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**Study of Treatment and Conservation of Greco Roman Sarcophagi**

**Carved from Igneous Rocks Applied on one selected Sarcophagus**

Submitted by

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# Summary

This thesis entitled on “ **Study of treatment and conservation of Greco Roman sarcophagi carved from igneous rocks applied on one selected object** ”, including five chapters, discussion of results, recommendations and references .

## **Chapter One**

### **Study of some igneous rocks and the evolution of Greco Roman sarcophagi carved from them**

This Chapter includes studying the most important igneous rocks that commonly used in Greco-Roman periods, detailing the manufacturing techniques of sarcophagi, methods of their formation, mineralogical composition, physical and mechanical properties, also studying the progress of the Greco-Roman sarcophagi whereas domical sarcophagi were prevalent in that period resulting from the influence of the third intermediate period, in addition to the analytical study of the sarcophagi types which carved from andesite stone in Alexandria tombs in the Greco-Roman periods. This chapter also includes the development of cutting methods for hard stones in the Greco-Roman period where that period has witnessed a great development in stones cutting techniques, besides to the tools which used in quarrying whereas iron tools were used extensively in that period, also this chapter tackles the most important quarries of igneous rocks used in the Greco-Roman periods and their locations .

## **Chapter Two**

### **Study the Deterioration Factors of the Greco- Roman sarcophagi carved from igneous rocks**

This chapter corresponds the endogenous deterioration factors of igneous rocks which depend on the nature of their formation from molten magma or lava at high temperature as a result forming Plutonic, Hypabyssal and Extrusive rocks. Also tackles the exogenous deterioration factors including physiochemical deterioration factors consisting of variations in air temperature ,moisture and its different sources , salts, atmospheric pollutants and wind, where these factors lead to weakening the internal structure of the stone and become less resistance in the face of other deterioration factors. The biological deterioration factors play a serious role in the deterioration processes of the archaeological stones, where its dangerousness not less than physiochemical deterioration factors, especially if the suitable conditions are available, biological deterioration factors include microorganisms, insects, birds and plants, the exogenous deterioration factors also include man-made deterioration factors including incorrect treatments which caused deformation and destruction of archaeological stones.

### **Chapter Three**

#### **Study of treatment and conservation of Greco Roman sarcophagi carved from igneous Rocks**

This chapter tackles the most important scientific methods used in the recording , examination , analysis , and studying of scientific techniques and materials used in conservation and restoration of sarcophagi carved from igneous rocks .

### **Chapter Four**

#### **Examinations and Analyses of some Greco-Roman sarcophagi carved from igneous rocks**

This chapter deals with methods of examination and analysis which were performed on three types of igneous rocks: granite, granodiorite and andesite whereas sarcophagi in the Greco-Roman period were carved from them. Samples from these rocks were examined by using stereo microscope, polarizing microscope, scanning electron microscope and were analyzed by x-ray diffraction method .

Examination and analysis were performed by polarizing microscope, x-ray diffraction and EDX showed that granite is composed of microcline, quartz, albite, biotite, hornblende and orthoclase. Andesite is composed of albite, andesine, biotite, orthoclase and augite. Granodiorite is composed of quartz, Albite, microcline, biotite, hornblende and orthoclase. Granodiorite contained a quartz content similar to granite, but it has a higher felsic mineral composition of plagioclase feldspar. Examination by stereo microscope, polarizing microscope and scanning electron microscope showed that an erosion of mineral grains, presence of cracks, pits, voids on the surface, salts crystallization, broken crystals, also alteration of feldspar to kaolinite and biotite to chlorite have been observed .

## **Chapter Five**

### **Experimental and Applied Study for treatment, restoration and conservation of one selected Greco-Roman sarcophagi carved from andesite**

This chapter divided into three parts as follow:

**Part one** includes the first steps of the experimental study. A group of pure polymers has been tested with and without adding nano silica particles in addition to testing nano polymer to select the best one to consolidate and protect the selected andesite sarcophagus in the applied

study. Also an experimental study has been carried out on two kinds of mortars to choose the best one for the completion process.

### **The Experimental Study of Consolidation and Protection Materials**

Consolidation and protection materials used in experimental study have been divided into three groups, the first group contains the polymers, this group has included three pure polymers, these polymers were (Kimistone K55, Wacker OH 100 and Remmers KSE 300), the second group contains the nanomaterials included the previous polymers reinforced with SiO<sub>2</sub> Nanoparticles in addition to nano polymer Surfapore T .

### **Experimental Study of completion mortars**

The experimental study also included testing two kinds of mortars with different percentage , the first mortar is composed of andesite powder + crushed andesite + Kimistone K55 reinforced with SiO<sub>2</sub> Nanoparticles) within 2:1:0.5, also used the same components of this mortar within 3:1:0.5 . The second mortar is composed of andesite powder + crushed andesite + Survapore T) within 2:1:0.5, also used the same components of this mortar within 3:1:0.5. The most suitable one will be used in the restoration processes of sarcophagus carved from andesite.

This part also tackles the various steps of the artificial ageing methods which were performed on the treated samples in order to identify the extent of stability and resistance of the selected consolidants materials, as well as it were compared together in order to choose the most suitable one to consolidate the selected sarcophagus, Kimistone K55 reinforced with SiO<sub>2</sub> Nanoparticles and the mortar composed of andesite powder + crushed andesite + Kimistone K55 reinforced with SiO<sub>2</sub> Nanoparticles )

within 2:1:0.5 have given the best physical and mechanical properties after aging process in experimental study .

**The second part** of this chapter deals with the documentation study of the selected sarcophagus carved from andesite under study, starting with the archaeological and artistic documentation by photographic recording and ending with the geometrical recording .

**The third part** of this chapter tackles the practical application on the selected sarcophagus carved from andesite, mechanical cleaning has been carried out using soft brushes and spatulas to remove dirt layers in order to reveal the sarcophagus surface. Dental drilling has been also used to remove cement layers which was used in past treatment processes.

Chemical cleaning has been carried out using Ethylene Diamine Tetracetic Acid (EDTA) to remove iron corrosion spots, acetone has also given a good result in cleaning writings by marker pens on sarcophagus surface. The process of collecting broken parts of sarcophagus has been carried out using stainless steel rods with epoxy 1092 and andesite powder. The completion process were carried out using a mortar composed of (andesite powder + crushed andesite + Kimistone K55 reinforced with SiO<sub>2</sub> Nanoparticles) within 2:1:0.5 which has given the best physical and mechanical properties after the aging process. Finally, the consolidation process of the sarcophagus carved from andesite has been carried out using Kimistone K55 reinforced with SiO<sub>2</sub> Nanoparticles which has given the best physical and mechanical properties after aging process in experimental study.

### **Results and Recommendations**

This study has been ended with a general discussion of the results that have been reached, as well as some important recommendations which were determined from the study.