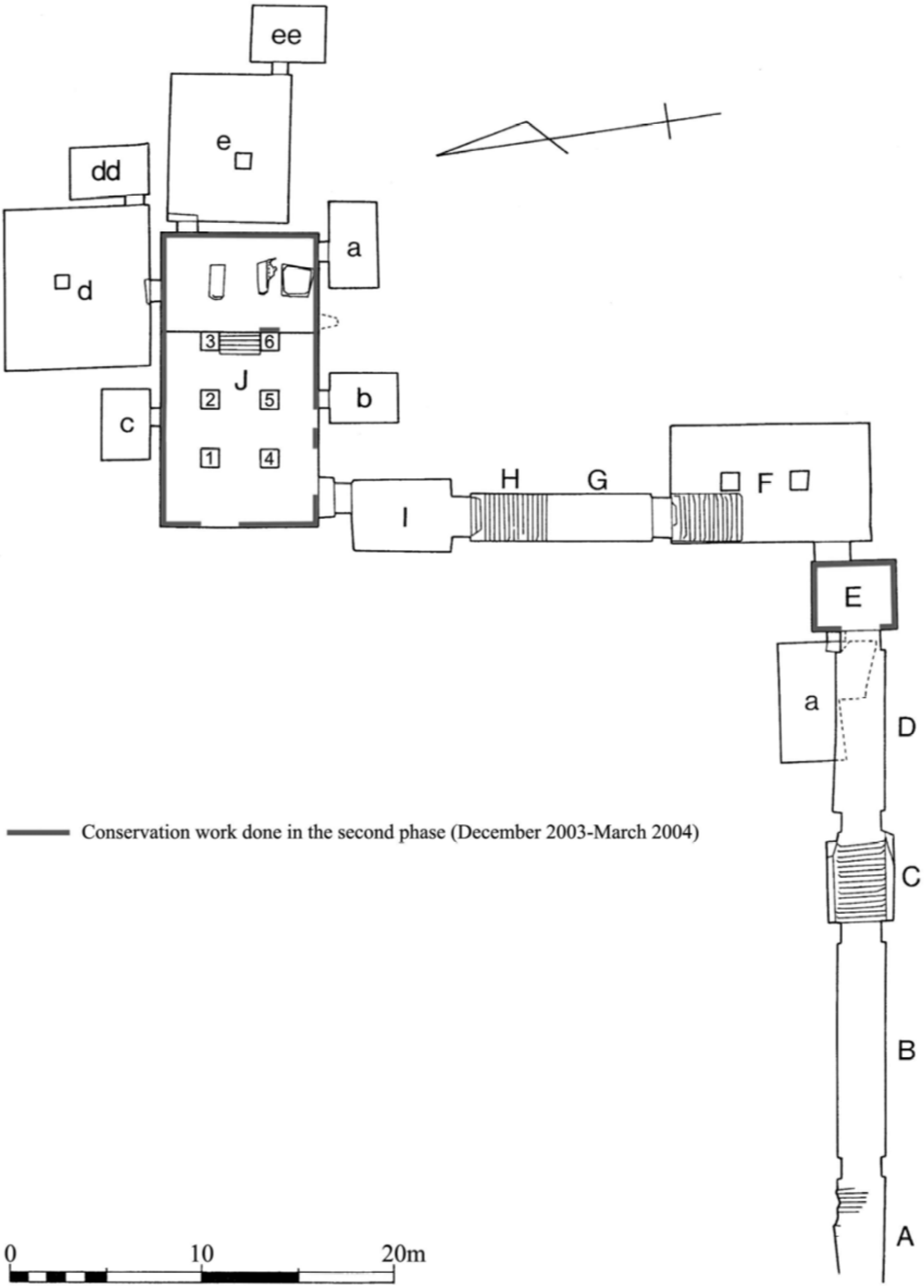


Fig.1 The plan of the royal tomb of Amenophis III (KV 22)

Fig.2 Location of the tomb in the Western Valley of the Kings

Fig.3 The entrance of the tomb with ventilation system

Fig.4 Italian conservators working

Fig.5 Japanese conservators working

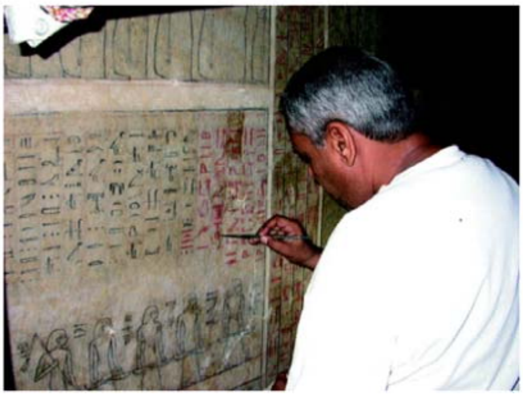


Fig.6 Egyptian conservator working

Fig.7 Egyptian conservators working

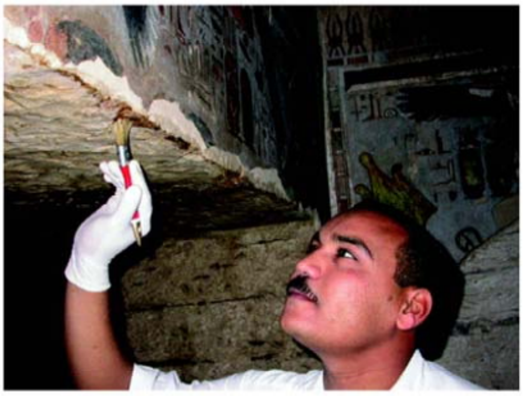


Fig.8 Conservation trainee

Fig.9 Chief conservator Dr. Capriotti instructing

Fig.10 Fragment found from the shaft

Fig.11 Reattachment of the fragment

Fig.12 Room E south wall before conservation

Fig.13 Room E south wall after conservation

Fig.14 Detached fragments from the wall along the crack of the north wall in room J

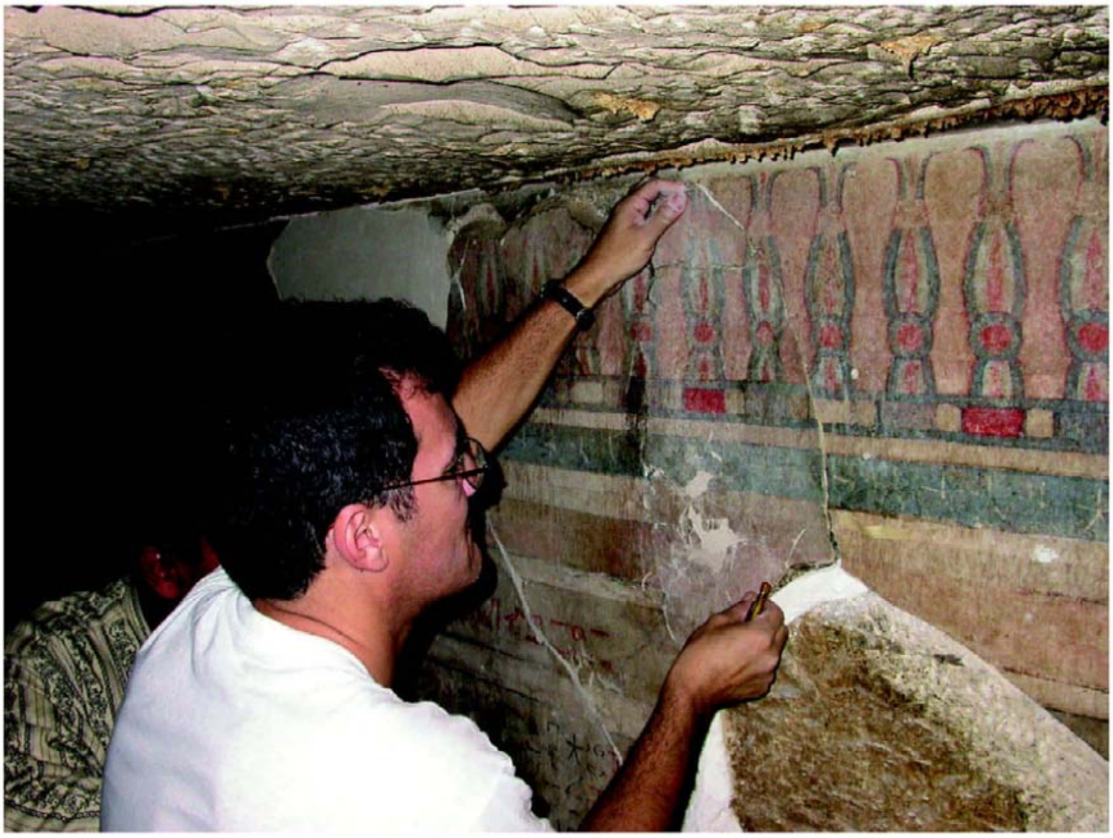


Fig.15 Execution of the reattachment of the fragments

Fig.16 The twelfth hour of the *Book of Amduat* on the east wall in room J before conservation

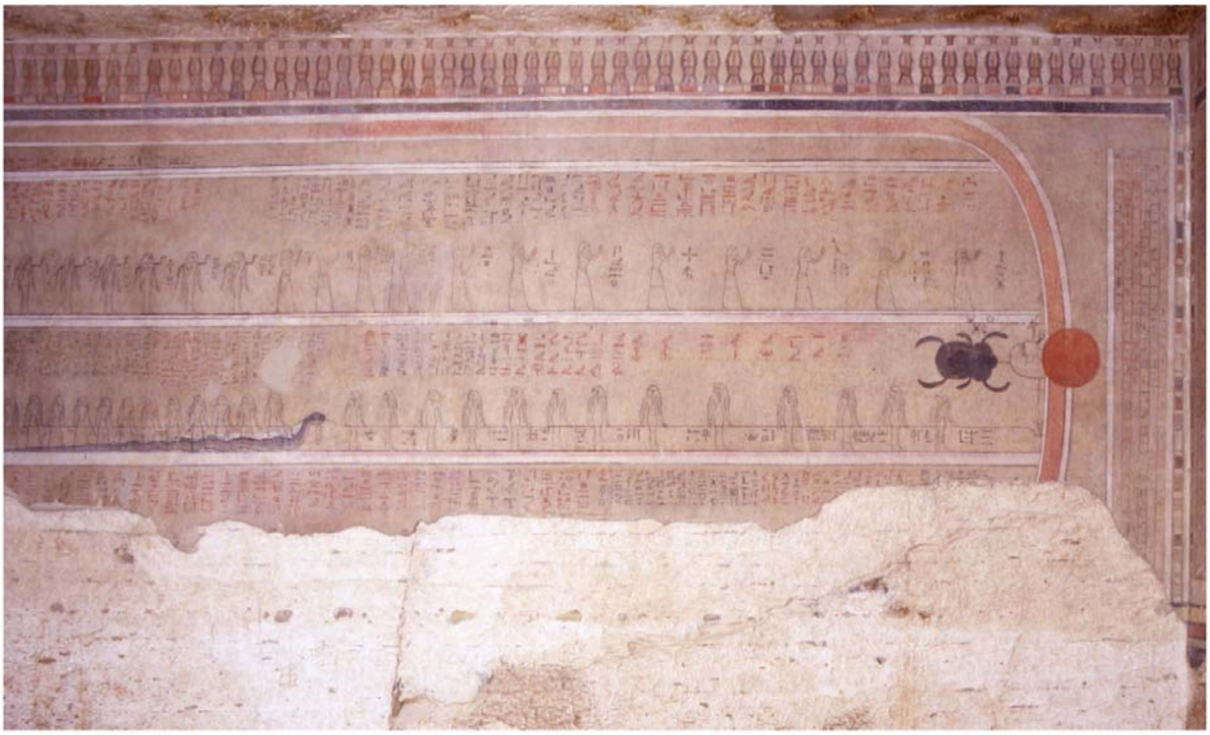


Fig.17 The twelfth hour of the *Book of Amduat* on the east wall in room J after conservation

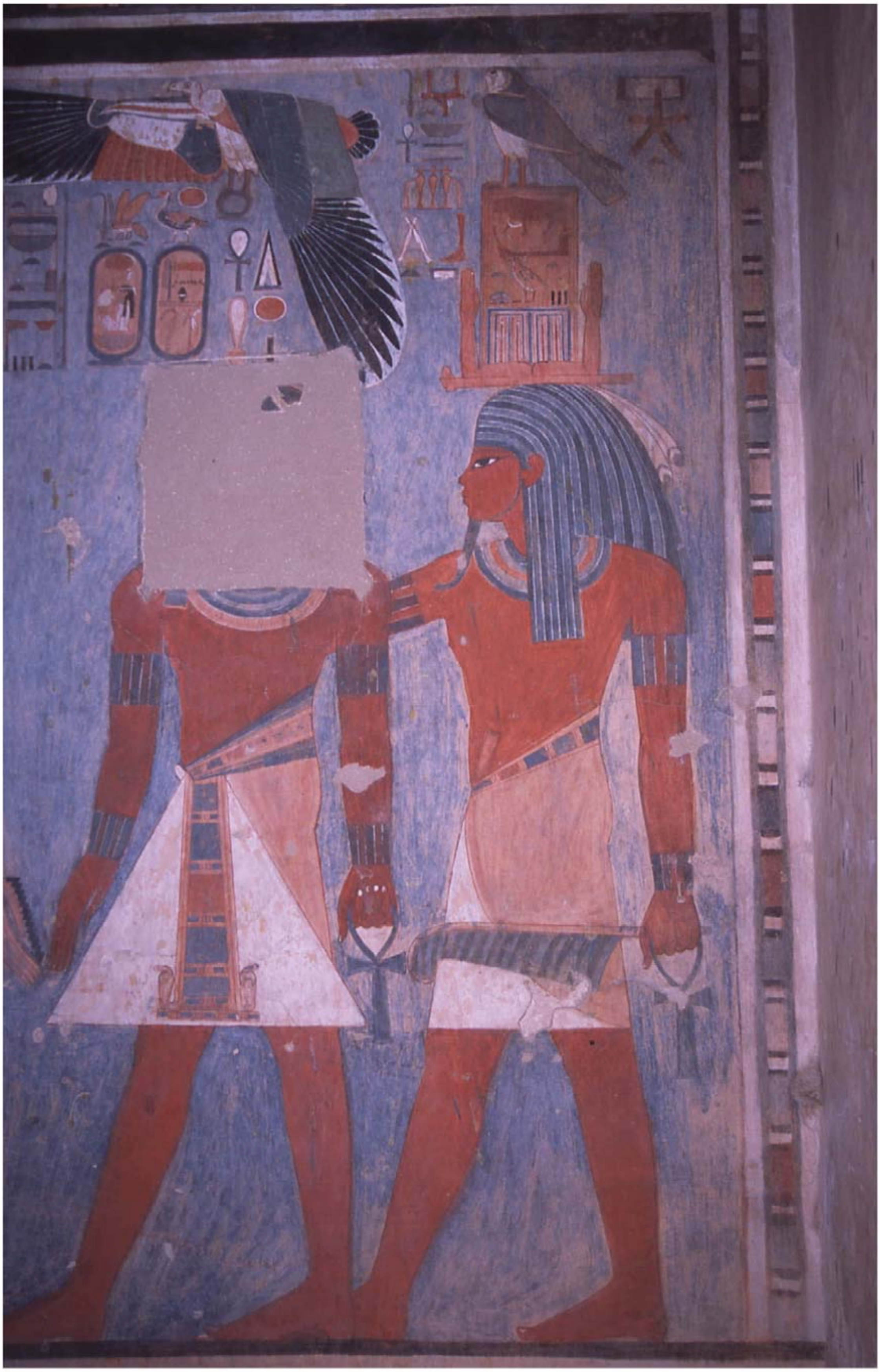


Fig.18 Figure of Amenophis III and *ka* of Tuthmosis IV in room E south wall

2. Microenvironmental Evaluation

(1) Environmental Management in the Royal Tomb of Amenophis III

Harue IGARASHI [1)] and Tsugunori MURAMATSU [2)]

1) Conservator, Tokyo

2) Environment Specialist for Conservation, President, Fumitech Co., Ltd., Tokyo

1. Work Environment

During the first long-term season, especially in April, difficulty and a change of physical condition were reported by the conservators working in room J. An oxygen shortage caused by the rise of the temperature in the tomb, an increase in carbon dioxide, and the transpiring of solvents, as well as an increase in personnel were responsible for the difficulties. It seemed that the air which stagnated in back needed to be ventilated by increasing the number of exhaust pipes, and introducing of fresh air. In the second long-term season, the re-arrangement of the portable wind-fan for sending fresh air etc. was made shortly after the work resumed in December, and the condition inside the tomb was improved significantly.

2. Temperature and Relative Humidity

According to the data by which logging was carried out from the temperature-and-relative-humidity meter, a considerable difference could be observed through the year in room B (Figs.1, 2). Since the location of the logger was near the ground, or outside, it is considered that it could be easily influenced by the temperature and relative-humidity of the open air.

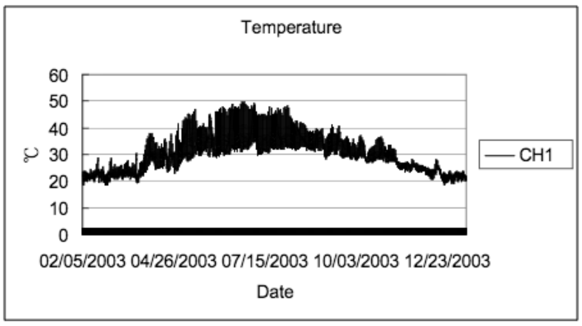


Fig.1 Temperature in room B

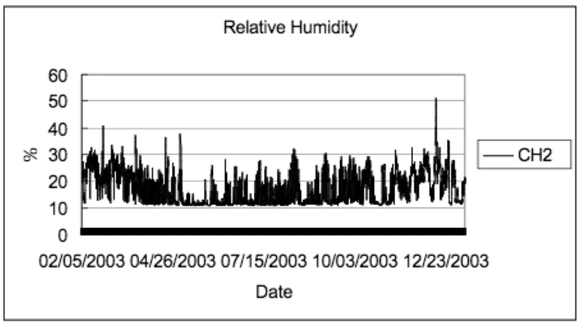


Fig.2 Relative humidity in room B

In room J, the change of temperature and relative humidity during the year was not as remarkable in comparison to room B (Figs.3, 4). The working conditions were improved by the introduction of fresh air or improvement of the exhaust environment.

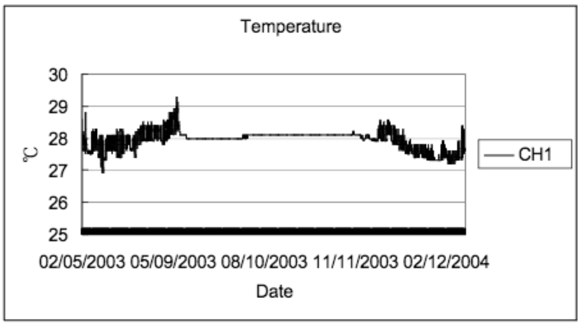


Fig.3 Temperature in room J

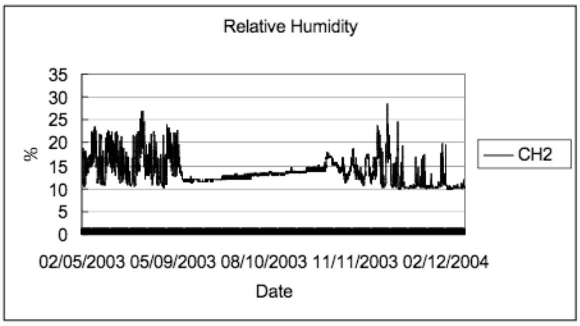


Fig.4 Relative humidity in room J

During the working seasons, rise in room temperature was recorded at certain moments, like on February 9, 2003 and March 2, 2004. The cause for these changes may be the influence of lighting for photographic documentation and other working conditions.

Regarding the change of temperature during a working day, when the work started in the morning, the temperature in room J rose to an average of 28.3 degrees C after 7 o'clock, and after 1 o'clock, when the workers left the room, the temperature dropped to an average of 27.8 degrees C. The same general condition was recorded for relative humidity; humidity was seen to rise and decline from Rh13% to Rh11% simultaneously with the start and end of the work (Fig.5).

The results of the temperature and relative humidity measurements showed the improvement in ventilation by fresh air (open air) introduction, etc.

Moreover, temperature and relative humidity levels during a non-working period were stable in room J, so there is less variation than during a work period. This will be a important reference for planning for preservation management, degradation prevention, etc. in the future.

3. Recommendations for the Future

The shift to preservation environment management from a work environment should be considered. The future management plan should be developed in accordance with scientific data. For example, carbon dioxide and oxygen concentrations in relation to temperature and relative humidity should be measured to provide a work environment analysis and preservation environment analysis.

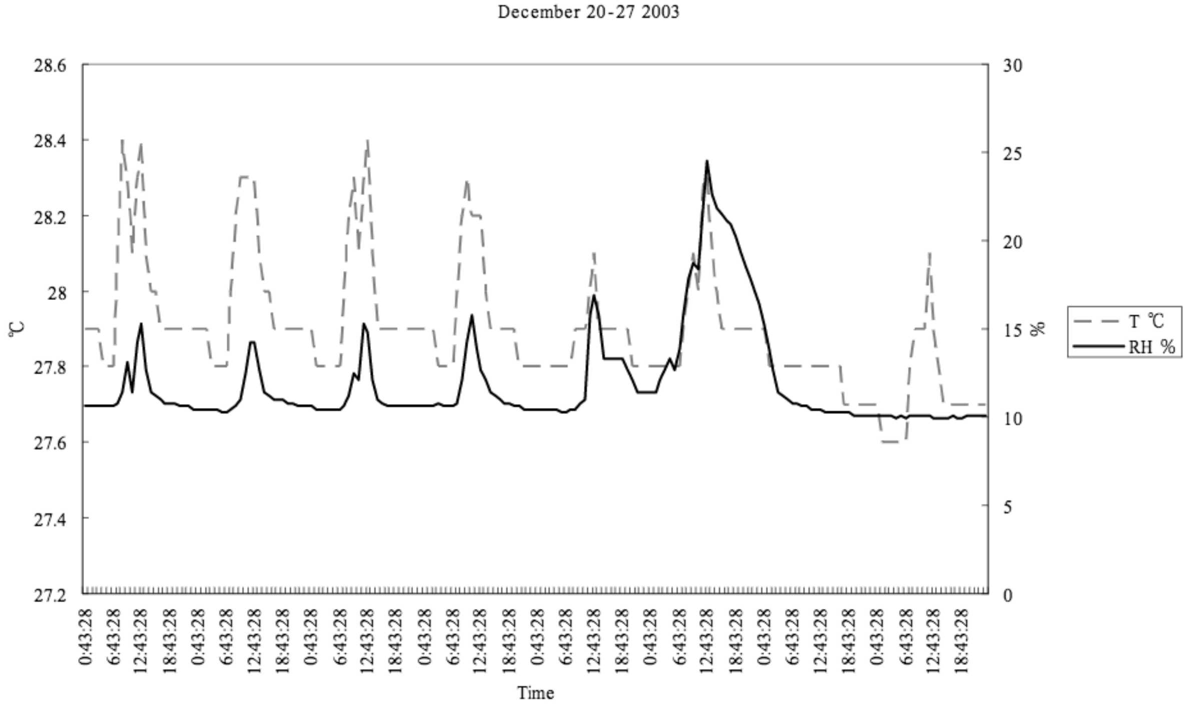


Fig.5 Temperature and relative humidity variation in room J during working days

(2) Measurement of Thermal Environment and Indoor Air Quality in the Royal Tomb of Amenophis III

Shin-ichi TANABE[1] and Junta NAKANO[2]

1) Professor, Department of Architecture, Waseda University
2) Research Associate, Department of Architecture, Waseda University

Introduction

This report describes the thermal environment and indoor air quality measured inside the royal tomb of Amenophis III. The objective of this survey was to acquire the basic data on the current indoor environmental conditions of the tomb for recommendation of an appropriate ventilation system and ventilation conditions.

1. Outline of the Survey

(1) Methods

Indoor environmental survey was carried out from March 2 to 6, 2004 in the royal tomb of Amenophis III. Thermal environment and indoor air quality were investigated while the conservation works were in progress. Air temperature and relative humidity were measured at 9 points inside the tomb, and outdoor temperature, humidity, and solar radiation were recorded simultaneously. Indoor air quality was measured by various detectors in 3 rooms, with and without ventilation. The measurement items are given in Table 1 and measurement points are given in Fig.1.

(2) Ventilation conditions

The entrance gate was the only ventilation inlet / outlet of the tomb. One supply fan and three exhaust fans mounted just outside the entrance were used to enhance air exchange (Fig.5). Fresh outdoor air was supplied to room Je through a vinyl duct to avoid any sudden change of air condition inside the tomb (Fig.7). The measured air supply rate was 1200 m^3/h, which equaled to an air change rate of 0.8 1/h (Fig.8) for the entire tomb. Air was exhausted from rooms J and E, where various workers were engaged in restoration works. More than 10 electric fans were used to mix the air inside the tomb (Fig.6).

2. Results

(1) Outdoor conditions

Outdoor air temperature and solar radiation measured during the survey are presented in Fig.2. Precipitation was not observed throughout the survey. Because of the dry geographical nature of the area, outdoor air temperature rose up to 40°C during the day, while it decreased to as low as 20°C at night. Relative humidity was 10-15 %rh during the day, and 20-30 %rh at night.

Table 1 Measurement items and instruments

	Items	Range	Instruments
Air quality	Carbon monoxide	1-30 ppm	GASTEC Detectors
		2-50 %	
	Carbon dioxide	100-2000 ppm	
	Nitrogen compounds	0.2-5.0 ppm	
		NO_2:2.5-200 ppm NO: 5-200 ppm	
	Ammonia	1-30 ppm	
	Benzene	0.25-12 ppm	
	Ethanol	100-2000 ppm	
	Aromatic compounds	2-100 ppm	
	Acetone	50-4000 ppm	
	Formaldehyde	0.02-0.20 ppm	
Thermal environment	Temperature / humidity		ESPEC Thermo Recorder RS-11
	Air velocity		KANOMAX Climomaster 6511
	Solar radiation		EKO ML-020

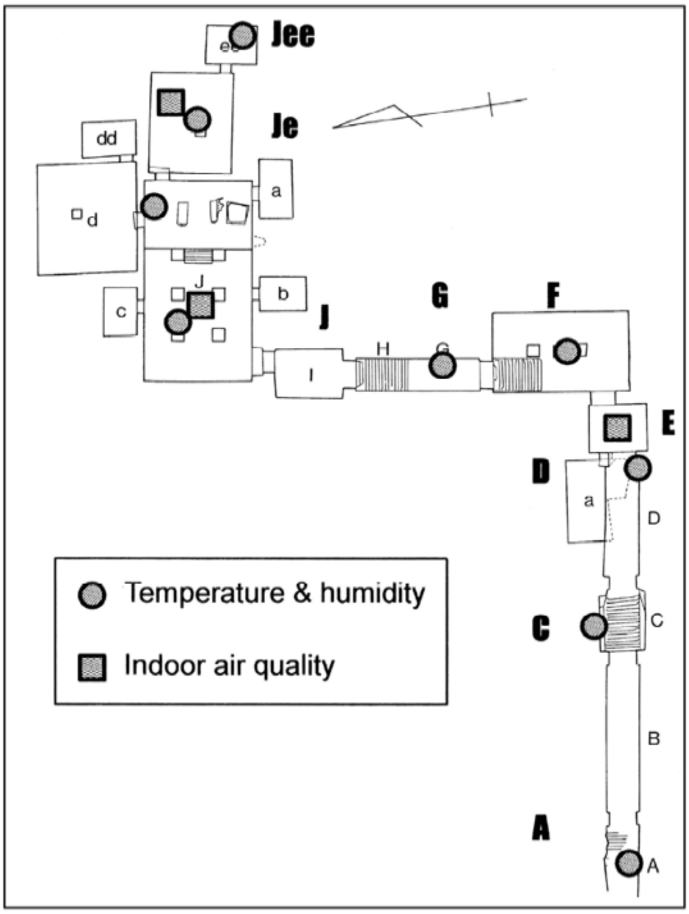


Fig.1 Measurement points

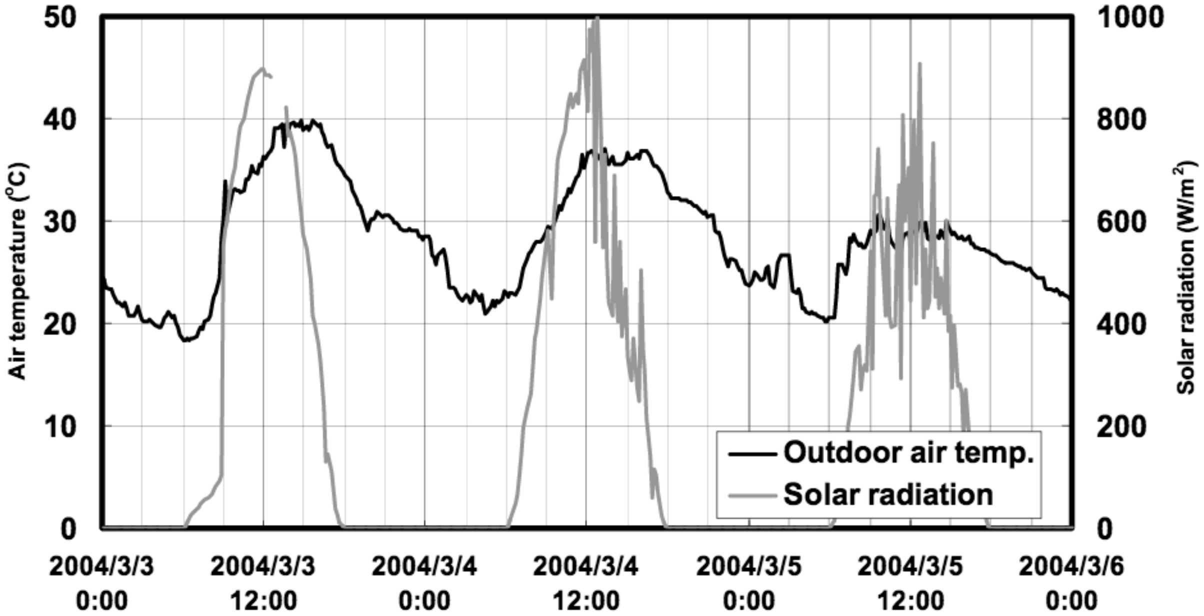


Fig.2 Outdoor air temperature and solar radiation

(2) Indoor thermal environment

Diunal fluctuations of indoor air temperature and humidity are shown in Figs.3 and 4 respectively. The indoor temperature of the tomb was confirmed to be fairly stable except for the working hours (7:00-13:00) when a rise of 1°C was observed. March 5 was an Islamic holiday, and air temperature was very stable throughout the day, despite the large outdoor temperature change. A rise of indoor humidity was also observed during the working hours, but the value gradually decreased to become stable after the work ended. Humidity differences were not observed within the tomb except for the unoccupied room Jee, where the humidity was slightly lower by 5%rh. The air temperature tended to be higher and more stable as one moved deeper underground, and the air temperature in the deepest room Jee was constant at 28.2°C.

Generalizing the results above, the air temperature and humidity of the tomb was stable deep inside the tomb at approximately 28°C 20%rh due to the large heat capacity of the rock structure. However, air temperature tended to be lower closer to the ground entrance due to outdoor air. An increase in air temperature and humidity was observed during working hours, due to humans and electric lamps, but the influence on the indoor environment was insignificant after work.

(3) Indoor air quality

Results of indoor chemical measurements and acceptable indoor concentration limit (8 hours exposure per day) proposed by the Japan Society for Occupational Health (JSOH) are presented in Table 2. Indoor air was sampled at room J (volume 400 m³, 10 workers), room E (volume 40 m³, 4 workers), room Je (volume 140 m³, no workers) and outdoors (Fig.9). Room J was measured with the ventilation system turned on and off. Carbon dioxide (CO_2) concentration was 850 ppm even without ventilation, which was satisfactorily lower than the limit for ordinary office buildings, 1,000 ppm, proposed by the Law for Maintenance of Sanitation in Buildings in Japan. On the other hand, a mixture of chemical

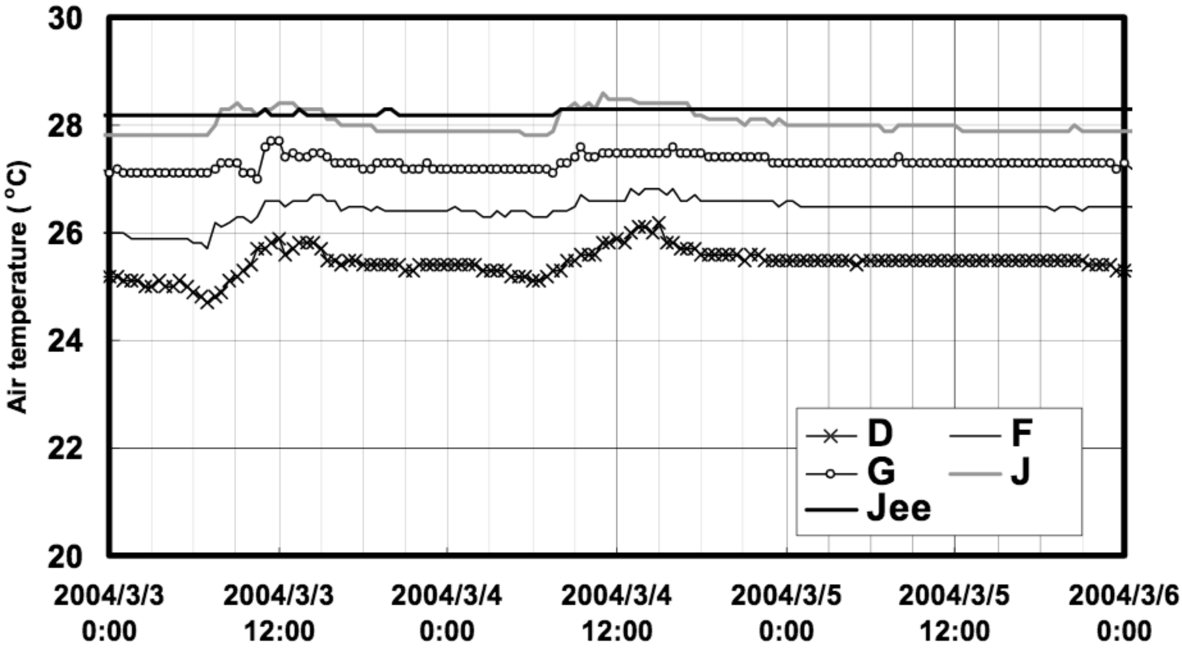


Fig.3 Air temperature fluctuation inside the tomb

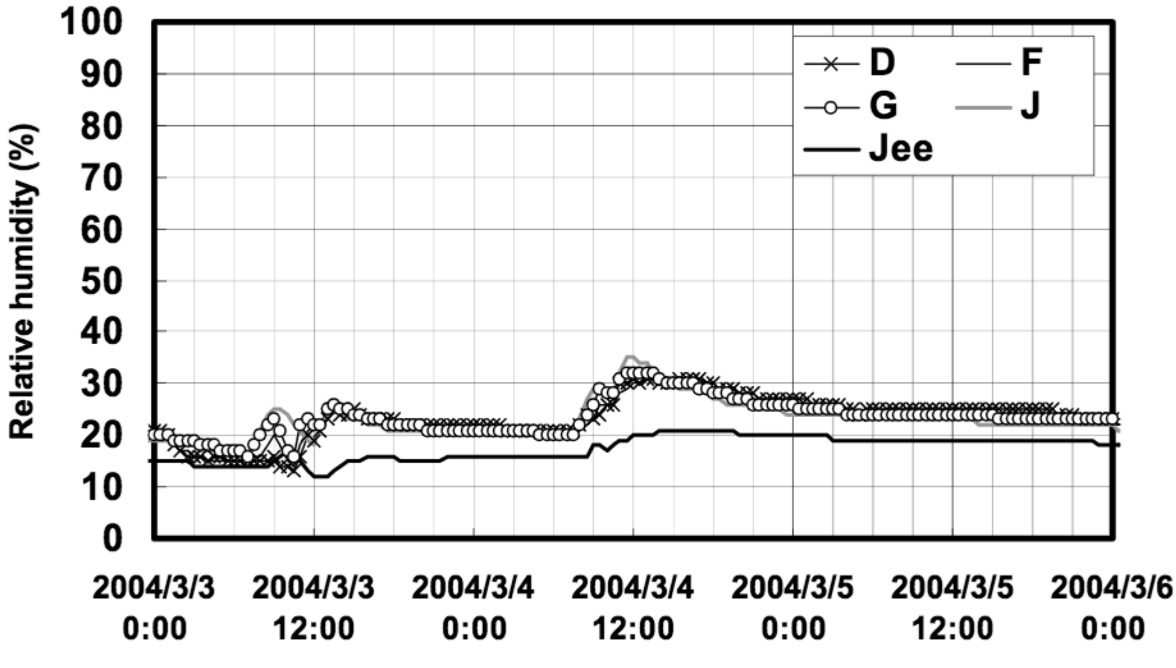


Fig.4 Relative humidity fluctuation inside the tomb

Table 2 Results of indoor chemical measurements (units: ppm, N.D.: not detected)

	Acceptable limit	Outdoor 2004/3/4 9:00	Room J 2004/3/3 7:50	Room J** 2004/3/3 12:00	Room E 2004/3/3 8:20	Room Je 2004/3/4 8:00
CO	50	N.D.	N.D.	N.D.	N.D.	N.D.
CO_2	5000	370	850	700	750	750
NO, NO_2	—	N.D.	N.D.	N.D.	N.D.	N.D.
Ammonia	25	N.D.	1.5	1.8	1	1
Benzene	—	N.D.	0.5	0.5	0.5	N.D.
Ethanol	—	N.D.	N.D.	70	70	100
Aromatic compounds	—	N.D.	3.5	2	1	1
Acetone	200	N.D.	30	N.D.	10	N.D.

***: Condition with ventilation*

solvents such as acetone, thinner, ethanol and ammonia were used for restoration works. As a result, volatile organic compounds (VOC's) were detected within the indoor air in every room. Because the recipe of solvents were various for different stages of restoration works, chemical emission was not constant, and the effect of ventilation on VOC concentration could not be confirmed. Nevertheless, these values were much lower than the acceptable limit proposed by JSOH and satisfactory as working conditions. Formaldehyde was detected within the entire tomb, but it was not one of the chemical solvents used inside the tomb. Formaldehyde detectors also react to acetaldehyde, and the presence of acetaldehyde was likely due to acetone use. Samples of solvents were collected from the site, and a chemical analysis is in progress (Fig.10).

(4) Ventilation in tombs

Of the 62 tombs excavated in the King's Valley, about 10 were open to public at the time. The only publicly open tomb with a ventilation system was Tutankhamen's tomb, which is rather small in size (volume 270 m^3) but is visited by a large number of tourists. The indoor temperature and humidity is likely to be affected by a large number of visitors even with a tomb the size of Amenophis III's, and ventilation conditions should be considered not only for human safety but also from the viewpoint of tomb conservation.

3. Conclusions

A survey was conducted to investigate the indoor environment of the royal tomb of Amenophis III under working conditions. Supply and exhaust fans provided the ventilation of the tomb at 0.8 1/h air change rate, and carbon dioxide concentration was satisfactorily low even compared to modern buildings. The indoor concentration of volatile organic compounds and other chemical substances was well below the acceptable limit proposed by the Japan Society for Occupational Health. The indoor working conditions were satisfactory with respect to human safety, and recommendations on ventilation should be made with regard to conservation of wall paintings. Further survey is required in this respect.

Fig.5 Supply and exhaust fans

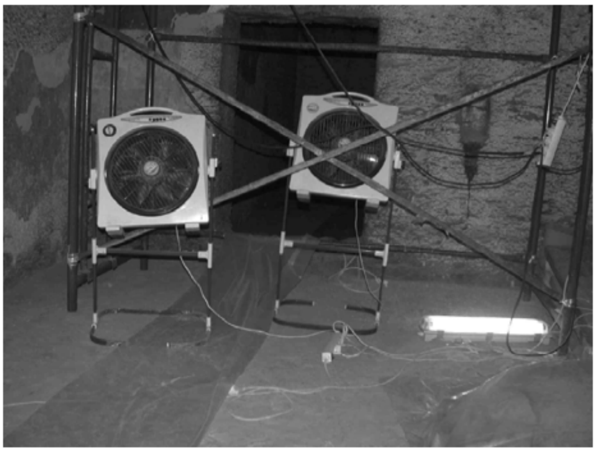


Fig.6 Fans for mixing the indoor air

Fig.7 Fresh outdoor air supplied through a vinyl duct

Fig.8 Measurement of supplied air volume

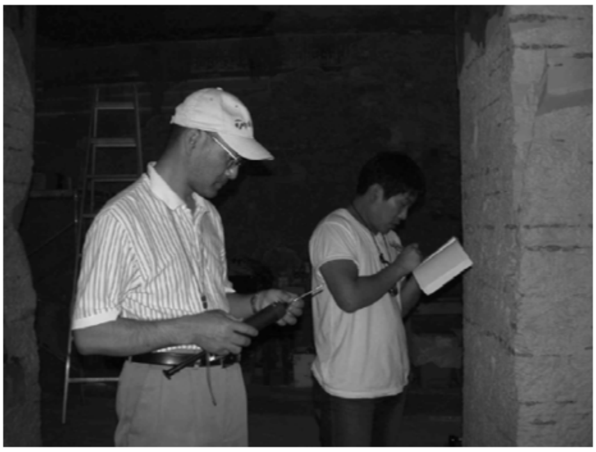


Fig.9 Chemical measurement

Fig.10 Chemical solvents

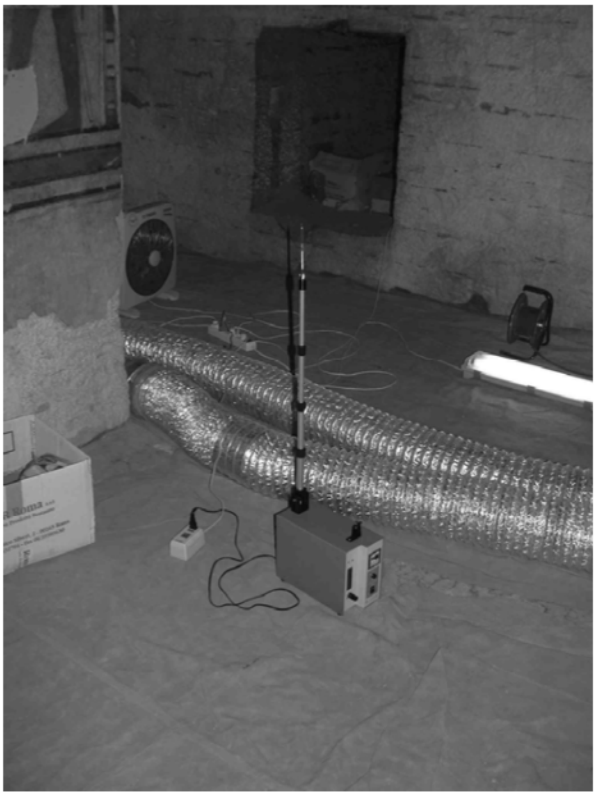


Fig.11 Chemical measurement

Fig.12 Temperature and humidity measurement

Fig.13 Temperature and humidity measurement

Fig.14 Ventilation system of Tutankhamen's tomb
(not operating at the time)

3. Analyses of the Pigments and Plaster

Analyses of Plaster and Pigments' Binding Media Conducted in the Laboratory of the SCA

Atef ABD ELKAWY[1], Ferial HASSAN[2], Pasha KAMIL[3], Wagdy YOUHANNA[4], Sakuji YOSHIMURA[5], and Akiko NISHISAKA[6]

1) Head of X-ray Laboratory, Conservation and Research Center, SCA
2) Director of I-R Laboratory, Conservation and Research Center, SCA
3) Chemist, UV Laboratory, Conservation and Research Center, SCA
4) Head of Chemical Analysis Department, Conservation and Research Center, SCA
5) Professor, School of Human Sciences, Waseda University
6) Ph. D. Student, Department of Archaeology, Waseda University

Introduction

Samples Nos.1-8 were chosen from the materials found during the excavations by Waseda University Egyptian Expedition and during the recent conservation project. These samples were taken to specialized laboratories of the Conservation and Research Center in the SCA for following scientific analyses: (1) Analysis to determine the components and proportion of each element in the plaster (qualitative and quantitative); (2) Analysis to determine the material used for the binding media in each pigment presented on the samples; (3) Analysis to determine the components of the whitish powder. Following a brief description of the samples, the reports of the results by each scientific laboratory are presented here.

Description of the samples (Fig.1):

1) Sample No.1: A fragment from the wall of room E, a part of a blue background, found during the clearance at the bottom of the shaft, Jan. 2003. (5.5×4.5×0.7 cm)
2) Sample No.2: A fragment from the ceiling of room E, painted black with a yellow star, found during the clearance at the bottom of the shaft, Jan. 2003. (7.0×6.5×1.1 cm)
3) Sample No.3: A fragment from the east wall of room I, a part of a blue background, found during the clearance of room Jb, Dec. 26, 1989. (6.5×5.5×1.5 cm)
4) Sample No.4: A fragment from the east face of the pillar 3 in room J, a part of a pink background, taken off during the work of temporal fixation of the crack by wooden support, Mar. 25, 1990. (3.5×2.8×1.4 cm)
5) Sample No.5: A fragment found inside the crack of the north wall in room J as ancient filling during our conservation work, Apr. 8, 2003. (5.5×4.0×2.3 cm)
6) Sample No.6: A fragment from the wall of room J, a part of the *Book of Amduat*, found in room Jd, Jan. 3, 1990. (2.1×1.2×0.8 cm)
7) Sample No.7: A fragment probably from the ceiling of room J, found during the clearance in room J, Jan. 2003. (4.2×3.3×1.4 cm)
8) Sample No.8: White powder of dirt (oxalate?) from the wall in room E, collected during the cleaning Feb. 2003.

(Sakuji Yoshimura and Akiko Nishisaka)

1. Analysis of the Compound by X-ray Diffraction (XRD)

The analysis of the eight samples from the royal tomb of Amenophis III, the Valley of the Kings, was done by using X-ray diffraction (XRD) in the Conservation and Research Center, SCA. The result of the analysis is given in Table 1, Figs.2-9.

Table 1 Result of XRD analysis

Sample No.	Location	The results	
		The compounds and minerals	Relative percentage
1	Room E (wall)	Anhydrite, $CaSO_4$	82.73%
		Gypsum, $CaSO_4/2H_2O$	8.78%
		Calcite, $CaCO_3$	8.48%
		Quartz, SiO_2	trace
2	Room E (ceiling)	Anhydrite, $CaSO_4$	80.74%
		Gypsum, $CaSO_4/2H_2O$	12.13%
		Calcite, $CaCO_3$	7.11%
		Quartz, SiO_2	trace
3	Probably room I (wall)	Calcite, $CaCO_3$	40.34%
		Anhydrite, $CaSO_4$	23.41%
		Quartz, SiO_2	24.53%
		Dolomite, $Ca(Mg, Fe)(CO_3)_2$	9.00%
4	Room J (pillar 3)	Anhydrite, $CaSO_4$	58.59%
		Gypsum, $CaSO_4/2H_2O$	22.92%
		Calcite, $CaCO_3$	10.11%
		Quartz, SiO_2	7.85%
5	Room J (crack/ wall)	Anhydrite, $CaSO_4$	33.80%
		Calcite, $CaCO_3$	33.33%
		Gypsum, $CaSO_4/2H_2O$	24.17%
		Quartz, SiO_2	8.12%
6	Room J (wall)	Calcite, $CaCO_3$	55.30%
		Anhydrite, $CaSO_4$	37.12%
		Bassanite	7.13%
		Quartz, SiO_2	trace
7	Probably room J (ceiling)	Anhydrite, $CaSO_4$	33.70%
		Quartz, SiO_2	28.19%
		Gypsum, $CaSO_4/2H_2O$	24.56%
		Calcite, $CaCO_3$	13.53%
8	Room E white powder	Quartz, SiO_2	62.40%
		Calcium oxalate hydrate	13.58%
		Anhydrite, $CaSO_4$	8.84%
		Gypsum, $CaSO_4/2H_2O$	9.73%

(Atef Abd Elkawy, Head of X-ray Laboratory)

2. Report of Infra-Red Analysis

(1) Obtained I-R results indicate that all the delivered samples numbered (1,2,3,4,5,6, and 7), mainly contain samgg (vegetable gum) as binding material (media). However, sample no.6 may indicate the presence of gerra. Some samples also show the presence of eggay.
(2) The charts of the delivered samples (Figs.10-16) are here with the used standards (Figs.17-19).

(Ferial Hassan, Director of I-R Laboratory)

3. Result of UV Lab

For analyzing the seven samples with different colours delivered by the Japanese archaeological mission (Waseda University) from the tomb of Amenophis III (KV 22), a UV instrument was employed. By dissolving the sample in suitable solvent, choosing the method (baseline), recording the spectra and comparing if with our spectroscopic library it is found that:

Sample (1) A fragment from the wall of room E, a part of a blue background contains vegetable gum.
Sample (2) A fragment from the wall of room E painted black with a yellow star contains concentrated vegetable gum as the binding medium.
Sample (3) A fragment probably from the east wall of room I, a part of a blue background contains vegetable gum (two colours).

Sample (4) A fragment from the east face of the third pillar in room J, a part of a pink background has binding medium vegetable gum.
Sample (6) A fragment from the wall of room J, a part of the *Book of Amduat* found in room Jd, contains vegetable gum.
Sample (7) A fragment probably from the ceiling of room J, has vegetable gum as a binding medium.
Conclusion: Vegetable gum is used in all samples as binding material.

(Phasa Kamil, Chemist, UV Laboratory)

4. Chemical Analysis Report

The seven samples from the royal tomb of Amenophis III were analyzed by using chemical analysis. The results are as shown in following Tables 2 and 3.

Table 2 Partial chemical analyses (acid soluble)

Sample No.	Location	CaO%	MgO%	Na_2O%	K_2O%	SO_3%	L.O.1	Combined water	Insoluble residua
1	Room E (wall)	33.3	0.25	0.17	0.32	36.48	10.0	2.57	13.1
2	Room E (ceiling)	35.75	0.5	0.17	0.26	38.18	8.5	3.34	14.0
3	Probably room I (wall)	40.31	2.01	0.25	0.11	14.35	25.0	0.92	19.0
4	Room J (pillar 3)	35.05	3.52	0.30	0.28	23.5	19.1	0.83	18.0
5	Room J (crack/wall)	33.65	2.27	0.19	0.26	22.35	17.0	4.03	19.0
6	Room J (wall)	35.05	6.3	0.42	0.11	25.73	N.D	N.D.	N.D
7	Probably room J (ceiling)	28.04	0.76	0.04	0.32	27.66	6.0	8.66	30.0

Table 3 Partial chemical analyses for water soluble constituents

Sample No.	Location	Ca^{++}%	Mg^{++}%	Na^{+}%	K^{+}%	SO^{-}_{4}%	CL^{-}%
1	Room E (wall)	2.0	0.25	0.06	0.16	3.31	0.31
2	Room E (ceiling)	2.31	0.30	0.06	0.13	3.98	0.17
3	Probably room I (wall)	2.11	0.46	0.125	0.05	—	0.27
4	Room J (pillar 3)	3.55	1.06	0.15	0.15	2.34	0.15
5	Room J (crack/wall)	2.8	0.759	0.1	0.15	3.52	0.13
6	Room J (wall)	0.5	—	0.03	0.075	—	0.08
7	Probably room J (ceiling)	2.06	0.91	0.025	0.18	—	0.08

N.B.: Ca^{++} & SO^{-}_{4} give unreliable results, perhaps due to the fine nature of the calcium sulfate components present in the samples, of which a part can dissolve in water. Therefore the results of: Ca^{++}& $SO\text{-}_4$ determined in the water soluble constituents should not be taken into consideration.

(Wagdy Youhanna, Head of Chemical Analysis Laboratory)

5. Concluding Remarks

The results of analyses provided plenty of information regarding the materials employed in the ancient paintings, which is useful not only for the conservators but also for Egyptologists. Furthermore, the slight differences among samples were reported. Such variation is of great interest in terms of plastering and painting technique and/or recognizing the possible historical background of the work in the royal tomb of Amenophis III. It is hoped that more research will be conducted in the future. Finally, we would like to express our appreciation to Dr. Ahmad Shwaib, Director of the Department of the Conservation of the SCA for his cooperation for the analyses. We would also like to express our thanks to the local SCA office in Luxor for their arrangements in delivering the samples to Cairo.

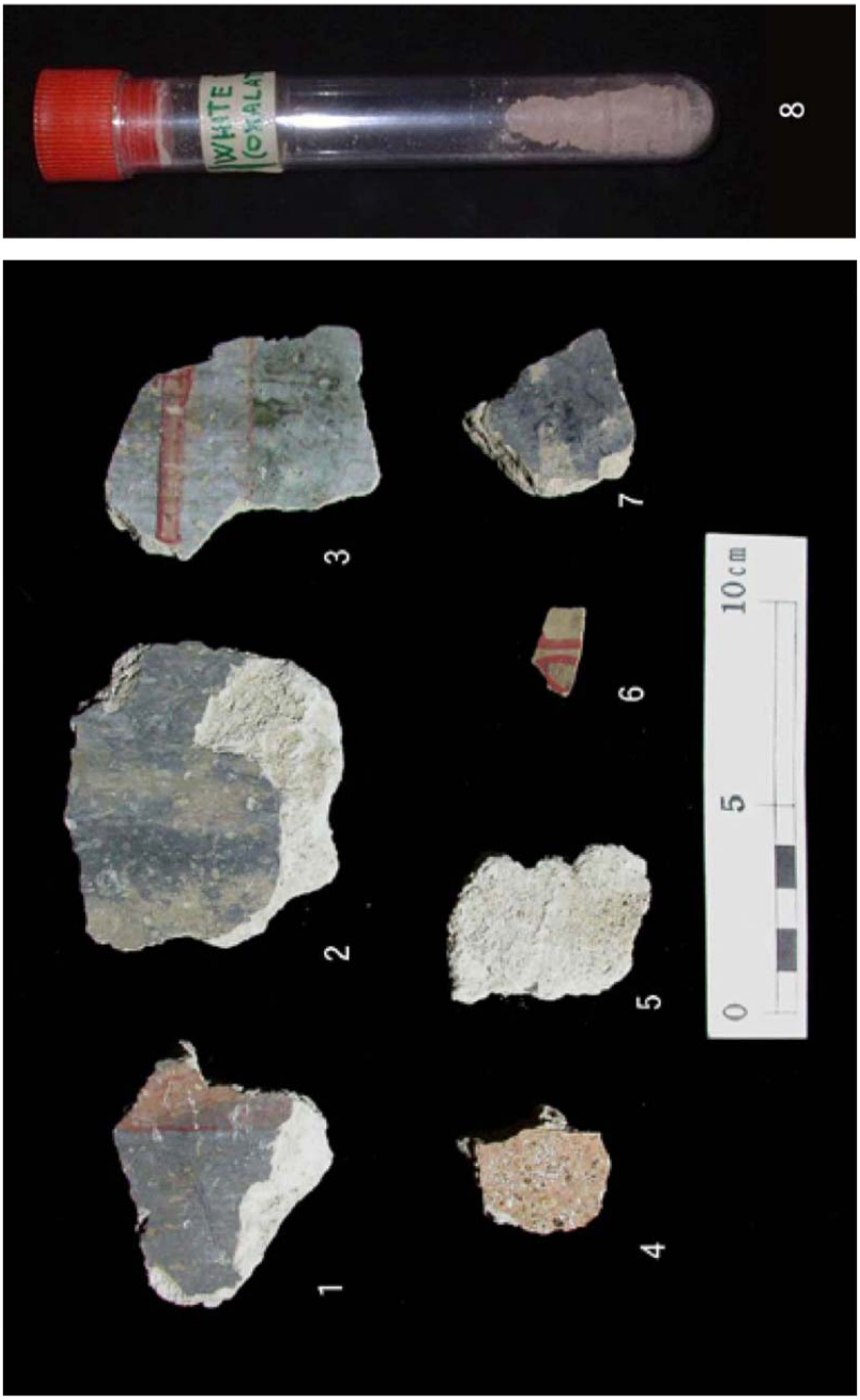


Fig.1 Samples for analyses (Nos.1~8)

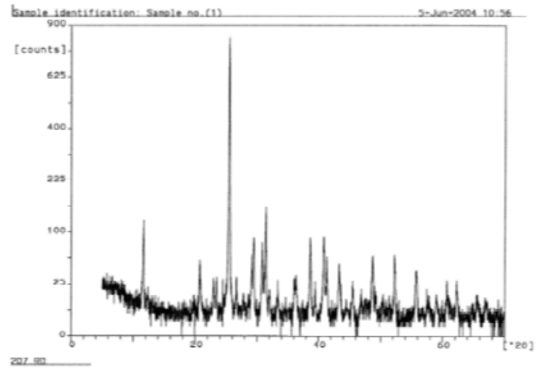


Fig.2 Sample No.1

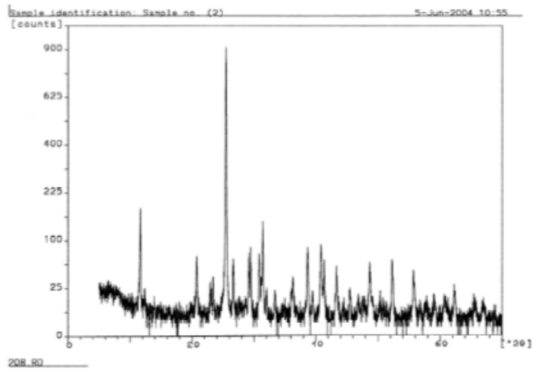


Fig.3 Sample No.2

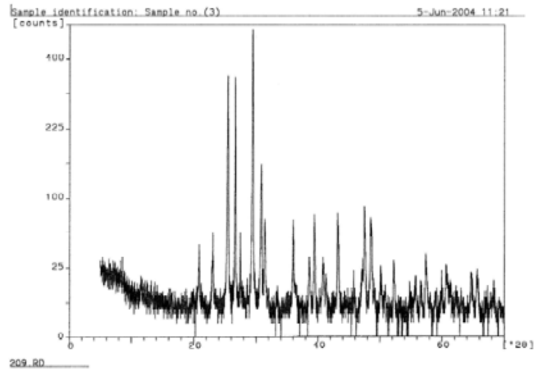


Fig.4 Sample No.3

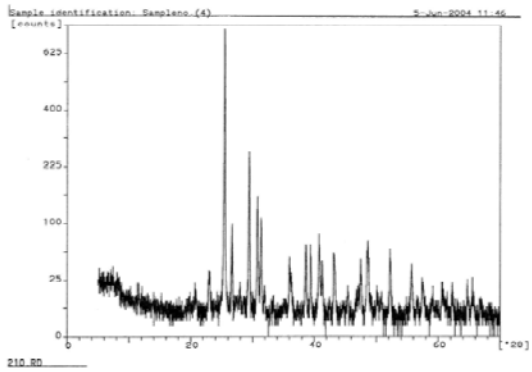


Fig.5 Sample No.4

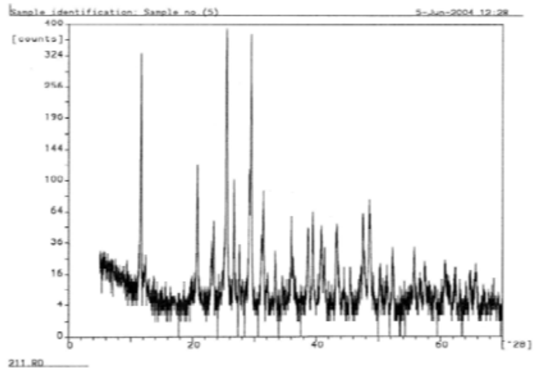


Fig.6 Sample No.5

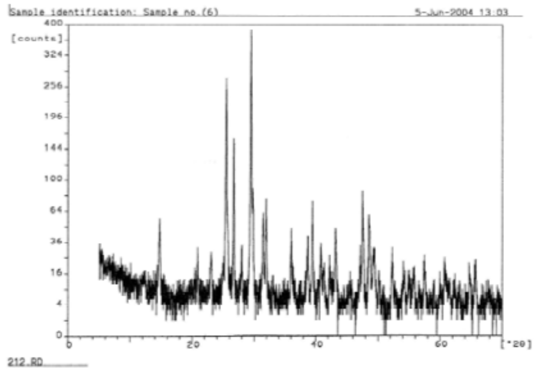


Fig.7 Sample No.6

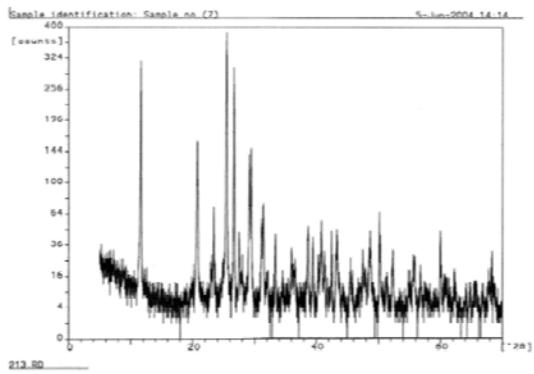
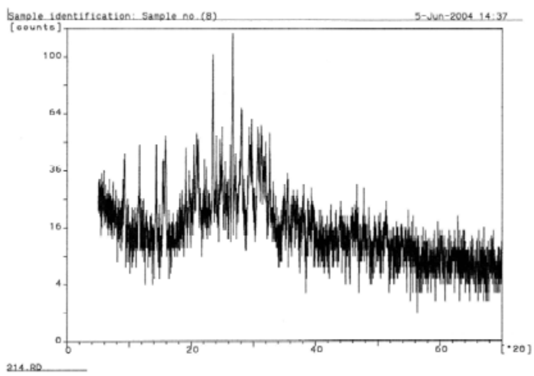


Fig.8 Sample No.7



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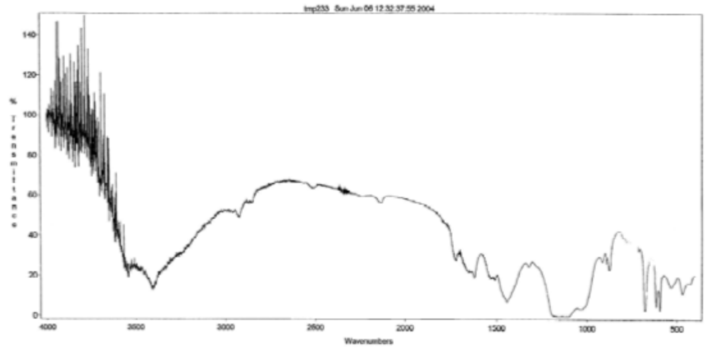

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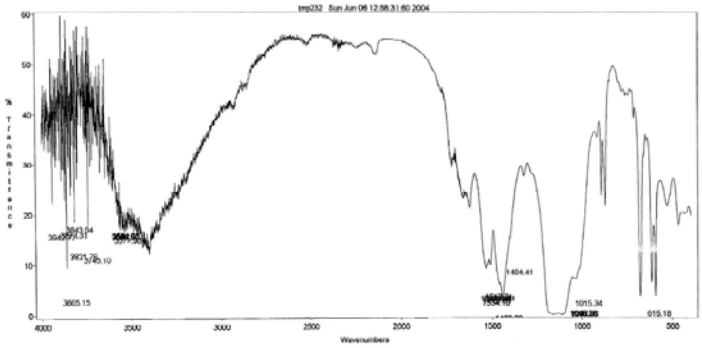

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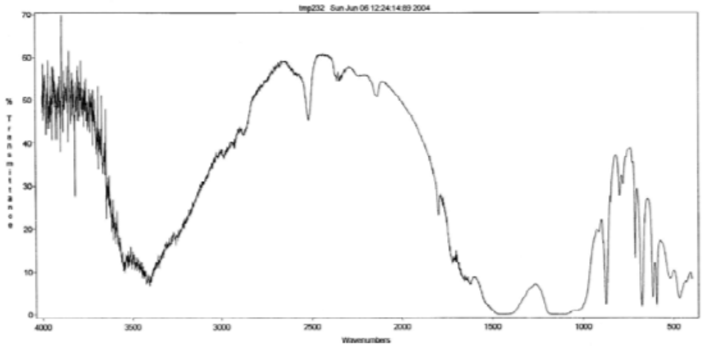

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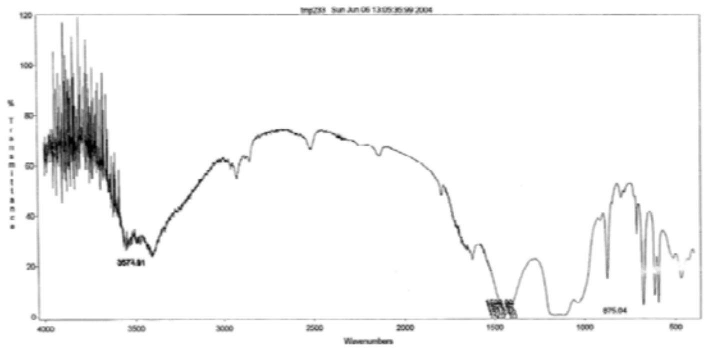

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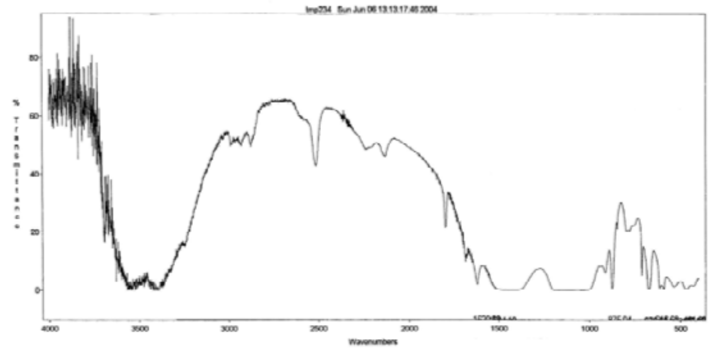

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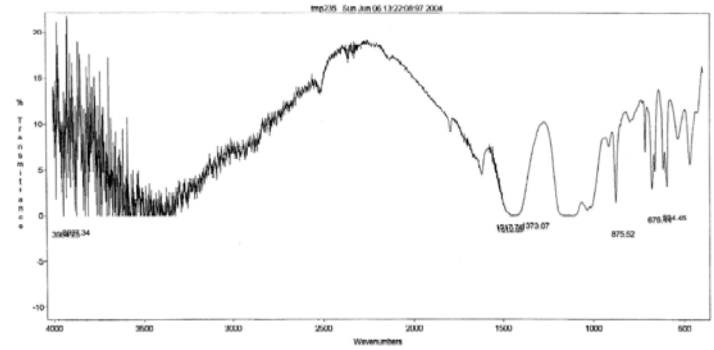

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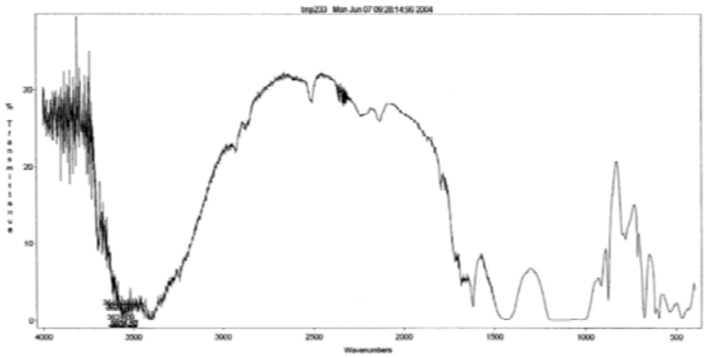
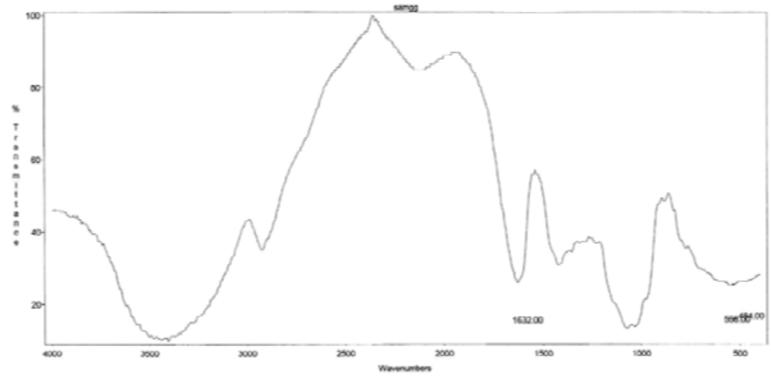


Fig.16 Sample No.7



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3372.00	11.14	3404.00	10.00	3440.00	10.18
3476.00	10.46	3504.00	11.04	3568.00	14.36

Fig.17 Samgg

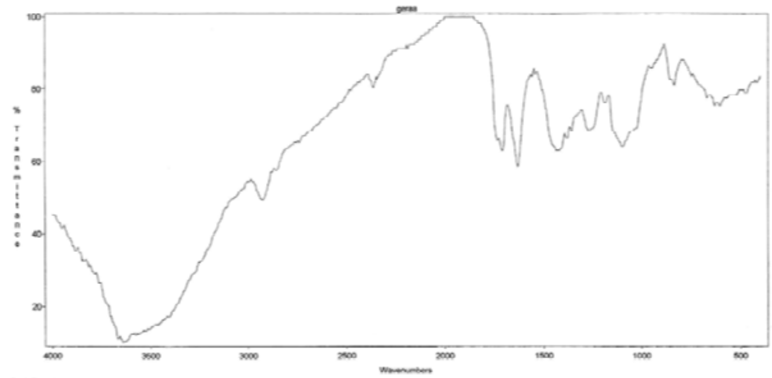

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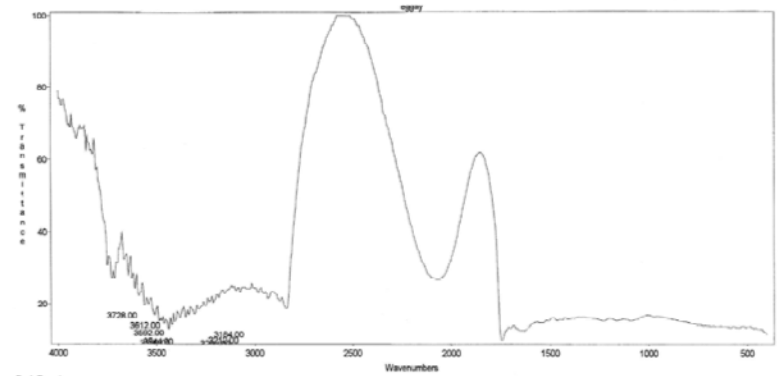
Fig.18 Gerra



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3304.00	17.19	3352.00	16.58	3380.00	16.28
3436.00	13.11	3464.00	14.61	3488.00	15.29
3512.00	17.03	3544.00	20.04	3560.00	19.69
3592.00	22.33	3612.00	24.44	3728.00	27.24

Fig.19 Eggay

4. Rock Mechanical Investigation

Responses of *In situ* Monitoring System at the Royal Tomb of Amenophis III during the Second Phase

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2) Professor, Department of Marine Civil Engineering, Tokai University
3) Professor, Department of Civil Engineering, Nihon University

Introduction

The tomb of Amenophis III has been deteriorating and some fracturing of pillars and walls have already taken place. The fracturing of the wall between room J (burial chamber) and room Jd is very severe and it may cause a major stability problem to the tomb. The authors installed *in situ* monitoring systems to observe the response of the fractured wall between room J and Jd and pillars of room J and room Je of the tomb to environmental variations such as temperature and humidity throughout the tomb, and the seismicity of the region during the second phase. The results obtained from the *in situ* monitoring systems have been presented herein and their implications are discussed with an emphasis on the stability of the tomb.

1. Brief Outline of *In situ* Monitoring System

The detail of *in situ* monitoring system is described in the report for the first phase by the same authors. Therefore, a brief description of the system is given in this sub-section.

(1) Environmental monitoring system

The environmental *in situ* monitoring system consists of temperature and humidity sensors and loggers in order to measure the temperature and humidity variations throughout the tomb, and it was installed on March 17, 2003. It has been in operation since then, and the measurements were carried out at a sampling rate of one hour during the second phase.

(2) Monitoring system for rock mass behavior

As stated previously in the details given in the report for the first phase, the wall between room J and Jd is in critical condition. The stability of this wall has an important role on the overall stability of the tomb in the vicinity of room J and adjacent rooms such as Je, Jc, and Jd. Acoustic emission monitoring units, consisting of acoustic emission sensors together with their amplifiers and loggers installed at the wall between room J and Jd, at the pillar of room Je and at pillar 3 of room J, have been in operation since March 17, 2003. In addition, a displacement gap gauge installed at the same wall together with amplifier and logger units has been measuring the displacement response of the fracture at a sampling rate of one hour.

2. Results of Measurements

(1) Temperature and humidity measurements

The results of measurements were downloaded on February 16, 2004. From the six instruments, we were only able to download data from the four instruments installed at room, B, F, Jd, and Je. Nevertheless, the results are sufficient to have a general idea of the temperature and humidity measurements for a period of almost one year throughout the tomb. Fig.1 shows the variations of temperature and humidity between March 20, 2003 and February 16, 2004. As noted from the figures, temperature variations in room Je and Jd remain almost constant throughout the measurement period, and this value is about 28°C, except the period of human activity in the tomb. The human activity period associated with the cleaning of the wall paintings of the tomb started in December and ended in the middle of March. During these periods, the temperatures fluctuate within a range of 5°C. These periods are easily noticed in the figure.

The mean temperature of room F is about 1°C below that of rooms Je and Jd. Since the location of room F has a higher elevation and is directly connected to the entrance, the fluctuation of the temperature of this chamber is larger. The fluctuation range is about 7°C during the human activity period and thereafter it remains almost constant. The largest temperature variations were observed at the entrance of the tomb. The highest temperature is about 40 °C in June (note that the entrance of the tomb is situated at the northern side of the West Valley) and the lowest temperature is about 10°C during the period between December and February. Furthermore, the daily fluctuation is about 10-12°C during the human activity period and it is about 5-7°C when there is no human activity in the tomb.

The mean humidity in room Je and Jd is about 20-22% when there is no human activity in the tomb. However, the daily fluctuations become very large and they range within 10 to 40%. The humidity of room F is higher, as it is directly connected to the entrance. The humidity variation at the entrance of the tomb ranges between 10 to 65% during the period of measurement. During summer, the humidity is lower, while it becomes larger during the winter period. In other words, June is the most dry month of the year while December is the most humid month of the year.

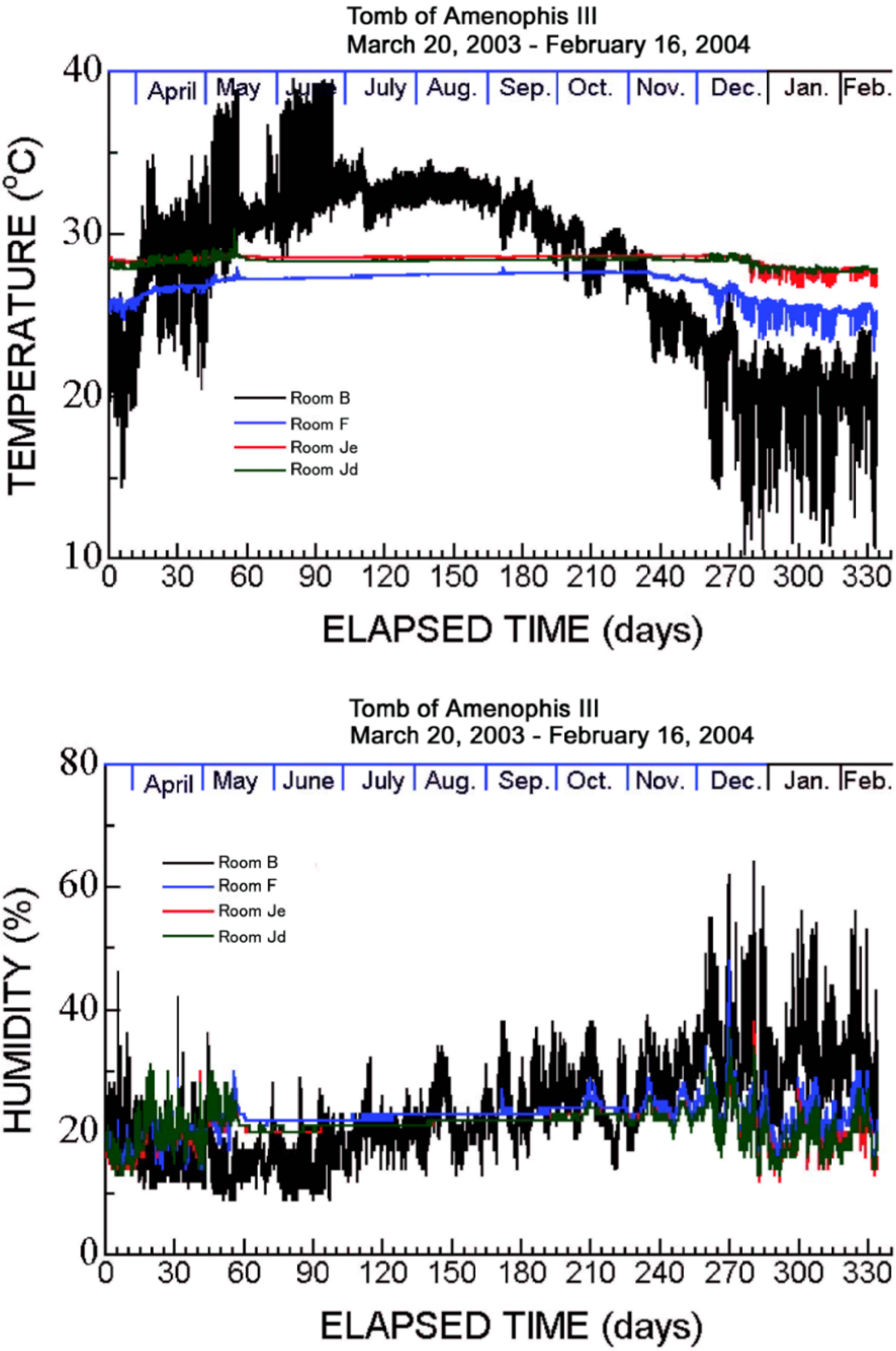

Fig.1 Temperature and humidity variations with time

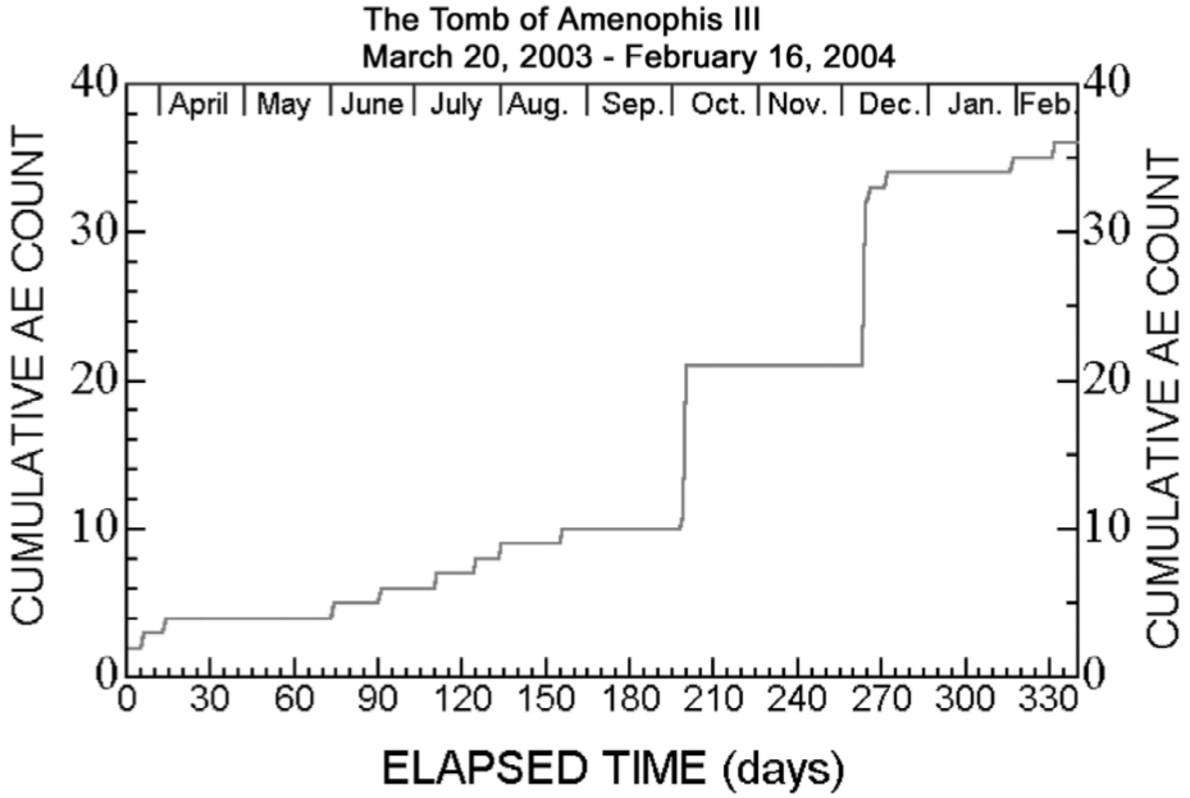

Fig.2 Acoustic Emission response of the sensor AE3 with time tomb

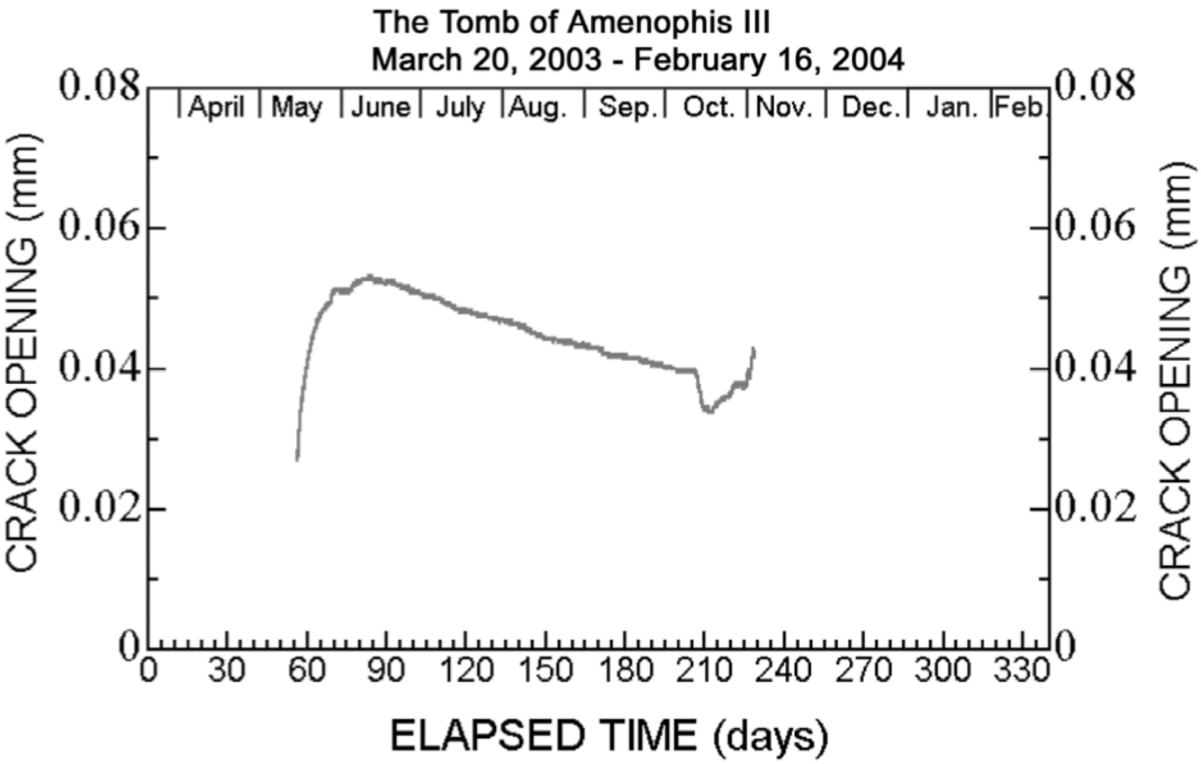

Fig.3 Displacement response of the fracture with time

(2) Rockmass behaviour monitoring measurements

Acoustic Emissions observations were done at four locations. Since the human activities within the tomb may cause some acoustic emission events, the acoustic emission counts occurring during the day are not taken into account, and special emphasis was given to those that occurred after the work hours (from 19 PM till 6 AM of the next day). If this criterion is implemented to the results of measurements, there is almost no acoustic emission activity for AE instruments numbered AE1, AE2, and AE4, while the AE instrument numbered AE3 showed a distinct acoustic emission activity during the period of measurements as shown in Fig.2. After a relatively calm period between April and May, acoustic emission activity started in June and continued in a linear fashion. After a calm period in August, a very sharp acoustic emission activity started at the beginning of October. Another sharp acoustic emission activity was observed at the beginning of December, at which time the cleaning operation in the tomb started. These acoustic emission activities clearly indicate that localized cracking has taken place in the wall between rooms J and Jd.

The data from a displacement gap gauge installed at the relatively continuous open fracture on the north wall of room J is only available for the period between May 15 and November 3, 2003. Fig.3 shows the response of the displacement gap gauge during a forementioned period. The maximum range of the displacement is within 0.05 mm. Soon after the installation of the gap gauge, the displacement of the fracture showed the mode of opening. It seems that the opening displacement of the fracture is related to the temperature variations at the entrance of the tomb, even though the temperature of the room in which the gauge is installed remains almost constant. Although it is difficult to make a quantitative statement about the effect of the outside temperature, it would be natural to expect that the deformation behavior of the tomb would be influenced by the atmospheric temperature variations and crustal straining due to the motion of the earth. However, a sudden variation in the displacement response occurred in October 11, 2003. After a certain closure, the crack started to open up. At this moment, it is very difficult to make further comments. Nevertheless, the sudden changes of displacement variation should be associated with some new crack occurrence in the north wall of the main chamber.

(3) Regional seismicity

It is known that regional seismicity may also influence the deformational and acoustic emission response of the tomb. Therefore, the regional seismicity was investigated through the databases of some seismological institutes. Although the Seismological Institute of Egypt gathers the seismological data, their data is not accessible through the Internet. Therefore, the data used in this section was gathered from databases of the Israel Seismological Network (ISN), the National Earthquake Information Center (NEIC) of United States and the International Seismological Center (ISC). Although the database of the Israel Seismological Network covers earthquakes down to a Magnitude of 2.8, their cover area does not extend down to the Luxor area. On the other hand, NEIC covers the whole area. However, it omits the earthquakes having a magnitude less than 4, while the ISC has a better coverage of the region. Fig.4 shows the epicenters of earthquakes. The most significant earthquake relevant to the period of measurement occurred on June 6, 2003 (231 km north of the tomb) along Nile River. Another earthquake occurred on April 21, 2004 near by the Red Sea shore (207 km away from the tomb) and this earthquake is on the fracture zone which passes through King's Valley, extends to the Aqaba Gulf, and joins the Dead Sea Fault Zone (it is also known as Levant transform fault zone).

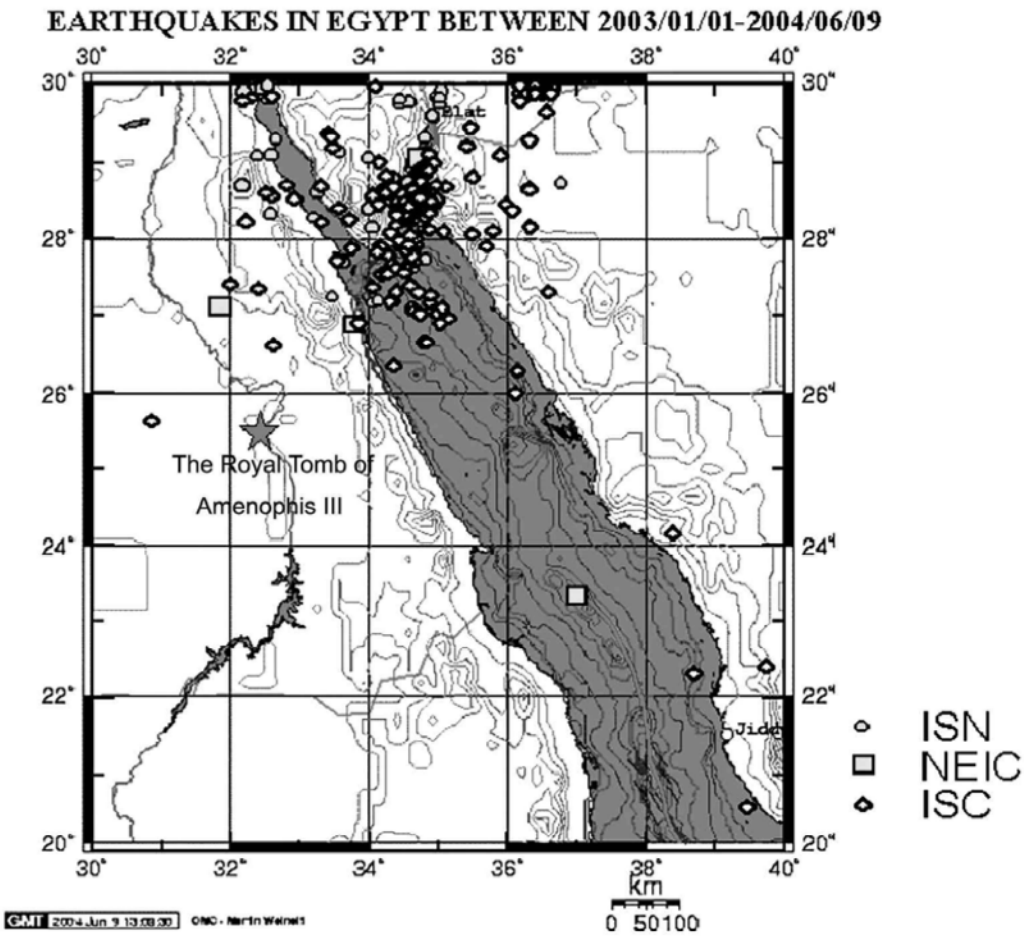

Fig.4 Regional Seismic activity and epicenter locations

3. Discussions

All relevant data are re-plotted in Fig.5 in order to discuss the implications of the measurement results from *in situ* monitoring systems. It seems that the acoustic emission activity started at the end of May 2003 has some relation to the seismic activity along the Nile River to the north of the tomb. If the outside temperature increases, the whole hill should expand. Consequently the inward closure of the tomb should occur, which subsequently may cause the opening of the fracture. On the other hand, if the outside temperature decreases, the reverse response should occur, provided that the surrounding rock behaves linear elastically. The sudden increase of AE activity and subsequent variation of displacement response simply implies that some new fracturing took place, and this further led to the opening of the fracture. In other words, there is a high possibility of further propagation of the existing fracture in the north wall of room J.

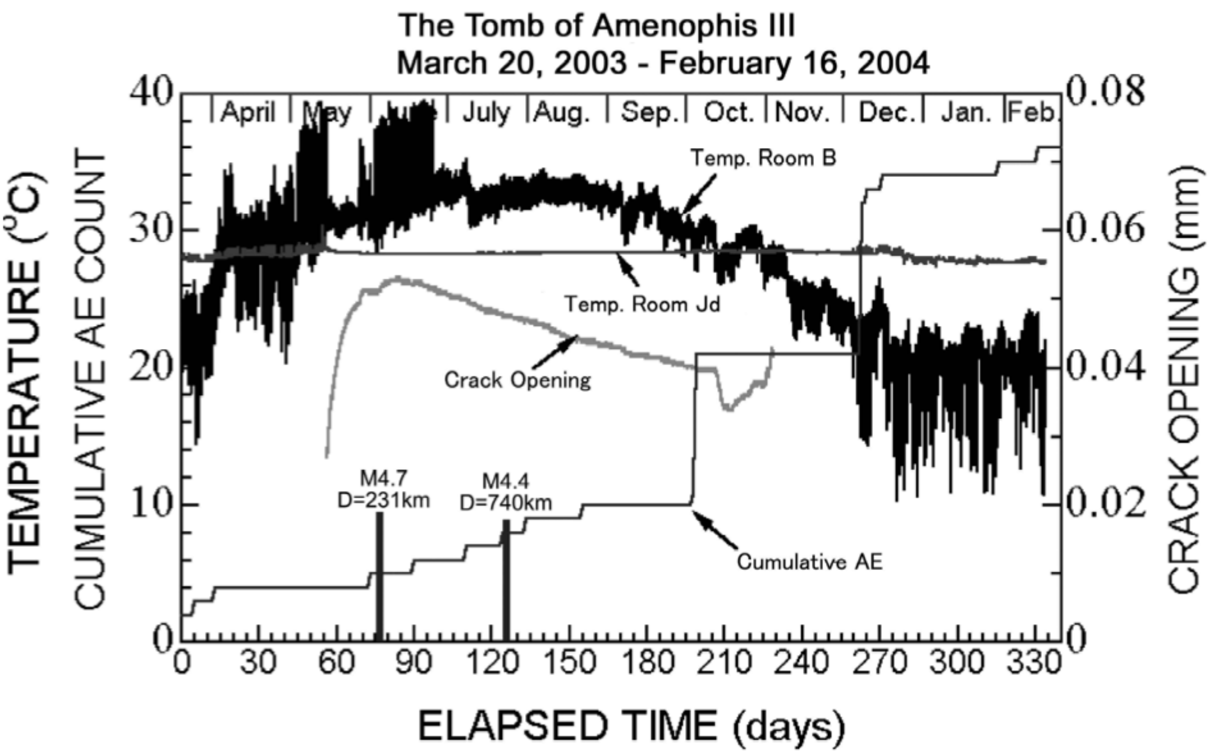

Fig.5 A comparison of parameters measured by *in situ* monitoring systems during the second phase

5. Egyptological and Art Historical Studies

(1) Egyptological Observation

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Introduction

In December, 2003 and March, 2004, I made Egyptological and archaeological observations of the inscriptions and paintings on the walls of rooms E, I, and J in detail as the conservation program went on. This paper briefly describes the result of the observations.

1. Room I

As a result of the cleaning of the walls, I could make observations of paintings on the walls clearly, especially with regard to the figures of the pharaoh and deities. Having compared the portraits and their costumes (Figs.1-3) on different walls in detail, I studied on the differences and the chronological order of the paintings. Also, I studied the portraits of Amenophis III on the walls of KV 22 (Figs.4-8) in comparison with his portraits from his memorial temple at Kom al-Hettan (Fig.9).

Fig.1 Costume of Amenophis III in room I

Fig.2 Costume of Amenophis III in room I

Fig.3 Costume of Amenophis III in room I

Fig.4 Portrait of Amenophis III in room I

Fig.5 Protrait of Amenophis III in room I

Fig.6 Portrait of Amenophis III in room I

Fig.7 Portrait of Amenophis III in room I

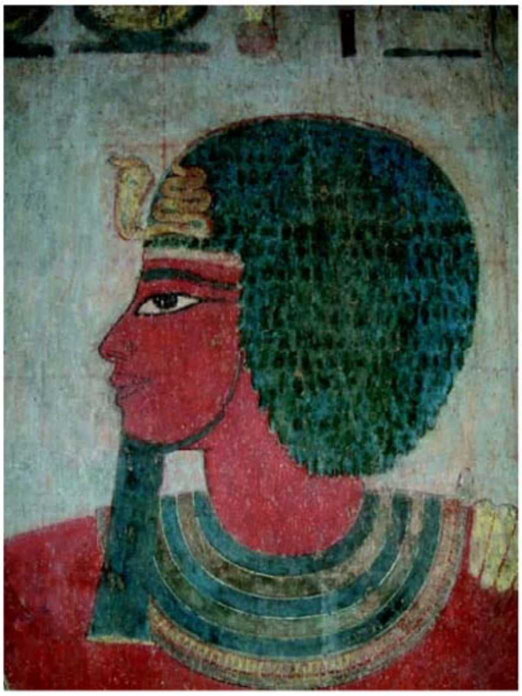

Fig.8 Portrait of Amenophis III in room I

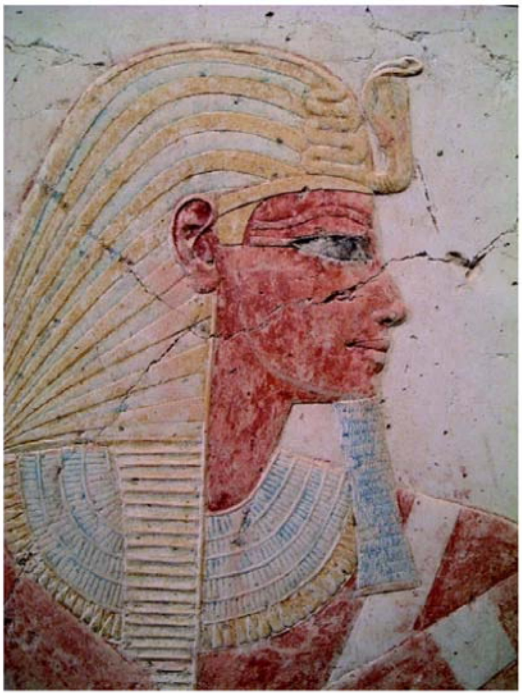

Fig.9 Portrait of Amenophis III from Kom al-Hettan

2. Room J

(1) The *Book of Amduat* (Fig.10)

After cleaning the surfaces of the walls, the inscriptions and vignettes of the *Book of Amduat* have been cleared. By observation of the text of the prologue near the eastern corner of the south wall, we could discover the memorandums of the inscriptions for copying the text. It is very important for us to study the process of copying of the text of the *Book of Amduat* by ancient Egyptian scribes. The clear inscriptions and vignettes enable us to study the figurative designs and the paleography of the *Book of Amduat*.

a Memorandum 1

b The Detail of 1

c Memorandum 2

d Detail of vignette at twelfth hour

e Inscription of the *Book of Amduat*

Fig.10 The memorandums of the inscriptions for copying the text

The full-scale of re-copying of the texts and vignettes will be necessary after finishing the conservation work in room J.

(2) Pillar 6 in room J

In the last season, we found that all the toes of the left foot were drawn for the figure of the Western Goddess on the east face of pillar 6 (Fig.16); this is a characteristic feature of the so-called 'Amarna style' art. The east face of pillar 6 has finished being cleaned in this campaign (Fig.11). I could observe the paintings on the face. Judging from observations, the decorations on the east face of pillar 6 were painted in different stages (Figs.12-15).

Fig.11 Pillar 6 east face

Fig.12 Pillar 6 east face detail (1)

Fig.13 Pillar 6 east face detail (2)

Fig.14 Pillar 6 east face detail (3)

Fig.15 Pillar 6 east face detail (4)

Fig.16 Pillar 6 east face detail (5)

It is clear from the styles of figures and inscriptions that pillar 3 and pillar 6 were decorated in the later stage. Particularly, the east and south faces of pillar 3, and east and north faces of pillar 6 seem to have been decorated at the very end. However, the four faces of pillar 3 and 6 have not yet been fully cleaned in the present campaign, which does not allow me to give a report in detail.

(3) Black draft lines for construction purpose

We observed black lines under the plaster surfaces of the walls in room J. They seem to have been drawn for the purpose of rock cutting before the decoration was done. If we draw imaginary lines from where the black lines were drawn on the wall, we can find the pillars. They seemed to have an architectural function for determining the positions of pillars during construction.

They give us knowledge of how the rock cutting was done, so they should be preserved. However, as they are to be hidden under the plaster and decoration, we should keep traces of these somehow in the conservation work.

(2) Egyptological Comments on the Work Undertaken in the Royal Tomb of Amenophis III

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Introduction

The royal tomb of Amenophis III was officially discovered by members of Napoleon's Mission to Egypt in 1799. After its discovery, the great pioneers of Egyptology visited the tomb as early as the middle of the 19th century. They reported on the tomb's various decorations in their documents:

J.-F. Champollion in 1829 wrote [1]: "Les tombes royales véritablement achevées et complètes sont en très-petit nombre, savoir: celle d´Aménophis III (Memnon), dont la décoration est presque entièrement détruite;... Quelques parois conservées du tombeau d´Aménophis III (Memnon) sont couvertes d´une simple peinture, mais exécutée avec beaucoup de soin et de finesse. La grande salle contient encore une portion de la course du soleil dans les deux hémisphères; mais cette composition est peinte sur les murailles sous la forme d´un immense papyrus déroulé, les figures étant tracées au simple trait comme dans les manuscrits, et les légendes, en hiéroglyphes linéaires, arrivant presque aux formes *hiératiques*."

R. Lepsius in 1845 wrote [2]: "Das andere (= Tomb of Amenophis III) liegt weiter vorn im Thale, ist von größerer Ausdehnung und mit schönen, aber leider durch Zeit und Menschenhände sehr verstümmelten Skulpturen bedeckt."

It is striking that both of these "giants" of Egyptology mentioned the regrettable state of the tomb observed in their research. Despite the few Egyptological studies carried out in the tomb since that time, no conservation work of the wall paintings was carried out on this fantastic monument of human heritage. Considering this history of research on the royal tomb of Amenophis III, the ongoing comprehensive conservation work on the decoration conducted by the mission from the Institute of Egyptology at Waseda University, under the auspices of the UNESCO/Japan Trust Fund, will be a milestone in Egyptology.

The followings are short sketches of the fruitful results of the work obtained up to the late stages of the second phase. Because of the present writer's "major", most are based on comments from an epigraphic point of view.

1. Room E

After trial cleaning in the first phase, the consolidation and cleaning of the wall paintings were carried out in the second phase. For this work the shaft of room E was covered by artificial flooring, so that one can see now the wall paintings at close range.

The cleaning phase has, to our great surprise, revealed some unrecorded inscriptions. In the first scene on the south wall an image of *ka* (spirit, or personality) of Tuthmosis IV is visible with its inscription, and this scene was published by J.-F. Champollion with a drawing of N. L'Hôte[3]. In the cleaning process the name of the goddess Nekhbet with her epithet "the White of Hierakonpolis", and the entire inscription relating to the goddess Nut are now readable. These corrections were not difficult to surmise. As well, in addition the text of *ka* is totally new. Behind the "Horus name" of Tuthmosis IV on the head of the image of his *ka*, a group of signs *pr dw3t* are now clearly visible. This means "Chamber of morning"; "Chamber for cleaning" and follows the sentence before the "Horus name". The whole text could be translated as follows: "the living royal *ka*, lord of the Two lands, foremost of the Robing room and the Chamber of morning."

In the north-west corner of the north wall another image of the *ka* of Tuthmosis IV is depicted. As in the case of the south wall, the corner was covered in bat droppings. After removing them, the same group of signs *pr dw3t* appeared, so the whole of the legend of the *ka* is identified with that of the ones on the south wall.

On the right side of the east wall, the Western Goddess stands in front of the king. This part was also heavily covered in bat droppings, and it seems that the space for the two images was too small, forcing them to be painted very closely together. These facts lead E. Hornung, who studied the wall paintings systematically in 1959, to suggest that no text had been written for the Western Goddess[4]. However, contrary to his suggestion, the text for the goddess has been discovered by cleaning the surface of the wall: *smi.t-imnt.t sḥtp=s ib di=s ʿnḫ nb snb nb* ; "Western Goddess: May she pacify the heart. May she give every life and every health."

It is very interesting to note that the signs have been written in a small size to save space. We now know that the complete depicted images of the king, the gods, the goddesses and *ka* in the royal tomb have their own legend.

2. Room I

In the north-east corner on the north wall an image of the *ka* partly survives. After cleaning the surface of the wall a part of a group of signs consisting of its legend is now visible. Again the image of the *ka* has the identical legend with those in room E.

The comprehensive cleaning of the wall paintings revealed not only unrecorded texts but also a part of the decoration process of the walls. An interesting example can be seen on the south-east corner on the east wall. The decoration of this corner was regarded as atypical, because there is no block border running vertically along the corner.

The upper part of this corner was badly covered by bat droppings, as is the case in most of the corners. After cleaning, traces of the changes in decorations were revealed (Fig.1).

Originally the right terminal of the border in the form of the sky was drawn just before the corner, however, it seems as an obvious mistake by the artist; the border must have terminated with a distance of one grid square of the drawing system from the corner in order to paint the vertical block border. Due to this reason the border in the form of the sky was reduced. On the other hand, the drawing of

Nekhbet just below the border was probably initiated from left to right of this wall, maybe before the changing of the length of the border occurred. Thus, the artists had to save space in order to be able to draw Nekhbet to the far right of the wall with her legend that consisted of very clustered hieroglyphic signs. According to this new evidence it is probable that the upper part of the wall paintings were executed first, then the images of the king, the gods and the goddesses were drawn on the wall. From evidence found prior to cleaning it is also plausible that the legends of the images were added afterwards.

As for the painting sequence, it can now be roughly reconstructed as follows: 1. paintings of the uppermost frieze and borders; 2. Nekhbet with her legend; 3. images of king, gods and goddesses; 4. legend of the images. This suggestion could be presented after the comprehensive cleaning in the royal tomb, and further studies on the wall paintings will no doubt give us more details concerning the process of tomb decoration by the ancient Egyptian artists.

3. Room J

The wall decoration of room J can be divided into two:

On the four faces of each of the six pillars: images of the king coupled with a god or a goddess.

On the four walls of the room: the *Book of Amduat*.

Before the comprehensive cleaning project the illegible part of the inscriptions, due to bat droppings, were scattered on both decorations. Through cleaning we are now able to read and document the whole preserved texts in room J. Future studies will contribute greatly to Egyptology.

One of the subjects to be studied is how the *Book of Amduat* was drawn on the four walls of room J. Such study will shed light on understanding work plans of the ancient Egyptian artists in the royal tomb; and may allow us to recognize the relation between the religious text and room J as the burial chamber of Amenophis III.

Through the study of the cleaned wall surfaces to the north-east corner, it is now plausible that the north end of the eastern-most wall was decorated with a part of the *Book of Amduat* first, and then the east end of the north wall was filled with parts of the same book as a continuation of the already executed part on the northern end of the east wall (Fig.2). Proof of this is the fact that the figures on the east end of the north wall were drawn very closely to save space. There is another reason for the decoration process here: 1. division of the *Book of Amduat* for the east and north wall; 2. furthest north part of the east wall was finished with the book; 3. the drawing process of the book at the north-east corner on the north wall went from left to right towards the corner.

Another interesting result from the comprehensive cleaning project is the revelation of a kind of draft of the ancient Egyptian scribes writing down the text from the *Book of Amduat* in a certain position: type A) write a group of top signs at the beginning of the line (Figs.3, 4)[5]; type B) write a group of the last signs on the bottom line in small size (Fig.5)[6]; type C) write a group of the last signs at the bottom of the line in full size in pale colours (Fig.6)[7]. In every case an appropriate colour, either black or red, was chosen for the draft.

From these results we can now understand how cautious the ancient Egyptian scribes were about making copies from their papyrus master versions of the *Book of Amduat*. It is hoped that further systematic research on the traces of the drafts will be undertaken by the mission.

4. Conclusion

The points mentioned above show that the comprehensive cleaning project of the wall paintings in the royal tomb of Amenophis III is a great contribution to Egyptology and to all the people who will visit or study the tomb in the future. We hope the many results of the project achieved until now and into its second phase can lead to the continuation of the project. The team, headed by Prof. Dr. S. Yoshimura, consisting of specialists from Egypt, Italy and Japan, have proven their professionalism through their ability and responsibility for the task and their commitment to the cultural heritage of the project.

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1) J.-F. Champollion, *Lettres Écrites d'Égypte et de Nubie en 1828 et 1829*, Paris 1833, pp.245-246.
2) R. Lepsius, *Briefe aus Aegypten, Aethiopien und der Halbinsel des Sinai*, Berlin 1825, pp.288-289.
3) J.-F. Champollion, *Monuments de l'Egypte et de la Nubie*, T.III, Paris 1845, Pl.CCXXXII, 3.
4) A. Piankoff und E. Hornung, "Das Grab Amenophis' III. im Westtal der Könige", in: *Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo* 17, 1961, p.120.
5) Figs.3, 4 show parts of the twelfth hour in the middle register of the *Book of Amduat*. Cf. E. Hornung (ed.), *Texte zum Amduat, Teil III: Langfassung*, g.bis 12. Stunde, Aegyptiaca Helvetica 15, Genève 1994, pp.829-831.
6) Fig.5 shows a part of the beginning of the fifth hour in the short version of the *Book of Amduat*.
7) Fig.6 shows a part of the sixth hour in the short version of the *Book of Amduat*.

Fig.1 Changes in decoration on the east wall in room I

Fig.2 The *Book of Amduat* around the north-east corner of room J

Fig.3 Type A) of draft

Fig.4 Type A) of draft

Fig.5 Type B) of draft

Fig.6 Type C) of draft

6. Social Environmental Research

(1) Notes for Conservation Planning and Human Development through the Conservation Activities in the Royal Tomb of Amenophis III

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Introduction

In this survey we drew out some points which should be considered for the future utilization of the royal tomb of Amenophis III, by concentrating on the actual conditions of the conservation project held at this tomb, and carefully comparing them with the present situation of other monumental sites. Two noticeable matters are discussed, one concerning tourism and the other regarding the future development of the Egyptian wall paintings conservation experts. For the first matter we have compared the actual condition of the tomb of Amenophis III to the other surrounding monumental sites. For the human resources development of Egyptian technicians we have considered the actual conservation project held at the royal tomb of Amenophis III.

1. Consideration for the Future Utilization of the Royal Tomb of Amenophis III

We have noted the actual conditions of the surrounding monumental areas and some decision shall be needed for the future utilization of this tomb. The following points were especially noted for comparing the actual conditions.
1) Exhibiting conditions inside the tombs
2) Landscape planning for tourism at the historical monumental site
3) Planning and the traffic accessibility of the district
4) Information accessibility
Comparing each site, many differences can be noted, especially due to the principles of each conservation project, in some cases headed by foreign missions. In conclusion, the royal tomb of Amenophis III needs to be considered from two major points of reference. First, its identity must be placed within the wide monumental area. An adjustment of the traffic network among the Western Valley's monumental sites will be needed. A well planned station for the traffic network is required to disperse the tourists, to lessen overloading a single monumental site. Second, the inner presentation plans after conservation must be considered. The tomb of Amenophis III is medium-large sized, and

fewer wall paintings exist. At the other sites in the Western Valley there was a lack of information for the tourist. There are possibilities for conservation records, and historical facts can be better displayed. This tomb offers the possibility of utilizing the unpainted rooms for presenting the records of the conservation and biographical notes about Amenophis III. Lighting plans are also important for the impression one gets. Considering other sites, directly lighted wall paintings did not turn out as well as had been hoped. Indirect lighting is preferred.

2. Consideration for the Human Resources Development

At the royal tomb of Amenophis III, conservation activity is done through cooperation between Italian, Japanese, and Egyptian staffs. The Italian chief conservator leads the staffs. Few interviews have been held with the staff at the tomb of Amenophis III. Table 1 shows an example of the comments from the Egyptian staff. Most Egyptian conservation staff are from the archaeology faculty, and it was their first experience with working in an international team. They realize that the technical method for conservation differs between nationalities. Without the guidance of the technical director, they indicate that it can be difficult to choose the most preferred method of conservation for challenging areas. The guidance of the director is not always recorded. For this reason, it may be helpful to publish not only the conservation record but also the standard guidance book for conservation throughout this conservation experience, and to utilize this for the education of the younger generation, together with the actual training at the site.

Table 1 Interview Data for the Human Resources Development of the Egyptian Wall Painting Conservators

Interviewing date	Feburary 29, 2004	Feburary 29, 2004
Age	25 years old	32 years old
Sex	female	male
Born in	Luxor	Luxor, Qurna
Family	single	married, wife, 1 daughter, wife four months pregnant
Education	2001 Graduated Cairo University 2003 Graduated Institution of Restration (specialize in painting, stone, metal)	Graduated Institute of Restoration Conservation of Archaeology Especially studied oil painting and wall painting
Career	After education, start to work in Archaeology faculty, the Department of Conservation, SCA	1993 Archaeology faculty, the Department of Conservation, SCA
Working experience	Worked few months in Luxor museum. Then restoration experience at Habu temple, Ramose, Qurnat-Murai and now Amenophis III.	First work was in Seti I, then worked in Deir al-Medina and many other sites for 10 years.
Impression of working at Amenophis III	Right now I work under the guidance of Giorgio. Beforehand I learned from Egyptians. It is my first experience to work in an international team. The most important thing for this work is experience. I see technical difference among nationalities, but since the goal is the same, I don't think it's so much a problem. I am a beginner here so I have much to learn.	It is my first experience to work with a foreigner. I have only learned from Egyptian technicians. It is a pleasure working with foreigners. I always come up with new discoveries, such as new techniques, new materials. I think that the goal for the restoration is same among all, but now I see many options for restoration. Giorgio is good teacher, gives me a relaxing atmosphere, encouragments. My former teachers were very strict. I think Japanese always try to do things too much perfect.
Favorite monument	Amenophis III. I am proud to work here	Menna
Prospects for the future	I am a lady, but I prefer to keep working as a restoration technician. Even though I get married, I would not like to stay home all the time.	I want to be like Giorgio. I want to keep on working in an international team, where I can always find new discoveries.
About the salary as a restoration technician	I am single so I live with my family. Egyptain ladies don't live alone, but I think the salary is enough for a lady to live alone.	Sometimes I think the salary is not always enough. For me, I own a bookshop in Qurna village. I have working staffs for the shop. My income becomes enough combining with the income of the bookshop.

(2) A Survey on Present Condition of the Valley of the Kings

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Introduction

Before making the decision regarding practical use, we surveyed the present condition of the Valley of the Kings for public presentation. Though the Valley of the Kings is comprised of the Main Valley and the Western Valley, registered tombs are distributed mostly in the Main Valley (Figs.1, 2). Therefore, there are some problems to be solved. As part of the investigation in connection with the present condition of the tomb of Amenophis III (Fig.3), we surveyed rest stations and signboards in the Main Valley.

1. Consideration for the Present Utilization of the Main Valley

Currently, the rotary of sightseeing buses is established at the turning point of the Valley of the Kings. Trolley buses shuttle to the Main Valley from here (Fig.4). The equipment indicating the Western Valley is only an arrow signboard set by a location map of the whole Valley of the Kings.

Sightseers can go to the main gate of the Main Valley by trolley bus (Fig.5). Here is presented an enumeration of buildings and signboards which are set in the Main Valley.

- Buildings
--- guard hut (Fig.6)
--- rest hut (Fig.7)
--- other hut
- Sign boards
--- guide board (location map and sightseeing map) (Figs.8-10)
--- arrow board (Fig.11)

There is a rest hut near by the main gate, sightseer can confirm whether tombs are currently open or closed by viewing an updated sign.

The front of KV62 serves as an open space in which tourists gathers (Figs.12-14). The fact that many tourists concentrate here is one potential problem.

3. Consideration for the Future Utilization of the Western Valley, through the Present Condition of the Main Valley

It is important to consider how to lead tourists from the turning point between the Main Valley and the Western Valley for planning the public presentation of the royal tomb of Amenophis III (Figs.15, 16). Furthermore, it is necessary to examine the trolley bus route to the Main Valley.

The most important problem is how to prepare for tourists, since the Western Valley has very few tombs.

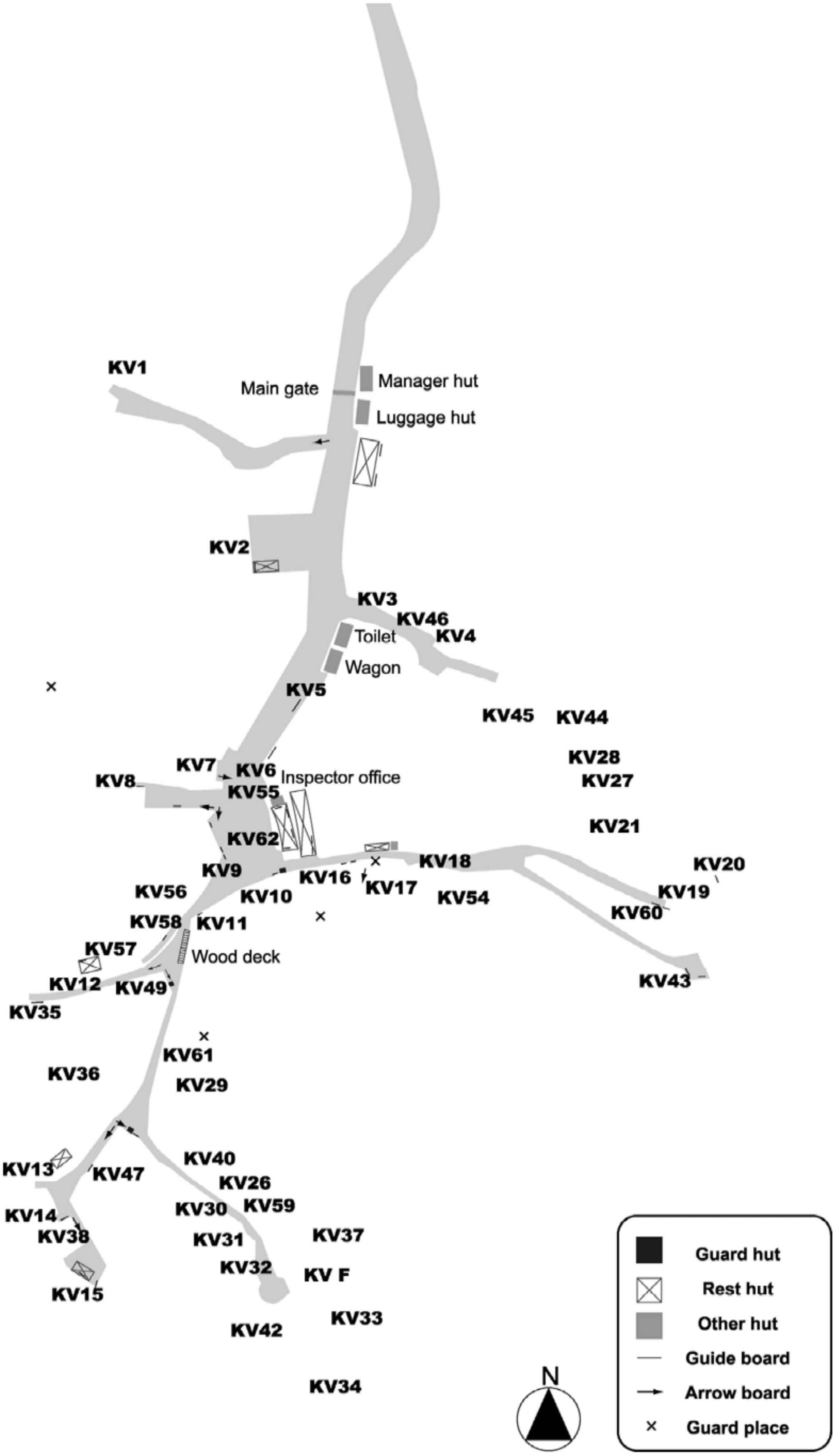

Fig.1 Map of the Main Valley

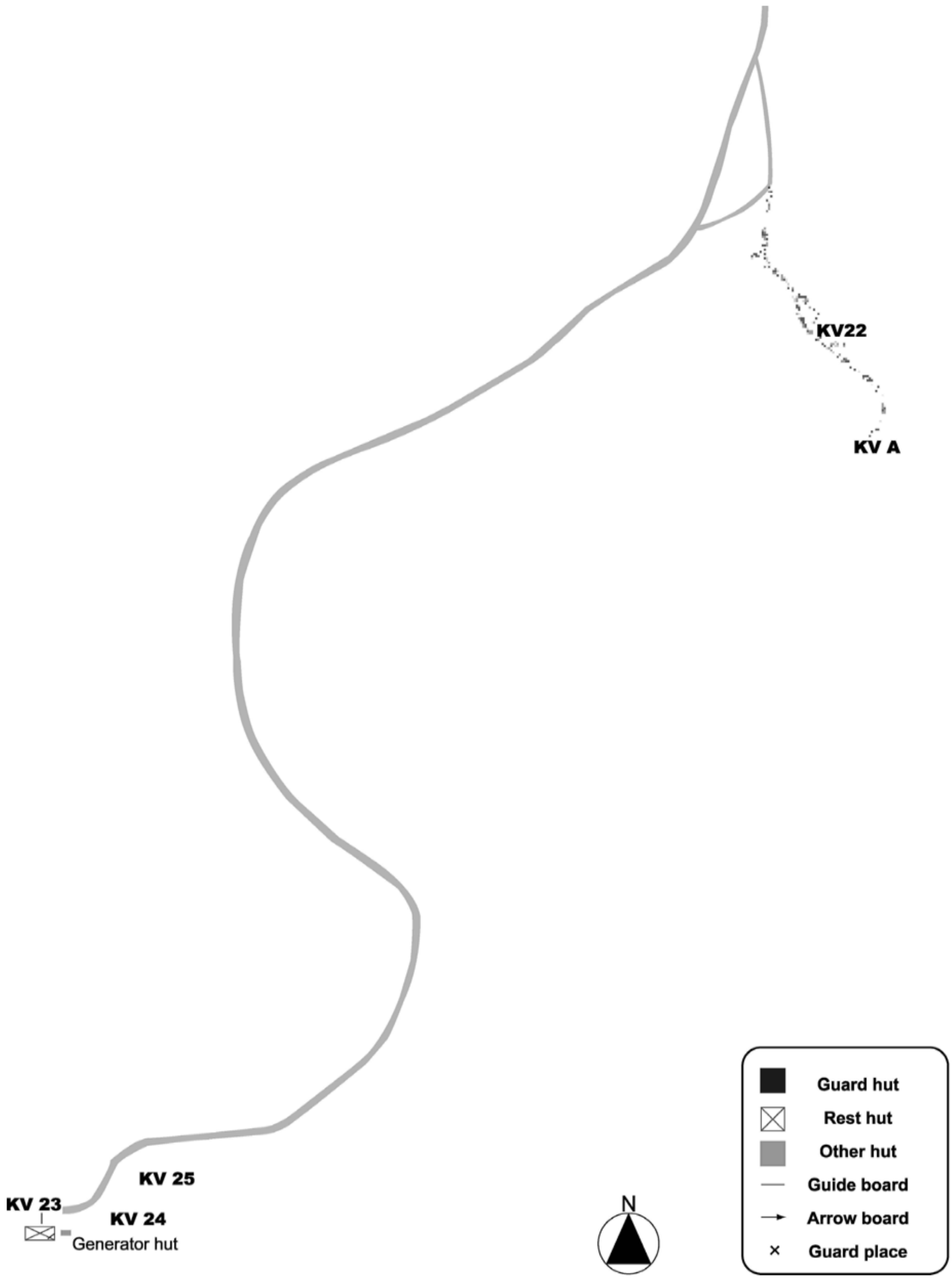

Fig.2 Map of the Western Valley

Fig.3 The tomb of Amenophis III

Fig.4 Trolley bus

Fig.5 Main gate

Fig.6 Guard hut

Fig.7 Rest hut

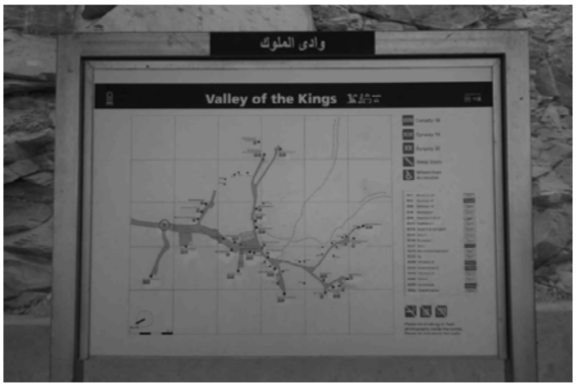

Fig.8 Location map

Fig.9 Sightseeing map

Fig.10 Sightseeing map

Fig.11 Arrow board

Fig.12 Front of KV62

Fig.13 Front of KV62

Fig.14 Toilet

Fig.15 Junction

Fig.16 Junction

7. Conservation of the Wall Paintings

(1) A Report on the Conservation Work on the Wall Paintings during the Second Phase

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2) Conservator, Tokyo
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Introduction

In this season, our conservation work was conducted mainly on the south wall in room J, which is decorated with the first and second hours of the long version of the *Book of Amduat*, and first to twelfth hours of the short version of the *Book of Amduat*. The main aim of this season by Japanese conservators was to complete the conservation of the whole painted surface of the south wall.

After having completed the work on the south wall, we have begun working on the west wall in room J, decorated with the third to sixth hours of the long version of the *Book of Amduat,* where the Egyptian conservators have already started their work. The conservation work itself was done under the direction of our chief conservator, Dr. Giorgio Capriotti, and the duration of our work was from December 3, 2003 to March 13, 2004.

1. Method of Conservation Work

(1) Consolidation

Before cleaning, we proceeded with consolidation of the detachments of plaster layer to avoid its further exfoliation. At first, the edge of the plaster layer was filled with *muna* to fix it and to stop the leaking of consolidants. *Muna* is consisted of gypsum mixed with fine and coarse grains of sand from the vicinity of the tomb, along with a small proportion of *hib*[1].

According to the condition survey, the detachment areas were carefully checked by softly tapping the surface of plaster to identify the extent and depth of the detachment not visible to the eyes. When a hollow sound resulted, consolidation was executed.

Prior to consolidation, drops of 50% alcohol in water were applied for better penetration of adhesives. The detachments of the plaster layer were consolidated to the bedrock by injecting acrylic resin (Primal AC33) and *muna* (Fig.1). Depending on the condition between plaster and bedrock, different percents of acrylic resin, or a mixture of acrylic resin and *muna* were used. For instance, in case of a large space between the rock and the plaster, pure acrylic emulsion or even filling (gypsum, very fine grains of sand and acrylic emulsion diluted with water) was injected. For the small part, solution of 50% acrylic emulsion in water was applied.

These materials were injected by different sizes of syringe through the cracks or lacunas of depth, and in some cases, through small injection holes which allow us to fix large amounts of detached area. Finally, lacunas were filled with *muna* (Fig.2), and this filling was lowered below the level of the painted layer and brushed to give a natural appearance.

(2) Cleaning

The main problem of disturbance and damage to the wall paintings was bat excrement and bacteria. The special solvents called *cleaning solution* was applied thorough tissues on the wall to absorb a lot of bat excrement from the wall (Fig.3). This *cleaning solution* is mixture of four solvents (2000cc distilled water, 500cc ethanol, 100cc acetone, 80cc ammonia) chosen by our chief conservator. After removing the tissues, we could remove softened residua of the dirt by using a scalpel (Fig.4). As the next step of the cleaning, we applied *anti bacterial solution* also thorough the tissues in order to suppress the reactivation of the bacteria. This *anti bacterial solution* is consisted of the *cleaning solution* and germicides.

In addition, a small amount of hydrogen peroxide water was used, especially on the heavy concentration of bacteria. On the whitish part caused by the remains of dirt, we cleaned it using a brush and sponge, or *anti bacterial solution* was applied by cotton with bamboo stick (Fig.5).

Due to moisture, a brown stain remained on the surface of the wall. In order to remove this, a special clay brought from Italy called *sepiolite*, mixed with water, was applied to the stain for removing the residua of the dirt (Fig.6). It was removed after being completely dried.

(3) Final presentation

Where blue and green pigments and some other weak pigments are present, application of 3-6% Paraloid B72 in thinner was executed for cohesion of seriously powdering pigments. Just after its application it was rubbed off with a sponge in order to prevent a glossy surface.

As the very last presentation procedure, in order to balance the tonality of the cleaned surface, the *dirty water*[2)] was applied with fine brush on the abrasions of the surfaces. The tone imbalance occurring between the whitish part caused by the abrasions could be veiled, and it will appear to have the same tonality as the surrounding *patina* of the ancient paintings.

2. Details of the Condition of the Walls before and after Intervention

(1) Room J south wall, eastern part

The first and second hours of long version of the *Book of Amduat*: (Figs.7, 8)

The lower edges of the paintings were already lost by exfoliation of the plaster. The bat excrement was concentrated on the upper part of the wall, and heavy concentrations of bacteria appeared in some places. In addition, there were some darker spots caused by dirt.

After cleaning, concretion of excrement and spots of bacteria were removed, and the text and figures of the *Book of Amduat* became clear. Previous intervention of consolidation by *muna* was removed and new filling was made.

(2) Room J south wall, central part

The first to twelfth hours of short version of the *Book of Amduat*: (Figs.9, 10)

The bat excrement was concentrated on upper part of the wall, especially on the east side, and the bacteria spots could be observed all over the surface. Darker spots were observed around the wall as well.

After cleaning, the text of the *Book of Amduat* became clear, and some evidence to reconstruct the process of the paintings, such as some drafts of the hieroglyphs and some mistakes and revisions by ancient artists, were uncovered.

(3) Room J west wall

The third to sixth hours of long version of the *Book of Amduat*: (Figs.11-14)

The condition was similar to the south wall, but the pigments of this wall, with grayish paints as background, seemed to be fragile. Middle and lower parts of this wall were already lost. The initial consolidation and cleaning in this part was started by Egyptian conservators and trainees, and the work was continued by us.

After cleaning, the text and figures of the third to sixth hours of the *Book of Amduat* became clear. The background color in the upper frieze seems to differ from the southern part to the northern part: the southern part, near the doorway to the room I, seems to be more yellow and the northern part seems to be reddish.

3. Conclusion

During three and half months of work, we have acquired more knowledge and experience regarding the conservation of ancient Egyptian paintings, since we could deal with different kind of situations of wall paintings, especially in room J. In addition, from close observation of the wall through the conservation works, we obtained new information about the technique and process of wall paintings in the royal tomb of Amenophis III. Such information as we have so far should be studied in detail to understand the art historical significance of the royal tomb of Amenophis III.

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1) *Hib* is very fine natural mixture of clay and lime. (cf. A. Lucas and J.R. Harris, *Ancient Egyptian Material and Industries*, London 1962, p.76; S. Rickerby, "Original Painting Techniques and Material Used in the Tomb of Nefertari" in M.A.Corzo and M.Afshar eds., *Art and Eternity*, Singapore 1993, p.45.)

2) *Dirty Water* is a technical term for the balancing water to give *patina,* obtained by pre-washed heart powder (brown Nile clay), diluted in water. (For more explanation, please refer to the report by G. Capriotti in this volume.)

Fig.1 Injection by syringe

Fig.2 Filling the lacunae

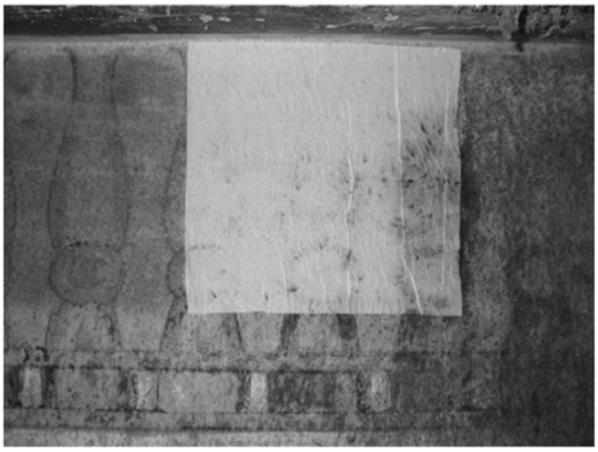

Fig.3 Absorption of dirt through tissue

Fig.4 Removal of residua with scalpel

Fig.5 Application of *anti bacterial solution* with cotton

Fig.6 Removal of residua by *sepiolite*

Fig.7 Room J south wall before conservation (1)

Fig.8 Room J south wall after conservation (1)

Fig.9 Room J south wall before conservation (2)

Fig.10 Room J south wall after conservation (2)

Fig.11 Room J west wall before conservation (1)

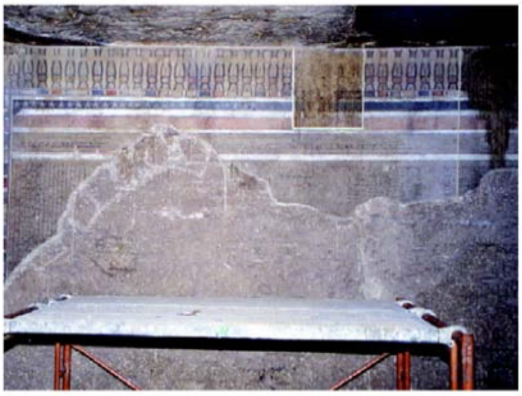

Fig.12 Room J west wall after conservation (1)

Fig.13 Room J west wall before conservation (2)

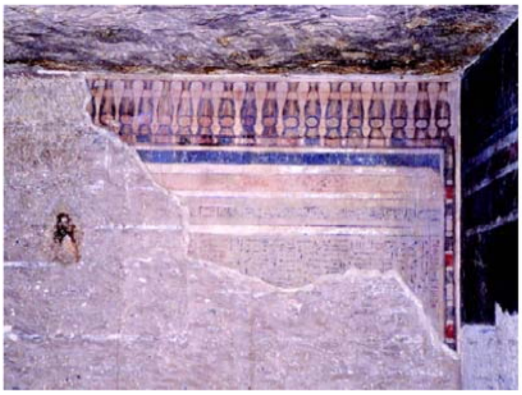

Fig.14 Room J west wall after conservation (2)

(2) A Report on the Tentative Employment of Ultraviolet Fluorescence Photography and Infrared Photography for the Conservation Work

Eriko NAKAU

Conservator, Tokyo

Introduction

In this season of the conservation project, ultraviolet fluorescence photography and infrared photography were performed in addition to the conservation work. Following is the material and procedures conducted in this tentative employment for the conservation work in rooms D, E, I, and J.

1. Ultraviolet fluorescence photography (Figs.1-4)

Film: Fuji SUPERIA iso1600 (35 mm)
Filter: Kodak 2-E
Illumination: Portable black lamp
Place of photography: Room E
Since the organic matter contained in dirt is fluorescent, the ultraviolet fluorescence photography was performed tentatively in order to record the state of the surface of wall before cleaning. The ultraviolet fluorescence photograph was also effective in distinguishing the dirt from a dark color because of the above-mentioned characteristic of the dirt. Furthermore, it was observed that wax had been adhered to the south wall at regular intervals, and also that the white color, used in room E, was itself fluorescent.

2. Infrared photography

Film: Kodak high speed infrared (35 mm)
Filter: Kenko R64
Illumination: Strobe
Place of photography: Room D, E, I, and J
The infrared photography was performed tentatively in order to record some graffiti less visible to the naked eye, and to compare the difference in use of colors between room E and room I. Furthermore, the infrared photograph was taken in order to investigate the inscription under the white glazing layer in room J.

Fig.1 Organic material contained in dirt

Fig.2 Organic material and wax

Fig.3 White pigment fluorescent

Fig.4 White pigment fluorescent

8. Photographic Documentation

A Report on the Photographic Documentation during the Second Phase

Tsuyoshi SASAOKA

Photographer, Sasaoka Photo Laboratory, Tokyo

Introduction

From February 23 to March 15, 2004, I have participated in shooting photographs in the second long-term season of the project for conservation of the wall paintings in the royal tomb of Amenophis III, started in December, 2003. The following gives the purpose and the method of the photographic recording.

1. Purpose

The purpose of taking pictures in this season was to record the condition of the wall paintings that were cleaned and conserved. We can realize how the wall paintings regained their beauty by comparing a picture taken before conservation last season with a picture taken this season. Close shots of the important hieroglyphics and figures which became clear during conservation work were taken to show the details.

2. Method

During the conservation work this season, the wall paintings in rooms E and J were cleaned. The photographic documentation work was carried out in these rooms. In each room, the photographs were taken by per shot every direction. Room J was photographed in several sections because the wall paintings were too big, and the photographic distance was not great enough because of obstacles such as pillars. The camera was set up on scaffolding when the shot was taken near the cover of the sarcophagus, since the height of the tripod was not enough for setting the camera in front of the wall paintings. I always set a level on the camera to keep the horizontality. The distance was kept uniformly from the wall paintings to the camera when a wall was divided into several shots.

I used a medium format camera (6×7)[1)] and a SLR camera (135)[2)] simultaneously. During this season, I used a SLR digital camera[3)] that carries a 6-megapixels CCD sensor. We have recognized superiority of digital photographs that allow us to construct the photographic database easily on a personal computer, and photographs can be shared among the persons in connection with this project. In the future we can use these on a web site.

As for the lighting equipment, 2, 4 or 6 300w tungsten photo bulbs were used. Therefore, color positive films for the tungsten light[4)] were used. I took photographs by color negative films[5)] for prints by a medium format camera as well. A Kodak Color Separation Guide was put in each shot in order to reproduce the correct color in printing, and a scale was put in each picture to know the exact size of the wall paintings. The same procedure was used for the shooting with the digital camera. The digital photographs were taken by raw image format, and the image can be managed and processed on exclusive software[6] in a personal computer.

3. Conclusion

I participated in this project both last and this season, taking photographs of the conditions of the wall paintings, and it was great pleasure to witness the progress of the work and to be able to record the monument. I am pleased if these photographs contribute to future research in Egyptology.

At last, I would like to express my thanks to Prof. Dr. Sakuji Yoshimura, the general director of this project and to UNESCO, who gave me an opportunity to participate in the work for the conservation of the royal tomb of Amenophis III, which is a precious heritage of the human race. I also thank the Italian and Egyptian conservators. Special thanks go to Ms. Akiko Nishisaka, Mr. Kunihiro Seto, Ms. Eriko Nakau, and Mr. Kazumitsu Takahashi. They lived with me at Luxor and they gave me a great deal of help with my photography.

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1) Mamiya RZ 67 Camera
2) Nikon F100 Camera
3) Nikon D100 Digital Camera
4) Kodak EPY Film (6×7 format), Kodak EPT Film (135 format)
5) Fuji REALA ACE Film (6×7 format)
6) Nikon Capture ver.3

9. Conclusion

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As regards the progress of the wall paintings conservation work and also as an attempt for international collaboration for saving the monument, the second long-term campaign was very successful. The intensive work of wall paintings conservation during these three and half months involved Italian, Egyptian, and Japanese conservators and trainees. Altogether fourteen conservators worked at the same time. This was made possible by the implementation of the sufficient ventilation system in the tomb and good management of the work by our chief conservator. Another factor for such a fruitful season was the cooperation by the SCA for dispatching the same conservators who had already participated in the first phase. It will be beneficial for the project if they could continue to join our mission in the next phases. Another achievement of this season was the training of young local conservators, and it is hoped that the region will benefit from their experience in the future.

By the end of this campaign, cleaning of the walls and pillars in room E, I, and J was almost completed. As a result, most of the walls were restored to bright polychrome colors, articulating the outstanding technique. Parallels are scarce, even in the prestigious tombs from the prosperous reign of this king. The contribution to Egyptology was immediate, revealing some unrecorded inscriptions which were previusly illegible. The work of fixation of the plaster layer on the walls was also completed this season in room E and J.

Nevertheless, it is obvious that more seasons are needed to complete the final rehabilitation and preservation of the site. To conclude this paper, we would like to point out some of the recommendations for future works. (1) Regarding the stabilization of the cracks in walls and pillars in room F, J, and Je (Figs.1, 2), urgent work should be executed for fixing and stabilizing the cracks in the tomb in accordance with the conclusions of the SCA, Italian and Japanese experts. (2)The conservation and display of the red-granite sarcophagus lid is the next priority (Fig.3). Display should be planned so that the lid's upper and lower surface, both inscribed with texts and elaborate carvings of figures, can be appreciated. (3) For the wall paintings conservation, cleaning and consolidation in room Je and ceilings (Fig.4) are necessary. Even cleaning the simple rock surface surrounding the painted area is important to beautify the tomb and to avoid future affects to the cleaned painted surfaces. (4) It is important to plan and install appropriate facilities to protect the site after the conservation work. The facilities, such as wooden floors, handrails, electric cables and lighting inside the tomb, should be planned so that these will not affect the original masonry and painted surface. As the expectation of the SCA is to open the site to the tourists, the continuation of environmental monitoring and adequate ventilation system must be planned, to avoid the dangerous effects of unrestricted visitors.

Fig.1 The crack in the wall between room J and Jd

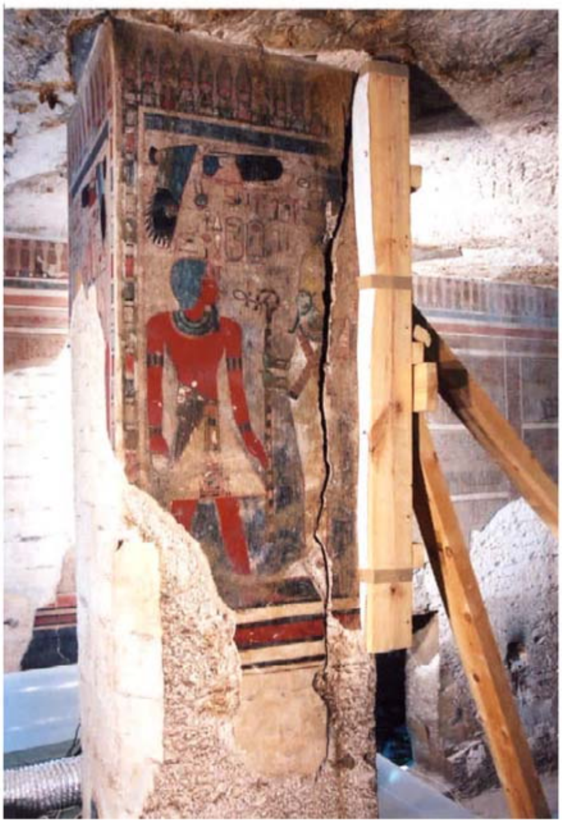

Fig.2 The situation of pillar 3 in room J

Fig.3 Red-granite sarcophagus lid

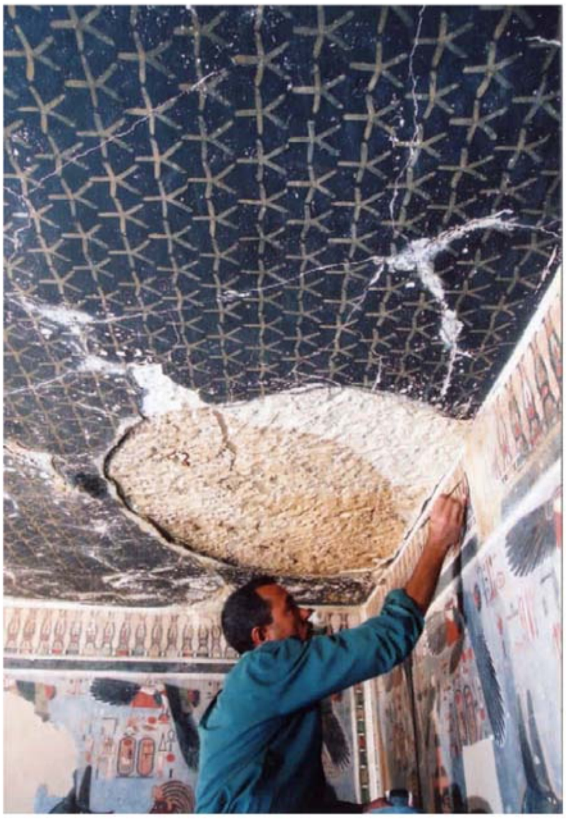

Fig.4 The ceiling, which needs to be consolidated

V. ADMINISTRATIVE REPORT

Tatsundo YOSHIMURA
Chief Administrative Manager,
Institute of Egyptology, Cairo Office, Waseda University

I would like to start my report by thanking all our dear participants and dear members in this remarkable project. I would like personally to thank Ms. Mounira Baccar, our project manager, for the continuous support and sincere efforts to facilitate all the administration and financial problems we had with the financial department at UNESCO. Without her participation the project would not have progressed as expected.

In the first season, the project faced several problems that could have affected our course of works. First, the shortage of time: we had a very short time to purchase all the equipment and material. Mr. Kawai, our field director, and I had to run between the retail shops to purchase the equipment. It was a bit difficult because of the time shortage. Then we had to pack all the material carefully and send it to Luxor before the arrival of the members. Second, there was the issue of security permissions. We had some problems in this area; specifically that we had to change two Italian conservators with a new Italian one. Also, three Japanese members could not work with us due to the delay of the project for three months. We had to submit new applications for these members. The Department of Security in the SCA needs three months prior to the work of any foreigner in Egypt, according to the regulations of the SCA. Thanks to the SCA, we were able to issue the security for the replaced Italian and Japanese members. Third, there was the issue of the Egyptian conservators, since the original start date was supposed to be in October, 2002. We contacted Dr. Ahmad Shwaib, Director of the Department of the Conservation of the SCA, to prepare several conservators to join our project. We met and negotiated with them every detail concerning their participation. We reached a mutual agreement, but because the start was delayed for three months all of them had to join other projects. So we were left with the conservators who were not occupied with other projects. Dr. Giorgio Capriotti, our chief conservators had to expend more effort to explain to the new conservators what to do, and how to do it. Fourth, I would like to thank Ms. Baccar and the UNESCO's Cairo office for delivering the budget of the local workers in a very short time. Without this, we could have faced financial problems. As recommendations for the second campaign, several administrative issues were presented at the termination of the first phase: 1) To start the next campaign in November 2003 and finish it before the end of March 2004, because the weather gets very hot in Luxor by mid March. 2) To submit all the applications for our members and participants before the end of July 2003, because the Department of Security in the SCA requires three months in advanced to issue the security permissions. 3) To do our best to have the same team of Egyptian conservators. 4) We would kindly like to ask Ms. Baccar to do her best to pass our new budgetary plan for the coming season, because the time plan is dependent on how fast the budget is passed through the bureaucratic procedures.

In the second season we did not face the same problems as the first campaign. The only problem we faced was the delay of the Egyptian customs for releasing the conservation material coming from Rome. The delay was about 15 days. Thanks to our chief conservator Dr. Capriotti and his good connection with other foreign missions, he was able to manage this delay by asking other foreign missions to lend us conservation material, which we returned when we received ours.

I would like to thank my team, Mr. Ashry, our administrative executive, and Mr. Yussef, our financial controller, for their dedication for this project. Finally, I would like to thank every participant in this project. Thank you all.

VI. END NOTES

Sakuji YOSHIMURA
Professor, School of Human Sciences, Waseda University

It is our pleasure to have finished the first and second phase of the conservation project of the wall paintings in the tomb of Amenophis III, with the presence of UNESCO, the Supreme Council of Antiquities, Ministry of Culture, Arab Republic of Egypt, and Institute of Egyptology, Waseda University, Japan.

Before writing about this project, I would like to introduce the history of the field work in Egypt by Waseda University. In 1966 we began working in Egypt. Subsequently, our first full-scale excavation was carried out at Malkata south. In the course of excavations, we discovered mud-brick architecture at a mound called "Kom al-Samak". From the stamped cartouche on the bricks, it turned out that the building was made by Amenophis III, the owner of the tomb which we are now conserving. It is notable that we uncovered steps painted with the images of different ethnicities such as Syrian, Nubian, and others. The excavations have also yielded thousands of fragments of the wall paintings that once decorated the walls of the building. Then we started work in the palace of Amenophis III and in the nobles' tombs from the same period, to make comparisons with the wall paintings from "Kom al-Samak". Thanks to the kind approval of the former Egyptian Anitquities Organization (EAO), now the Supreme Council of Antiquities (SCA), we were granted permission to work at the royal tomb of Amenophis III in 1989. The work included mapping, excavation, documentation, epigraphic study, and electromagnetic survey. This project is a logical follow-up to our previous work on the monuments from the time of Amenophis III. The tomb has been known for many years, since Howard Carter's work in 1915. A number of objects were uncovered during the excavations inside and outside of the tomb. At the same time, it was realized that urgent conservation work is needed to protect the tomb to prevent further deterioration and collapse of the wall paintings in the tomb.

Now we are very pleased to conduct the real conservation project for this precious treasure of humankind, with the prestigious support of UNESCO. It is notable that the project is being carried out by a staff of difference nationalities in close cooperation with the SCA. Here I would like to express deep gratitude to Dr. Zahi Hawass, Secretary General of the SCA, for granting the permission to carry out this important project. I am grateful to Mr. Sabri Abd al-Aziz, Dr. Ahmad Shwaib, Dr. Samia al-Mallah, Dr. Holeil Ghaly, Mr. Mohammad Aasem, Mr. Ali Asfar, Mr. Ibrahim Soliman and other staff of the SCA for their kind cooperation. And we should not forget the name of Dr. Giorgio Capriotti,

who is the chief conservator of this project.

Finally, I would like to express our deep gratitude to UNESCO, in particular to our project manager, Ms. Mounira Baccar, for her unfailing work at UNESCO's headquarters in Paris. We are also grateful to Japan's Ministry of Foreign Affairs for its kind support and understanding.

In order to plan the third and fourth phases, it is necessary to discuss in detail the working process, results and the work that was not completed during the first and second phases. Based on these discussions, we would like to make a new plan immediately after publishing this report.

The further aid and support from the Division of Cultural Heritage of UNESCO and Japan Trust Fund and cooperation from the SCA will be highly appreciated in every aspect.

VII. APPENDIX

Agenda of the Tripartite Meetings

Brief Diary of the Work

JAPAN TRUST FUND FOR CULTURAL HERITAGE
EGYPT
UNESCO

PROJECT FOR THE CONSERVATION OF THE WALL PAINTINGS OF THE ROYAL TOMB OF AMENOPHIS III IN THE WESTERN VALLEY OF THE KINGS

(536EGY4070)

Tripartite Meeting for First Long-term
29 April – 30 April 2003

Tuesday 29 April
Visit and discussion in the tomb – West Bank

Wednesday 30 April
9:00-11: 00 Meeting at Mercure Hotel (meeting room) – East Bank

Chair: Jiro Kondo
Welcoming address by the Representative of UNESCO: Mounira Baccar
Welcoming address by the Representative of SCA: Sabri Abd al-Aziz, Holeil Ghaly
Welcoming address by the Project Director: Sakuji Yoshimura

Session 1: Review and evaluation of the work of this ongoing campaign:

- Report on the ongoing campaign by Nozomu Kawai
- Report on the conservation work by Giorgio Capriotti
- Administrative issues by Tatsundo Yoshimura
- Remarks by Jiro Kondo
- Comments by Ahmad Shwaib
- Discussion by participants

Session 2: Plan and proposal for the next campaign

- Plan for the next campaign by Nozomu Kawai
- Issues for the next campaign by Sakuji Yoshimura
- Plan of the conservation work for the next campaign by Giorgio Capriotti
- Administrative issues for the next campaign by Tatsundo Yoshimura
- Comments for the next campaign by Sabri Abd al-Aziz
- Discussion by participants
- Concluding Remarks by Mounira Baccar

JAPAN TRUST FUND FOR CULTURAL HERITAGE
EGYPT
UNESCO

PROJECT FOR THE CONSERVATION OF THE WALL PAINTINGS OF THE ROYAL TOMB OF AMENOPHIS III IN THE WESTERN VALLEY OF THE KINGS

(536EGY4070)

Tripartite Meeting for Second Long-term
6th March 2004

Saturday 6 March

9:00-11:00 Visit and discussion in the tomb – West Bank

12:00-14: 00 Meeting at Mercure Hotel (meeting room) – East Bank

Chair: Jiro Kondo
Welcoming address by UNESCO Representatives: Gadi Mgomezulu, Mounira Baccar
Welcoming address by the Representative of SCA: Sabri Abd al-Aziz, Holeil Ghaly
Welcoming address by the Project Director: Sakuji Yoshimura

Session 1: Review and evaluation of the work of this ongoing campaign:

- Report on the ongoing campaign by Akiko Nishisaka
- Report on the conservation work by Giorgio Capriotti
- Administrative issues by Tatsundo Yoshimura
- Remarks by Jiro Kondo
- Comments by Ahmad Shwaib
- Discussion by participants

Session 2: Plan and proposal for the next campaign

- Recommendations and remarks by Sakuji Yoshimura
- Recommendations and remarks by Giorgio Capriotti
- Recommendations and remarks by Sabri Abd al-Aziz
- Open discussion by participants
- Comments by Gadi Mgomezulu, Mounira Baccar

Brief Diary of the Work

The First Phase:

December 27, 2002 - January 12, 2003
· Meeting with Prof. Dr. S. Yoshimura, Mr. T. Yoshimura, Mr. N. Kawai and Mr. M. Ashry for the plan of the project
· Purchasing materials and equipment
· Transporting materials and equipment from Cairo to Luxor
· Arrival of the members in Luxor
· Preparation of the work in Luxor

January 13 - 27
· Meeting with local headquarters of SCA
· Cleaning of the tomb, setting up anti-dust sheets in the tomb
· Setting up the lighting system in the tomb
· Excavation in room E (shaft chamber) to set up scaffoldings on its floor
· Setting up wooden staircase in the tomb
· Setting up ventilation system and generators
· Setting up the scaffoldings and floor in room E
· Starting conservation works under the direction of Dr. G. Capriotti
Italians: room I, Egyptians and Japanese: room J, pillars
· Visit of Dr. Zahi Hawass, Secretary General of SCA and his delegation
· Photographic documentation of the work

January 28 - February 10
· The work by Ms. H. Igarashi and Mr. T. Muramatsu for the working environment of the tomb
· Photographic documentation of the wall paintings by Mr. T. Sasaoka
· Visit of Dr. Ahmad Shwaib, Director of the Department of the Conservation of SCA
· Conservation works
· Photographic documentation of the work

February 15 - 27
· Research on the conservation of the sites by Ass. Prof. S. Hasegawa
· Photographic documentation of the wall paintings by Mr. T. Sasaoka
· Microbiological investigation of the tomb by Dr. H. Arai
· Second Visit of Dr. Ahmad Shwaib and the visit of Mr. Mustafa Abd al-Gadel, Director of Conservation at Giza area
· Conservation works
· Photographic documentation of the work

March 1 - 6
· X-ray florescence and diffraction analyses and microscopic observations of pigments and plaster by Prof. Dr. M. Uda and Mr. M. Tamada
· Arrival of two Egyptian conservation assistants, Mr. Mohammad Assas and Mr. Ahmad Shwaib, and start of their work on the north-west corner of the wall in room J
· Conservation works
· Photographic documentation of the work

March 8 - 13
· Works and Observations by Ass. Prof. J. Kondo
· Continuation of X-ray analyses of pigments and plaster
· Observation of the pigments on the wall paintings
· Conservation works
· Photographic documentation of the work

March 15 - 20
· Initial work on the rock mechanics by civil engineers Prof. Dr. Ö. Aydan and Prof. Dr. H. Tano
· Observation of the wall paintings
· Conservation works
· Photographic documentation of the work

March 22 - 27
· Observation and study of the iconography of the wall paintings
· Conservation works
· Photographic documentation of the work

March 29 - April 3
· Arrival of Prof. Dr. S. Yoshimura and his supervision of the work
· Conservation works
· Observation and study of the wall paintings
· Photographic documentation of the work

April 5 - 10
· Arrival of Dr. E. Nakau, a Japanese assistant conservator
· Arrival of Mr. Mustafa Osman and Mr. Sayed Ataya, trainees from Cairo
· Conservation work: starting the south wall by Japanese and north wall by Egyptian
· Documentation and observation of the cleaned wall paintings
· Photographic documentation of the work

April 12 - 17
· Completion of the work in room I by Ms. C. Tocci
· Conservation work concentrating on the walls in room J.
· Observation and evaluation of the wall paintings in room I after completion
· Photographic documentation of the work

April 19 - 24
· Conservation work concentrating on the walls in room J
· Observation and documentation on the wall paintings
· Photographic documentation of the work

April 26 - May 1
· Arrival of Ms. Mounira Baccar, Prof. Dr. S. Yoshimura, Ass. Prof. J. Kondo
· Tripartite meetings at the tomb and Hotel Mercure in Luxor (April 29-30)
· Arrival of Prof. Dr. M. Hamada, Prof. Dr. Ö. Aydan, Prof. Dr. H. Tano, civil engineers
· Arrival of Ms. M. Ohno, wall paintings specialist
· In site discussion of the work by experts during the meetings
· Conservation work concentrating on the walls in room J
· Observation and documentation on the wall paintings
· Photographic documentation of wall paintings by Mr. T. Sasaoka
· Photographic documentation of the work

May 3 - 15
· Visit of Mr. Sabri Abd al-Aziz, Mr. Ayman of the Ministry of Culture and an environmental expert from UNESCO
· Conservation work concentrating on the walls in room J
· Observation and documentation of the wall paintings
· Photographic campaign by Mr. T. Sasaoka
· Photographic documentation of the work

May 9 - 15
· Final check of the conservation works under the supervision of Dr. G. Capriotti
· Conservation work concentrating on the walls in room J
· Observation and documentation on the wall paintings
· Photographic campaign by Mr. T. Sasaoka
· Photographic documentation of the work
· Cleaning of the tomb and its outside

The Second Phase:

December 1 - December 5
· Transporting materials and equipments from Cairo to Luxor
· Arrival of the members to Luxor
· Preparation of the work in Luxor
· Meeting with local headquarters of SCA

December 6 - December 22
· Setting up scaffoldings and lightings
· Resuming conservation works under the direction of Dr. G. Capriotti
· Receiving of two conservation trainees Mr. Mohammad al-Azam and Ms. Afaf Mohammad from the local office of SCA
· Reattachment of two fragments by Dr. G. Capriotti in room J north wall, which has been detached in the previous season
· Reattachment of a fragment which has been excavated at the bottom of the shaft, room E in the previous season

December 23 - January 18
· Arrival of Ass. Prof. J. Kondo and observations and evaluation of the conservation work
· Continuation of the work by Italian, Japanese, and Egyptian conservators
· Selecting plaster samples for scientific analyses in the laboratory

January 19 - February 9
· Continuation of the work by Italian, Japanese, and Egyptian conservators
· Setting up scaffoldings and lightings on the east wall of room J
· Starting cleaning work of the rock on the periphery of the wall paintings by local workers
· Planning for improvement of the staircase and the iron door to facilitate the entrance

February 10 - February 29
· Continuation of the work by Italian, Japanese, and Egyptian conservators
· Arrival of Ms. C. Caldi and conservation work in room E
· Arrival of Mr. T. Kikuchi and observation and egyptological study of the wall paintings
· Arrival of Prof. Dr. S. Yoshimua and supervision on the work
· Arrival of Prof. Dr. T. Nakagawa and observation and study of the environment and architecture
· Arrival of Mr. T. Sasaoka and photographic documentation of the walls

March 1 - March 5
· Continuation of the work by Italian, Japanese, and Egyptian Conservators
· Sending the samples for analyses in the laboratory of the SCA
· Environmental investigation by Prof. Dr. S. Tanabe
· Collecting data and maintenance of instruments for rock mechanical monitoring and temperature and humidity measurements and sending the data to the experts for assessment
· Continuation of photographic documentation of the cleaned walls by Mr. T. Sasaoka
· Modification of the iron door to widen the entrance in order to facilitate
· Dismantling the cement stairs at the entrance which was in bad condition, and installing new wooden staircase
· Installing the sledge in room B, D, G and building a temporary wooden support to pillar 3

March 6 - March 15
· Arrival of Representatives from UNESCO, Mr. Gadi Mgomezulu, Ms. Mounira Baccar
· Tripartite meeting at the tomb and Hotel Mercure in Luxor (March 6)
· Documentation and observation of the cleaned wall paintings by Prof. Dr. S. Yoshimura and Ass. Prof. J. Kondo
· Dismantling the scaffoldings in room J for photographic documentation
· Continuation of photographic documentation of the cleaned walls by Mr. T. Sasaoka
· Closing the site by blocking and sealing the entrance and departure of members