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INVESTIGATIONS OF MURAL PAINTINGS OF SETI I AND RAMESSES II TEMPLES AT ABYDOS – EGYPT

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Abstract

This paper provides technical studies on the mural paintings of two remarkable temples in Upper Egypt; namely the temples of Seti I and Ramesses II. It is the first one in a series of studies investigating these mural paintings and their deterioration aspects. Therefore, this study deals with the techniques used in performing these mural paintings, and their stratigraphical structure. Visual and optical examinations, scanning electron microscope attached to energy dispersive X-ray spectrometer (SEM/EDS), and X-ray diffraction (XRD) analyses are the methods used in this respect. These methods revealed that the murals of the two temples are characterized by their variable materials and techniques. Firstly, the ancient artist carved the scenes, in some cases, directly on the stone and used in this sunk reliefs, raised reliefs, and a combination of them, while in others he applied a rendering layer on these reliefs. Also, in one case he applied the rendering on the wall without reliefs. Secondly, he used the tempera technique in all the paintings. Thirdly, both of limestone and sandstone were used as a support for the murals. The mortar sample was mainly composed of gypsum, lime and sand. All the rendering samples contained gypsum and lime with different amounts of sand, while just two samples showed the presence of clay in addition to gypsum and lime that were arranged in layers in a unique form.

Keywords: *Abydos; Mural paintings; Stratigraphical structure; Optical microscopy; SEM/EDS; XRD*

Introduction

Abydos is named in Ancient Egyptian *Abdu*, Coptic *Ebot*, modern *al-'Arabat al-Madfuna*. It is an outstanding city, thus it is one of the most important archaeological sites of ancient Egypt [1]. It is located in the ancient Thinite nome (eighth Upper Egyptian nome) in southern Egypt, and it is about 15 kilometers western the River Nile [2] (Fig. 1). It has been reported that it has been linked anciently to the Nile by a canal [3]. Since it stands in Middle Egypt, Abydos is characterized by historical and geographical importance [4], and the necropolis area of the city was in use from the earliest times and benefited from royal patronage through out its history [5]. It was a cult center of the canine necropolis god Khentiamentiu whose temple existed here from very early times [6-7]. In the Fifth dynasty, his cult was gradually absorbed by that of Osiris, and the city soon became the focal point of the cult of Osiris [1]. There are two remaining temples located at Abydos: the temples of Seti I and Ramesses II (19^{th} Dynasty – New Kingdom).

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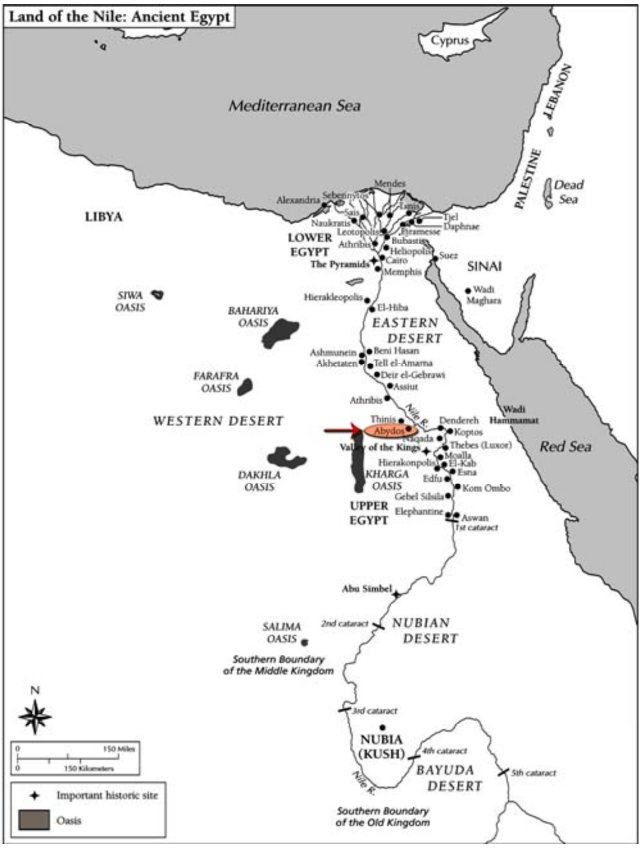
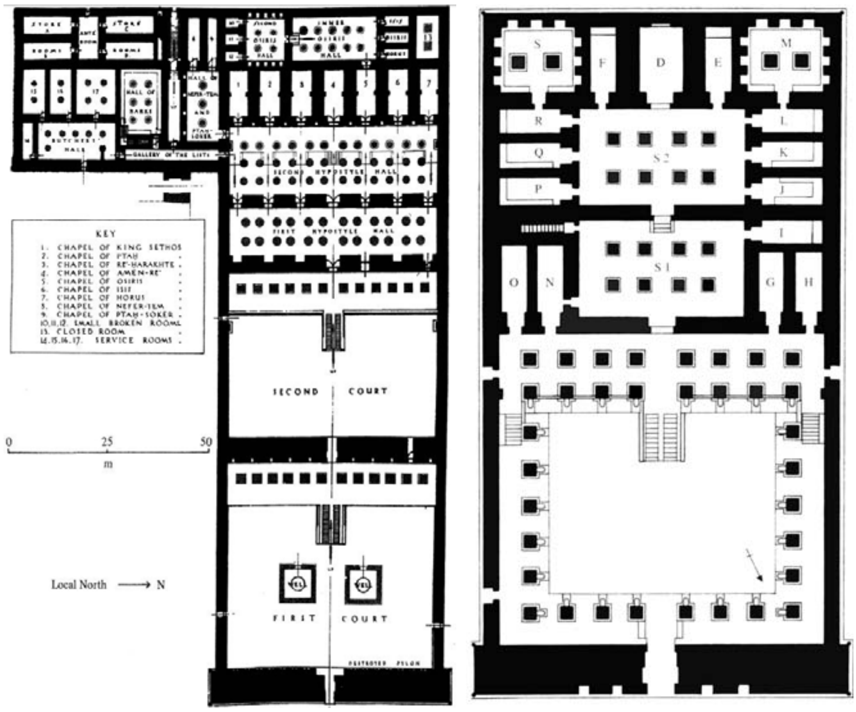


Fig. 1. Location of Abydos in Egypt. *(After Bunson, 2002)*

The temple of Seti I is the largest well-preserved building of the New Kingdom [2]. However, Seti I died before finishing the temple which was completed by his son Ramesses II. The plane of the temple is unique as it takes the shape of capital L (Fig. 2a), this may be due to the presence of an underground canal of water that made the foundation unsafe. Afterwards, this canal was enclosed by the Osireion. The technique of Seti's artists was unsurpassed; as his sculptures are in low relief and characterized by a wonderful delicacy of line and detail. While the style of art had changed in Ramesses II's time or whether Ramesses was employing inferior artists; but it is very noticeable that the work of Ramesses is inferior to that of Seti. Since the work is in hollow-relief, too deeply cut, and is entirely without the delicacy and finish of the earlier period [7].

Ramesses II built his small limestone temple about far 1/3 of a kilometer from the temple of Seti I to the northwest [6-8]. This temple is noted for its reliefs, which provide a description of the Battle of *KADESH* [5]. According to Murray [9], it seems that the artists who decorated the temple of Seti I worked for Ramesses too; if so the temple must date to the beginning of Ramesses' reign. The temple was dedicated to Osiris, thus his shrine is on the axis. However, other gods also had shrines but they are smaller than that of Osiris. The temple suffered from the hand of deliberate destroyer; as Mariette records that the old inhabitants of the villages nearest to the temple told him that Selim Pasha, the proprietor of the villages, systematically demolished the temple using the limestone blocks for building and for lime [9]. Unlike the temple of Seti I, the design of the temple of Ramesses II is more standard and is patterned after contemporary royal mortuary temples at Thebes [6] (Fig. 2b).



a **b**

Fig. 2. Plan of the temple of Seti I at Abydos: a -*After David, 1981*
and plan of the temple of Ramesses II at Abydos; b - *After Breitenstein,1999.*

Materials and methods

The collected samples were subjected to different analytical and examination methods, in order to get the right picture of the materials used in the murals of the two temples (Table 1). These methods are:

- Visual examination through field observation and using some magnifying glasses.
- Polarized Light Microscope (PLM): *MEIJI Techno ML 9000 microscope*
- Stereomicroscope: *BAUSH & LOMB* attached to illuminant device *Jenalux 20*
- SEM/EDS: *Jeol JSM 530* attached to EDS device *Oxford*
- XRD: *Phillips PW 1840*

Table 1. Codes of the collected samples.

Sample code	Location
S6B	One of the small six chapels in the temple of Seti I
ROB	The chapel O in the temple of Ramesses II
S6G	One of the small six chapels in the temple of Seti I
ROG	The chapel O in the temple of Ramesses II
S6R	One of the small six chapels in the temple of Seti I
RR1	The first hypostyle hall in the temple of Ramesses II
SY	The first court in the temple of Seti I
RKY	The chapel K in the temple of Ramesses II
RY	The first hypostyle hall in the temple of Ramesses II
S-Barques	Hall of Barques in the temple of Seti I

Results

Visual examination

Visual examination reveals that most of the two temples murals were carved on stone and the ancient artist used sunk relief and a combination of sunk/raised relief in the murals of façades which are exposed to sunlight, while he mostly used raised relief in the internal murals (Fig. 3). In some cases, the artist covered these reliefs with a thin layer of rendering before the application of paints, while in others he did not depend upon this layer; as he just applied a thin white layer on the reliefs to receive paints (Fig. 4A and B). However, the temple of Seti I contains some unfinished murals; as the artist carved the scene and applied the rendering layer without painting them (Fig. 4C). In addition, there are exceptions; as the artist performed his colored scenes directly on a rendering without carving. This clearly appears in the Hall of Barques in the temple of Seti I (Fig. 5).

Fig. 3. Combination of sunk/raised relief in the murals of façades:
A - Sunk relief and combination of sunk/raised relief in the temple of Seti I;
B - Sunk relief and combination of sunk/raised relief in the temple of Ramesses II;
C - Raised relief from one of the seven chapels in the temple of Seti I;
D - Raised relief from one of the small chapels in the temple of Ramesses II.

Fig. 4. Different preparation layers:
A - Flaking parts of the rendering layer from a mural painting in the temple of Seti I;
B - Paint layer over a white thin layer applied directly on the stone in the temple of Ramesses II;
C - Unfinished scene from the temple of Seti I.

Fig. 5. Direct painting without carvings:
A - Flaking parts of the rendering layer in the hall of Barques;
B - The paint layer over a rendering layer without carvings in the hall of Barques.

Optical examinations

In order to get a closer look at the stratigraphical structure used in the two temples; cross sections of different paint layer samples were made. Theses samples were embedded in *Canada balsam* and then were carefully polished. This, also, was accompanied by thin sections of the stone samples.

Limestone

The limestone sample of the temple of Seti I reveal homogeneous fine-grained structure under stereomicroscope (Fig. 6A). This is so clear in the prepared thin section, which shows fine grained calcite matrix (Fig. 7A, B and C). A scratch of the sample examined under plane-polarized light (PPL) reveals some euhedral rhombs of dolomite particles (Fig. 8).

Sandstone

A sandstone sample collected from the temple of Seti I is examined under stereo microscope and revealed that it is mainly composed of quartz particles; some of them are angular while others are sub-rounded. The particles differ in their size, and some are coated with red/yellow color (Fig. 6B). A thin section of the same sample illustrates sub-rounded and angular particles under PPL, and shows strong birefringent under cross polarized light (XPL) (Fig. 7D, E and F).

Mortar

The mortar sample, obtained from the temple of Seti I, under stereomicroscope shows fine particles of quartz and apparent porosity (Fig. 6C).

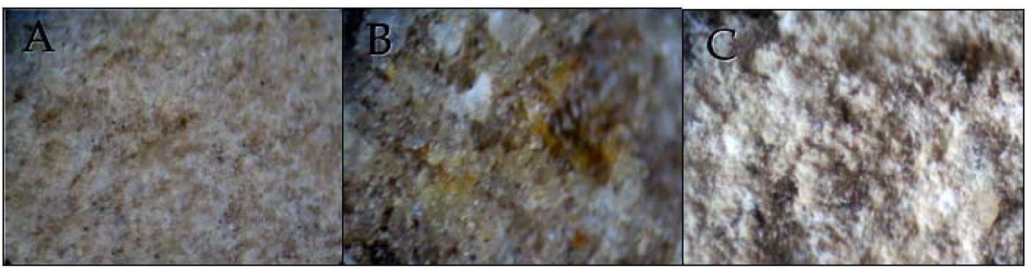


Fig. 6. Optical photomacrography of stone and mortar samples from the temple of Seti I under stereomicroscope:
A -Limestone sample shows homogeneous fine-grained structure (70X);
B -Sandstone sample shows particles of quartz differ in their size. In their shape, they are angular and sub-rounded. Some particles are coated with red/yellow color (70X);
C - Mortar sample shows the presence of fine quartz particles (70X).

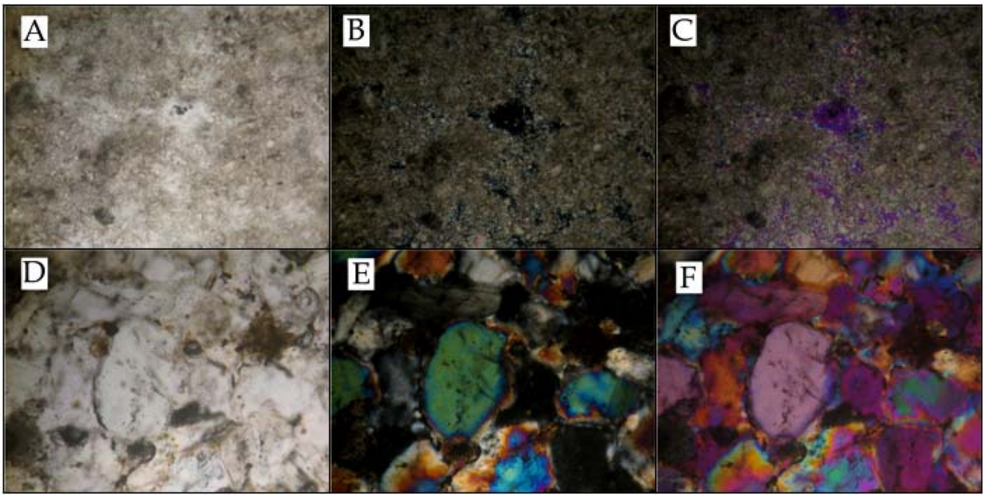


Fig. 7. Thin sections of limestone and sandstone samples from the temple of Seti I:
A - Limestone/PPL/100X: microcrystalline calcite matrix; B - Limestone/XPL/100X: The same field under crossed polars; C - Limestone/ The same field under the 1st order red compensator;D - Sandstone/PPL/100X: Sub-rounded/angular particles of quartz which differ in their size; E - Sandstone/XPL/100X: The same field under crossed polars shows strongly birefringent particles; F - Sandstone/ The same field under the 1st order red compensator.

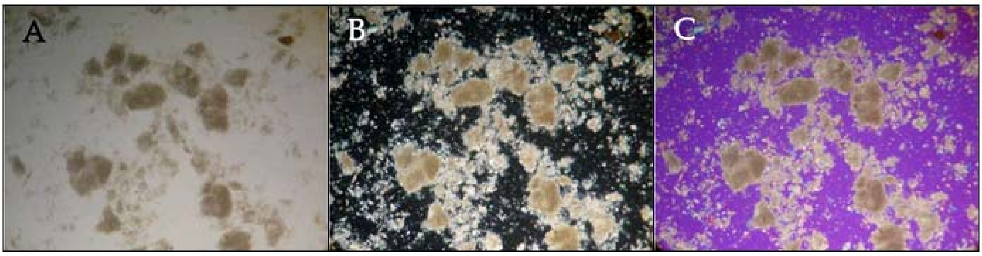


Fig. 8. Optical photomicrographs of limestone sample from the temple of Seti I:
A - PPL/100X: Fine Spherical grains of limestone with euhedral rhombs of dolomite particles;
B - XPL/100X: The same field under crossed polars;
C - The same field under the 1st order red compensator.

Rendering

The cross sections of paint layer samples provide information about the different types of rendering used in both temples (Figs. 9, 10 and 11). In addition to this, many samples were examined under stereomicroscope, and this concluded to that most of the samples are composed of coarse lime rendering, others are from fine lime rendering, and just two are characterized by multi-layers of lime and clay (Fig. 12).

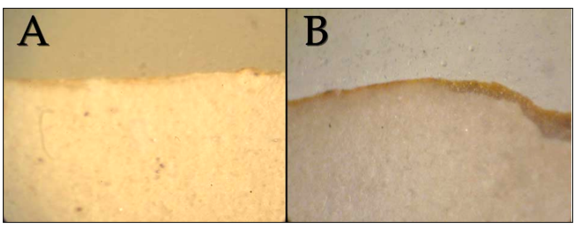


Fig. 9. Optical photomacrograph of polished cross sections samples:
A - Sample (SY) shows a thin yellow paint layer applied on a fine rendering (70X);
B - Sample (S-Barques) illustrates a yellow layer applied on a fine rendering (70X).

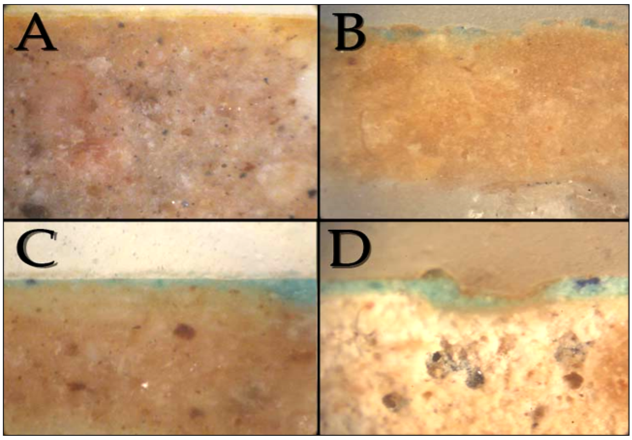


Fig. 10. Optical photomacrography of polished cross sections samples:
A - Sample (RKY) shows a thin yellow paint layer applied on a coarse rendering (30X);
B - Sample (ROB) reveals a faded blue layer applied on a coarse rendering (70X);
C - Sample (ROG) shows uneven pale green layer applied on a coarse rendering (70X);
D - Sample (S6G) illustrates a relatively thick green layer applied on a coarse rendering, also characterized by the presence of blue particles (70X).

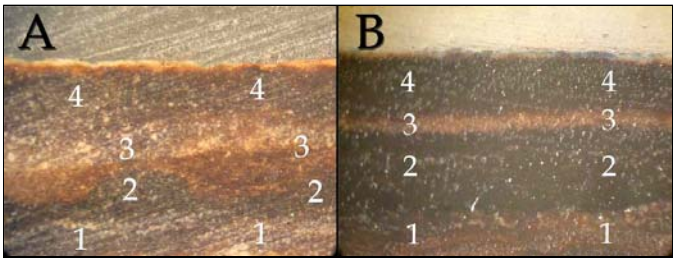


Fig. 11. Optical photomacrography of polished cross sections samples:
A - Sample (S6R) shows a degraded red paint layer applied on a thin white wash and a rendering composed of four distinguished layers of lime and clay (70X); B- Sample (S6B) shows a degraded blue paint layer applied on a thin white wash and a rendering composed of four distinguished layers of lime and clay (70X).

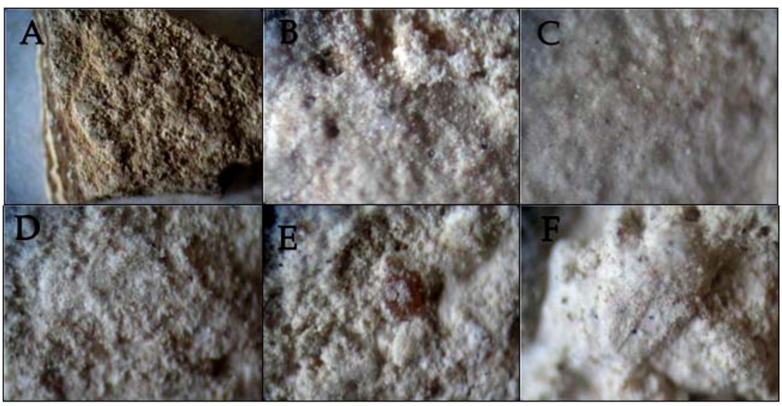


Fig. 12. Optical photomacrographs of different rendering layers from both temples under stereomicroscope:
A - Sample (S6B) shows coarse rendering composed of multi-layers of lime and clay (10X);
B - Sample (S6G) shows coarse rendering (70X); C - Sample (S-Barques) shows fine rendering (70X);
D - Sample (RR1) shows coarse rendering (70X); E - Sample (RKY) shows coarse rendering with remarkable large particle of quartz (70X); F - Sample (RY) shows coarse rendering (70X).

SEM/EDS and XRD analyses

Limestone

SEM micrographs show the fine grains of microcrystalline calcite (Fig. 13). EDS analysis (Tab. 2) shows Ca, O and C as the main elements with the presence of Al, Cl, K, Mg, Na, Si and S in small amounts. This is related to the outcomes of the XRD analysis which presents calcite as the major mineral, with minor amounts of magnesite, kaolinite, hellibrandite, and dolomite. In addition, thenardite, halite and aluminum silicate present in the sample as traces (Fig. 17A). Moreover, El-Gohary [10] reached, with the aid of the X-ray fluorescence (XRF) technique, that the limestone of the temple of Ramesses II contains mainly Ca then Te, Si and Mg with little amounts of Al and K. The XRD analysis reveals that the main mineral is calcite then dolomite, quartz, anhydrite and gypsum. Similar analytic studies were carried out on mural paintings in order to determine the chemical composition [11, 12] and microbiological attack [13, 14].

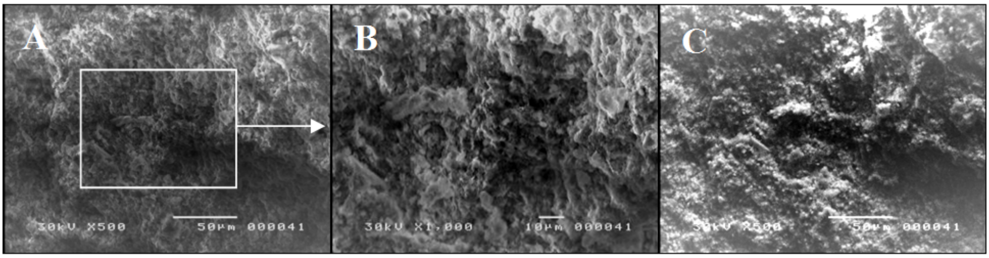


Fig. 13. SEM photomicrographs of limestone sample from the temple of Seti I:
A - Fine grains of microcrystalline calcite (500X);
B - The same field under 1000X magnification;
C - The same field under backscattered electrons (BSE) 500X.

Table 2. EDS microanalyses results of the collected samples

Sample no. / Elements	**Limestone**	**Sandstone**	**Mortar**	**S6B (rendering)**	**S-Barques (rendering)**	**RR1 (rendering)**	**RKY (rendering)**
Al	0.33	3.08	1.40	3.84	0.62	0.20	0.34
C	10.12	6.89	7.84	15.74	9.80	17.32	10.06
Ca	29.29	0.30	15.16	7.17	33.02	20.92	22.38
Cl	0.25	0.01	0.26	0.41	0.21	0.28	0.18
Cu	--	--	--	--	--	0.78	--
Fe	--	2.17	--	1.72	--	--	--
K	0.44	0.59	1.11	1.14	0.42	0.43	--
Mg	2.59	--	0.55	0.98	1.46	0.48	0.61
Na	0.16	0.14	1.90	1.29	0.10	0.04	0.01
O	52.86	57.30	55.74	53.51	51.08	47.49	53.75
P	--	--	--	0.96	0.30	--	--
S	0.07	0.07	11.63	5.23	0.25	11.01	11.50
Si	3.89	29.46	4.41	8.02	2.74	1.04	1.18

Sandstone

SEM photomicrograph shows variable sizes of quartz and under backscattered electrons (BSE), the particles have rough surface (Fig. 14). EDS analysis exhibits Si and O as the main elements, while Al, C, Ca, Cl, Fe, K, Na and S are presented in low different percentages. XRD analysis coincides with the former results, in which quartz is the major mineral, and traces of plagioclase, orthoclase, albite, calcite, microcline, hematite, thenardite and halite (Fig. 17 B). El-Gohary [10] analyzed sandstone samples from the temple of Ramesses II; XRF analysis shows that the main element is Si, then Fe and Ca, with few amounts of Al and Cl. In addition, XRD analysis shows that the main mineral is quartz and then calcite with the presence of kaolinite and albite in small quantities.

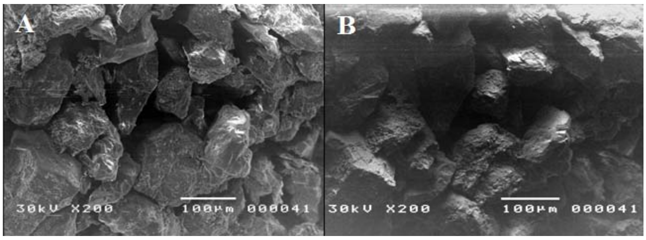


Fig. 14. SEM photomicrographs of sandstone sample from the temple of Seti I (200X):
A - Variable sizes of angular and sub-rounded particles of quartz;
B - The same field under BSE shows rough surface of quartz particles.

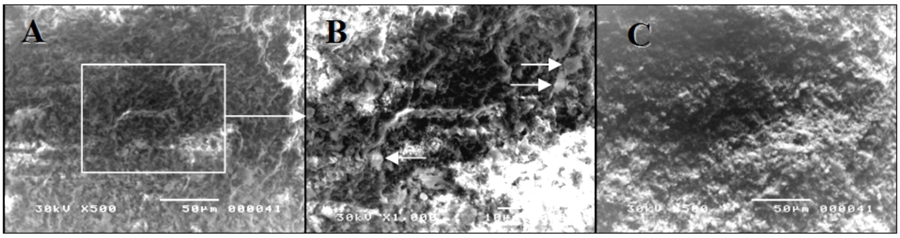


Fig. 15. SEM photomicrographs of mortar sample from the temple of Seti I:
A - Heterogeneous structure composed of fine grains (500X);
B - The same field under 1000X magnification shows the fine quartz particles;
C - The same field under BSE, 500X.

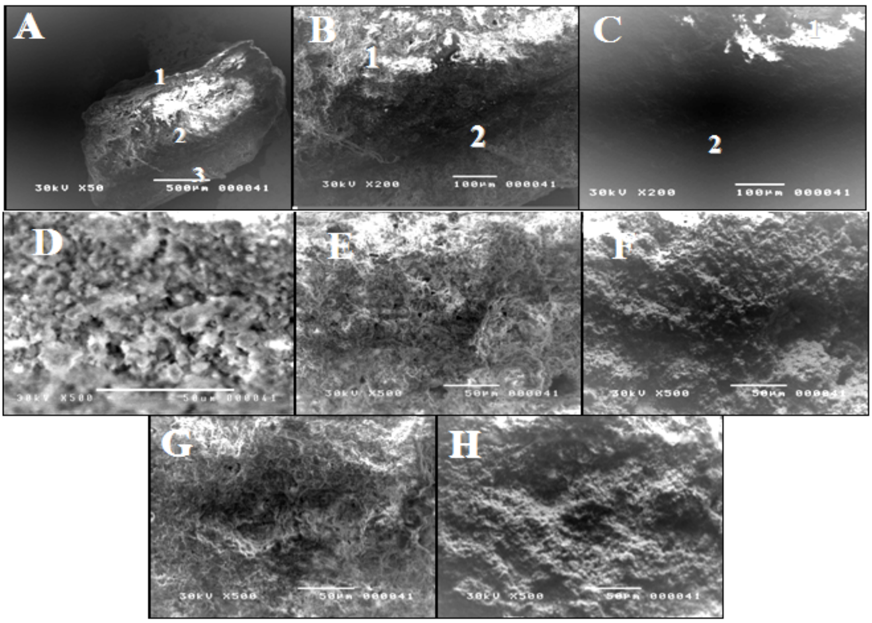


Fig. 16: SEM photomicrographs of different rendering samples from both temples:
A - Sample (S6R) shows three layers, *nos. 1 and 3* represent the clay layers and *no. 2* represents the lime layer (50X); B - The same field focuses on the boundary between two layers (200X); C - The same field, under BSE, focuses on the clay layer "*no. 2*" with the presence of the lime layer "*no. 1*" (200X); D - Sample (S-Barques) shows fine grains that form homogeneous surface (500X); E - Sample (RR1) shows a coarse rendering composed of fine grains (500X); F - The same field under BSE reveals cavities, which are distributed on the surface (500X); G - Sample (RKY) illustrates a coarse rendering (500X); H - The same field under BSE shows different cavities, which are distributed on the surface (500X).

Mortar

SEM photomicrograph shows heterogeneous structure composed of fine particles (Fig. 15). EDS analysis exhibits that C, Ca, O, S and Si are the main elements, with the presence of Al, Cl, K, Mg and Na in different low percentages. In line with this context, XRD analysis shows that gypsum, calcite and anhydrite are abundant in the sample, with traces of quartz, dolomite, kieserite and halite (Fig. 17C). Moreover, analyzed mortar sample from the temple of Seti I with XRD by Attia [15] shows that anhydrite was mainly detected with minor amounts of calcite and quartz.

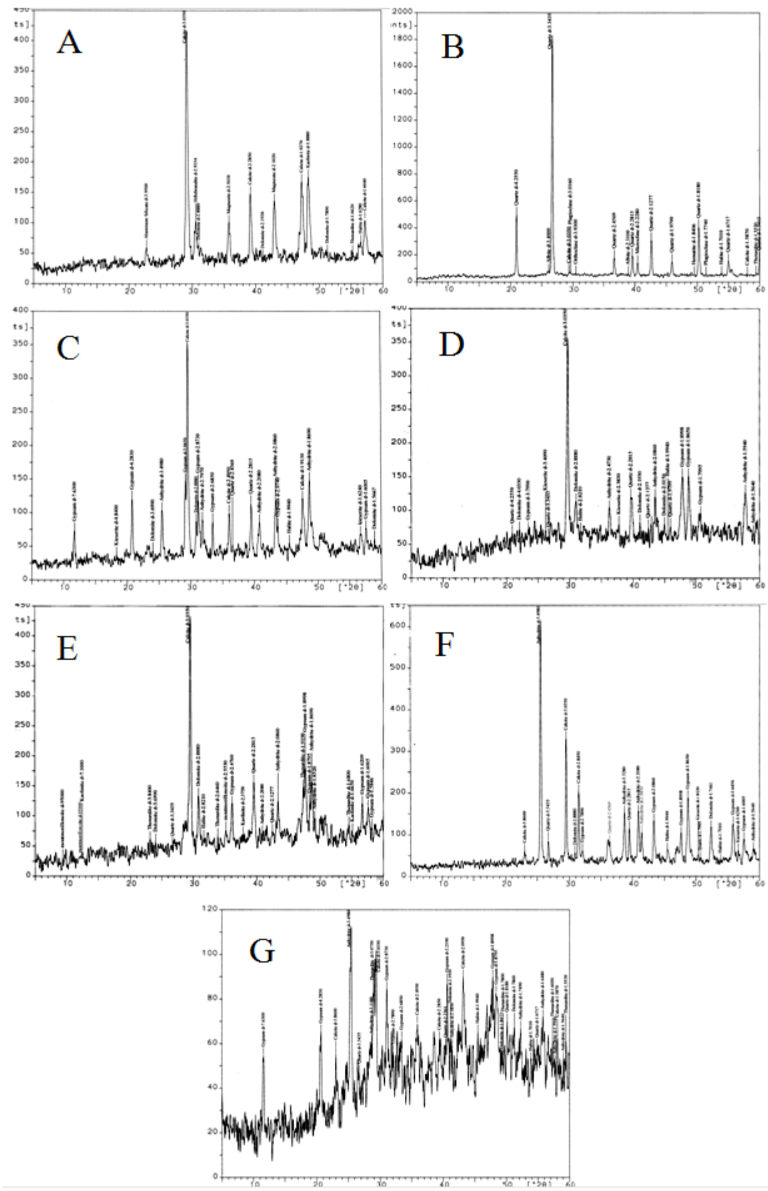


Fig. 17. XRD pattern of: A - limestone sample from the temple of Seti I; B - sandstone sample from the temple of Seti I; C - mortar sample from the temple of Seti I; D - the rendering sample (SY); E - the rendering sample (S6B); F - the rendering sample (RR1); G - the rendering sample (RKY).

Rendering

By the examination with SEM, sample (S6R) shows three alternative layers composed of clay and lime. Samples (RR1) and (RKY) illustrate coarse renderings, which are characterized by surfaces with variable cavities, while sample (S-Barques) reveals homogeneous surface composed of fine grains (Fig. 16). In this respect, EDS analyses exhibit the following results: sample (S6B) contains C, O, Ca, Al, Si and S as the main elements, with the contribution of Cl, Fe, K, Mg, Na, and P. Sample (S-Barques) contains mainly Ca, O, C and Si, in addition to Al, Cl, K, Mg, Na and P. In sample (RKY), O, Ca, C and S, are present in high levels respectively, and traces of Al, Cl, Mg, Na and Si. The coarse sample (RR1) contains Ca, O, C, S and Si with the presence of Al, Cl, Cu, K, Mg and Na in small percentages.

Different rendering samples were analyzed by XRD technique, and the results are as follows: in sample (SY), the major minerals are calcite and gypsum, the minors are anhydrite, dolomite and quartz, and the traces are kieserite and halite. In sample (S6B), the majors are gypsum and calcite, and the minors are anhydrite, quartz, dolomite, kaolinite and montmorillonite, and the traces are thenardite and halite. In sample (RR1), the major mineral is anhydrite, the minors are calcite, gypsum and quartz, and the traces are dolomite, kieserite and halite. Finally in sample (RKY), the majors are gypsum, calcite and anhydrite, the minor is quartz, and the traces are dolomite, thenardite and halite (Fig. 17D, E, F and G). A rendering sample, analyzed by Attia [15], is obtained from the falling parts that cover the ceiling of one of the six small chapels in the temple of Seti I. This sample contains mainly anhydrite and minor amounts of quartz and calcite.

Discussions

Mural paintings at Abydos temples are distinguished by their difference in stratigraphical structure. This probably resulted from the fact that Seti I built some parts of his temple and his son Ramesses II completed the rest of it. Variable types of reliefs were used in regard to inside and outside murals, which goes with the fact that sunk relief was used on outside walls and raised relief on interior ones, since bright sunlight has the effect of flattening raised relief and enhancing sunk relief [16]. In some cases these reliefs were covered by additional rendering layer before receiving the paint, while in one case the rendering was applied on a flat wall. Cross sections of paint layer samples reveal that all the paintings were performed by tempera technique. Most of the paint layers were thin which was common in this period of time [17].

The results obtained from the limestone sample illustrate that it is mainly composed of calcite with low amounts of impurities, whilst kieserite, thenardite and halite represent the salts gained from the upward groundwater and air pollution. The presence of these salts can form white rims at the surface as efflorescence, at the open ends of the capillaries or just beneath the surface as sub-efflorescence [18]. The presence of dolomite may be as a chemical deposit or by the dolomitization process [19], while hillebrandite $Ca_6Si_3O_9(OH)_6$ is a mineral occurs in contact zone between limestone and diorite [20]. Lucas and Harris [21] claims that the good quality limestone used in Abydos temples may be not local, despite the presence of two ancient quarries of fairy good stone in the neighbourhood. However, Liritzis et al. [22] state that the limestone used in the temple of Seti I may be derived from Sohag limestone formation.

Sandstone sample shows high levels of quartz particles cemented mainly by silica, with the presence of calcite, and iron oxides which is belonged to the type known as Nubia Sandstone [23, 24]. Thenardite and halite represent the common sulfate and chloride salts presented in the study area. Liritzis et al. [22] refer that the origin of sandstone from Abydos point towards Luxor in the eastern desert.

All the data of mortar assures that the used one, in the temple of Seti I, was composed of gypsum and lime and a low portion of fine sand. The presence of dolomite is an impurity, while kieserite and halite are the salts which affect the building. However, depending upon the results presented by Attia [9], another type of mortar may be used, which mainly consists of gypsum and minor amounts of lime and sand. The existence of anhydrite could be from the alteration of gypsum that is exposed to high degrees of temperature over time.

Different types of rendering have been observed in the two temples. All the samples were composed mainly of gypsum and lime. The fine rendering contains low portion of fine sand, whilst the coarse one contains relatively higher portion of fine/coarse sand. All the samples collected from the temple of Ramesses II were coarse. Two unique samples show the presence of clay in sequence with lime/gypsum layers (approximately four alternative layers). The detection of high amounts of anhydrite could be ascribed to the conversion of gypsum by high temperature over time. These samples also agree with all the formers (limestone, sandstone and mortar) in the existence of chloride and sulfate salts.

Conclusions

Based on the data presented using several methods of analyses and examinations, the paper has been managed to offer fair information concerning the techniques and the materials of the mural paintings in two of the most famous temples in Egypt. They are *Seti I* and *Ramesses II* at Abydos, in this respect, it has been found that:

- The mural paintings are characterized by a variety in their structure and types of relief, however, their technique was unified (tempera technique).
- The support of the murals was composed of both limestone and sandstone.
- The mortar was mainly composed of gypsum ($CaSO_4 \cdot 2H_2O$) with the presence of lime ($CaCO_3$) and low portion of fine sand (SiO_2).
- The rendering samples varied in their composition; most of them were composed of gypsum and lime with the exception of two samples which were composed of approximately four gypsum/lime and clay layers arranged alternatively. All the rendering samples differed in their homogeneity and their amount of sand; some of them were fine while others were coarse.

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