# Removal of the White Marine Deposits Disfiguring the Granitic Monumental Objects of Alexandria Lighthouse, Alexandria, Egypt

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[Abstract]

At the end of the last century, many of the monumental objects of Alexandria Lighthouse were lifted out from underwater and stored or exhibited at different places in Alexandria City. Although these objects had been desalinated and cleaned after being lifted from underwater, they still suffering from the presence of a large amount of white marine encrustations and concretions deposited on their surfaces. The main aim of the present work is to define and introduce an appropriate cleaning method to remove these deposits that are still disfiguring the surface of most (if not all) of these objects. Visual examinations, polarizing microscope and XRD methods are used to define the nature and the composition of these insoluble deposits. These deposits range from white to yellowish white in color, are relatively hard (about 3-4 by the Mohs scale) and their thicknesses range from millimeters to about 1 centimeter. Microscopic examination shows the impregnation of these deposits inside the exfoliation of the stone minerals (biotite) of the granitiods monumental objects. The XRD analysis indicated that the main components of these incrustations are the calcium carbonate minerals; mainly aragonite with calcite, in addition to quartz. The Physical-chemical method of cleaning processes has been applied in our work. For the present cleaning processes, poultices formed of EDTA +CMC alone or with other mixtures were tested for removing the considered insoluble deposits. Using EDTA 20% in the form of a poultice with the help of brushes and/or fiberglass is a safe and successful method to remove the insoluble white marine deposits disfiguring the granitic monumental objects.

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## 1 Introduction

The conservation and restoration of monumental stones has been studied by many authors (e.g. Torraca, 1967 and 2009; Clarke and Ashurst, 1972; Dukes, 1972; Caple, 2000; Fassina and Vianello; 2003; Doehne and Price, 2010). These different studies presented the different techniques for conservation and restoration, such as reassembling, consolidation, and cleaning.

The principle of cleaning the stone buildings or the artifacts is to remove the surface deposits without damaging the substrate (Normandin et al., 2005). In some cases, the cleaning process is the first step to be carried out; as it preserves the stone building materials or objects and exposes more of the original condition of the surface (Caple, 2000). It is important to recognize that the cleaning process is irreversible, which is why it should always be approached with care.

There are several reasons for cleaning the surfaces of the building stones and the stone artifacts such as: a) to remove the possible dangerous material produced and deposited by different processes of deterioration, b) to eliminate the unrelated materials such as dust and the remain of earlier treatments, c) pre-consolidation to let the consolidate materials penetrate into the stone and d) to get rid of disfiguring materials (Fassina and Vianello, 2003). Moreover, cleaning is an important step before any traditional treatment. However, cleaning can also cause damage to the surface of the monument in general and in particular to delicate materials resulting in the following disadvantages: a) removal of original material and loss of detail in fine carving work such as reifies in capitals and cornices. b) use of unsuitable methods or tools can produce formation of cracks in brittle materials. c) use of chemical cleaning can produce salts as deposits. Nonetheless, these risks can be minimized by using the scientific, tested methods that are executed by well trained professionals in the field of conservation.

The Alexandria Lighthouse (Pharos) archaeological site is essentially underwater today and is located just off the coast of Alexandria City. Its ruins consist of about 3,000 architectonic blocks and statues that lie on the seabed at depths between six to eight meters (Empereur, 1998; Hairy, 2004 and 2006). At the end of the last century, many of the monumental objects of Alexandria Lighthouse were lifted out from underwater and stored or exhibited at different places in Alexandria City. Although these monumental objects have been desalinated and cleaned after being lifted from underwater, a large amount of white insoluble marine encrustations and concretions are still distributed on their surfaces.

The main aim of the present work is to define and introduce an appropriate cleaning method to remove these insoluble deposits that are still disfiguring the surface of most (if not all) of these objects.

## 2 Nature of the Considered White Deposits

In order to define the suitable materials and methods for the cleaning processes, the nature and the composition of the considered, insoluble white, deposits have been determined. This was done through visual examinations, using a polarizing microscope and XRD analysis. The recognized white marine deposits are accumulated on the surfaces of the monumental objects due to the impact of the sea organisms. They range from white to yellowish white in color, relatively hard (about 3-4 by the Mohs scale) and their thickness ranges from millimeters to about 1 centimeter (Fig. 1). Polarizing microscope examination shows the impregnation of these deposits inside the exfoliation of the stone mineral (biotite) of the granitoid monumental objects (Fig. 2). The XRD analysis indicated that the main components of these incrustations are the calcium carbonate minerals, mainly aragonite with calcite, in addition to quartz (Fig. 3).

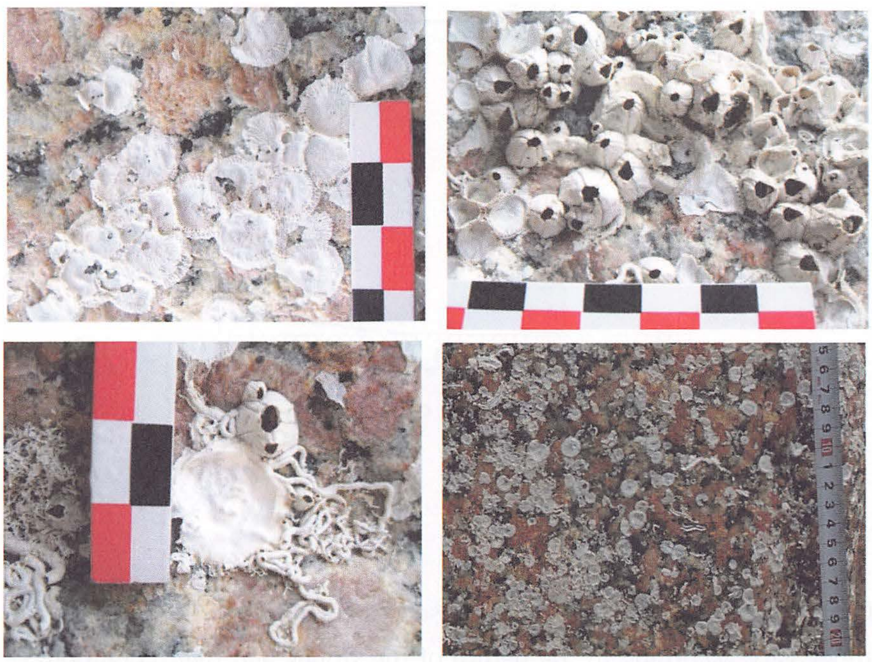

Fig. 1 Different shapes of the white insoluble deposits disfiguring the stone monumental objects of Alexandria Lighthouse

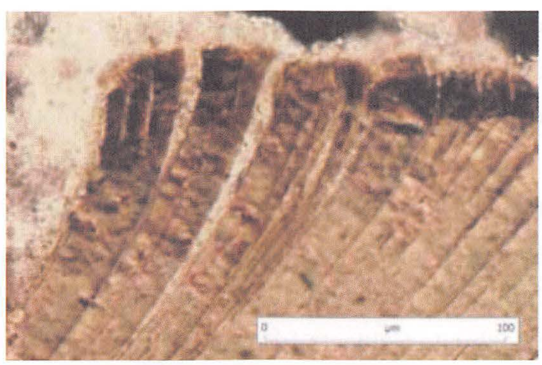

Fig. 2 Microscopic photograph showing the impregnation of the white deposits inside the exfoliation of the stone mineral (biotite)

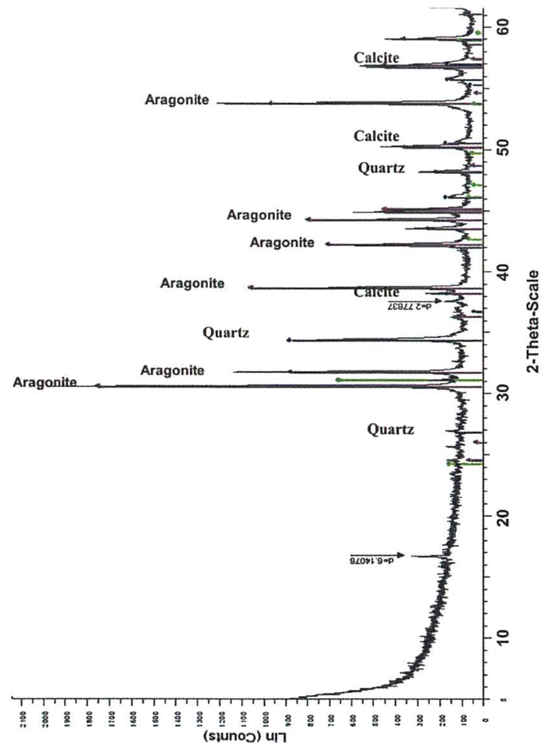


Fig. 3 XRD analysis of the white deposits disfiguring the Lighthouse monumental objects

3 Treatment and Field Work

According to Fassina and Vianello (2003), successful cleaning methods achieved on building or ornamental stones vary according to the nature of the stones and their conditions and to the nature of the deposits themselves. These methods can be done through three ways depending upon their administration principles: 1- through a physical-mechanical method, which is used to remove the deposits with the help of tools as brushes or micro-tools (scalpels, micro-chisels, and vibration etchers connected to low-speed micro-motors). Also, special tools and devices by using ultrasonic equipments and lasers can used for cleaning. 2- through physical-chemical method: which is a combination of using one of the tools with chemical materials and 3- through chemical method: which it is the use of different chemicals as cleaners (such as acids, alkalis and organic components).

We applied the chemical-mechanical method for cleaning the considered white insoluble deposits. The reasons for applying this method are: a) presence of the deposits encrustation on most, if not all, of the lifted exhibited objects from underwater. b) The difficulty of removing these encrustations using only mechanical methods.

The considered white insoluble deposits have been treated by different cleaning agents according to the results obtained from our small scale laboratory tests (cf, Nageh, 2013). These tests proved that poultices of Ethylene Diamine Tetraacetic Acid DiSodium ($EDTA.Na_2$; simply EDTA) plus CMC (Carboxyl Methyl Cellulose) alone or with other mixtures can remove the white deposits. In this respect, using EDTA, in the form of a poultice, for removing insoluble encrustations on different kinds of monumental objects, was adopted and discussed by different authors. Among of these authors are: Dukes (1972), De Witte and Dupas (1992), Thorn (1993), Woolfitt and Abrey (2000), Normandin et al., (2005) and Torraca (2009). Laboratory tests relevant to this subject are, also, documented by Arnold and Price (1976) and Gauri et al., (1976).

For the present cleaning field work two groups of cleaner agents in the form of poultices (six poultices) were applied. The three poultices of the first group were prepared by using EDTA in three concentrations (5, 10, and 20%) together with carboxyl methyl cellulose (CMC, 6%). The three poultices of the second group of cleaner agents were prepared using the same concentrations of EDTA and CMC, used in the first group, in addition to a modified mixture of what so called AB57 given by Mora et al., (1984). The used modified mixture of AB57 is formed only of sodium bi carbonate (4%) and ammonium bicarbonate (4%). CMC was added to the proposed cleaner agents to produce a paste and its concentration (6%) is similar to the amount introduced by Mora et al., (Op. cit).

The six different poultices were applied on the back surface of the monumental objects; each in a square measuring about 10cm x 10cm (Fig. 4). A cotton tissue and plastic sheet were used with adhesive tape to cover the compress. Pieces of cotton tissue (measuring 10cm x 10cm) were used as compresses. Each poultice was applied to its selected area by using a brush, after the area was wet by desalinated water. A plastic sheet covered the paste and the cotton tissue was fixed by using adhesive tape. A label was written above each poultice. The complete duration of the applied cleaners remained for seven days (one week). During these days, four investigations were carried out to record the result of each case (after 24h, after 48h, after 72h and after 7 days). After three hours, the results of observation were negative in all the six cases. The field temperature at the time of the tests was up to 18 °C during the day.

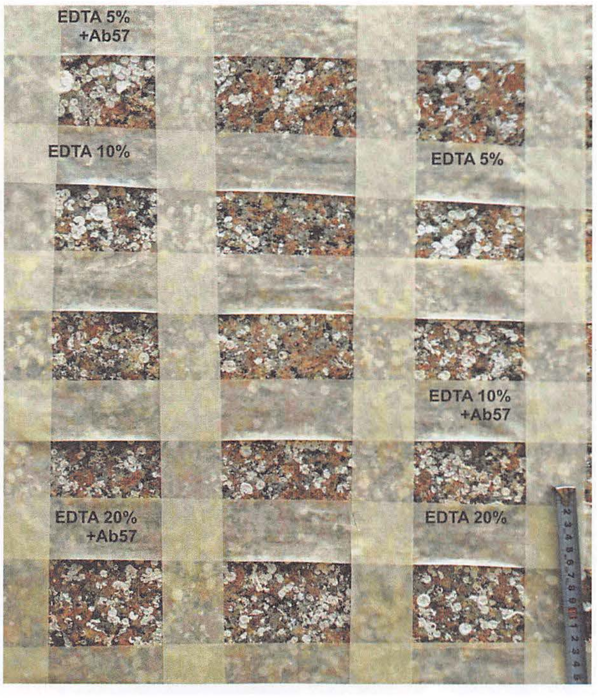


Fig.4 Showing the areas of the applied six poultices

4 Results and Conclusions

The results after 24h were almost negative except for EDTA 20%; which provided the etching for the thin concretion deposits (Fig. 5).

Fig. 5 Results of EDTA 20% after 24h

The second investigation was took place after 48h. The results were quite considerable in some cases. EDTA 20% (Fig. 6) and AB57+EDTA 20% (Fig. 7) showed the deposits were moderately cleaned. The thin deposit layers were etched, but the thick deposit layers were became less thick. EDTA 10% (Fig. 8) and AB57+EDTA 10% (Fig. 9) started to show progress in etching the deposits, and the thin deposits began to be removed. However, EDTA 5% and AB57+EDTA 5% (not shown here)showed only slight progress in removal of the deposits.

Fig. 6 Results of EDTA 20% after 48h

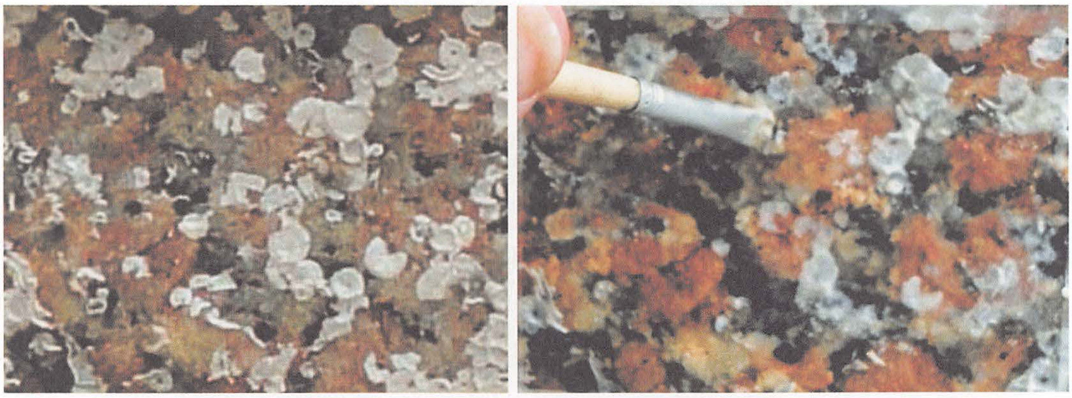

Fig. 7 Results of AB57+EDTA 20% after 48h

Fig. 8 Results of EDTA 10% after 48h

Fig. 9 Results of AB57+EDTA 10% after 48h during cleaning with a short-haired brush

The third investigation was done after 72 h (three days). This investigation showed the progress of cleaning in all the cases with varying degrees. EDTA 20% (Fig. 10) and AB57+EDTA 20% (Fig. 11) showed considerable progress in removing the deposits. Only the thickest deposits are still visible, while the very thin layer of deposits were completely removed. EDTA 10% (Fig. 12) and AB57+EDTA 10% (Fig. 13) also showed a visible change in the removal of the deposits but less than in the case containing EDTA 20%. EDTA 5% and AB57+EDTA 5% (not shown here)showed a slight (poor) progress in the removal of the deposits, even the thin ones.

Fig. 10 Results of EDTA 20% after 72h

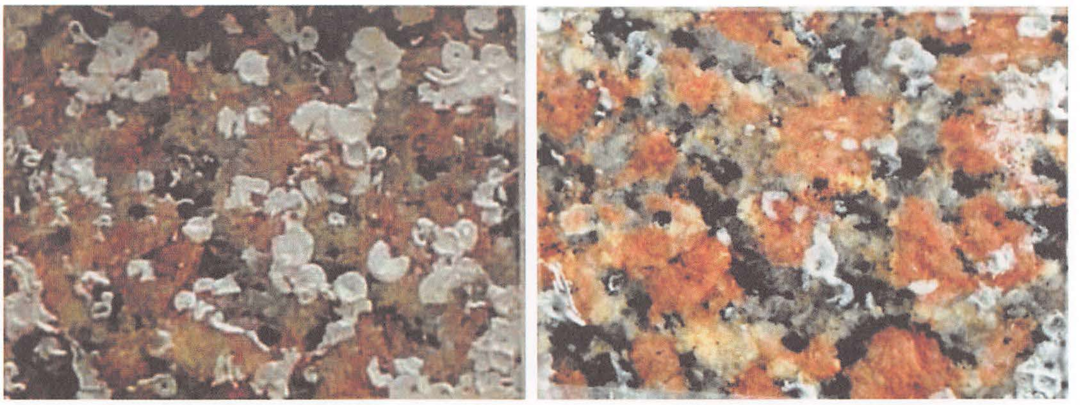

Fig. 11 Results of AB57+EDTA 20% after 72h

Fig. 12 Results of EDTA 10% after 72h

Fig. 13 Results of AB57+EDTA 10% after 72h

The fourth investigation was carried out after one week (seven days); it showed progress in the removal of the deposits for all the cases with various degrees. EDTA 20% (Fig. 14) and AB57 + 20% EDTA (Fig. 15) showed considerable results in removal of the white deposits. EDTA 10% (Fig. 16) and AB57+EDTA 10% (Fig. 17) came in the second level in the progress of removing the deposits. EDTA 5% (Fig. 18) and AB57+EDTA 5% (Fig. 19) gave a poor results in the cleaning the white deposits.

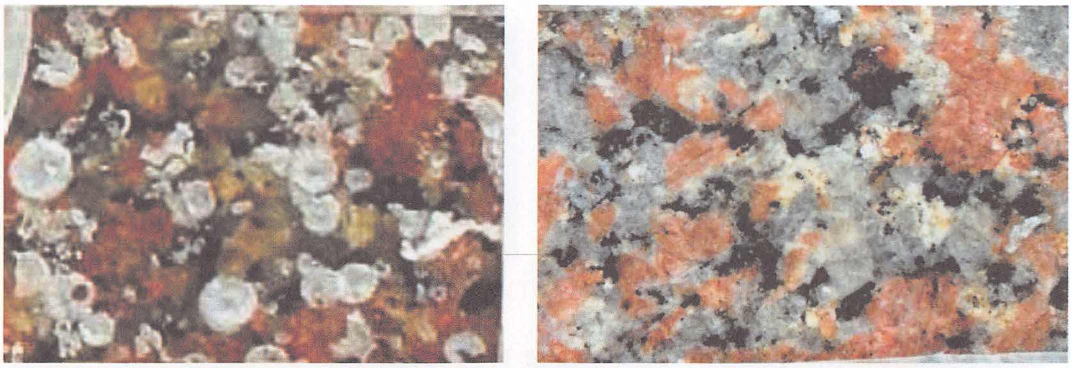

Fig. 14 Result of EDTA 20% after seven days

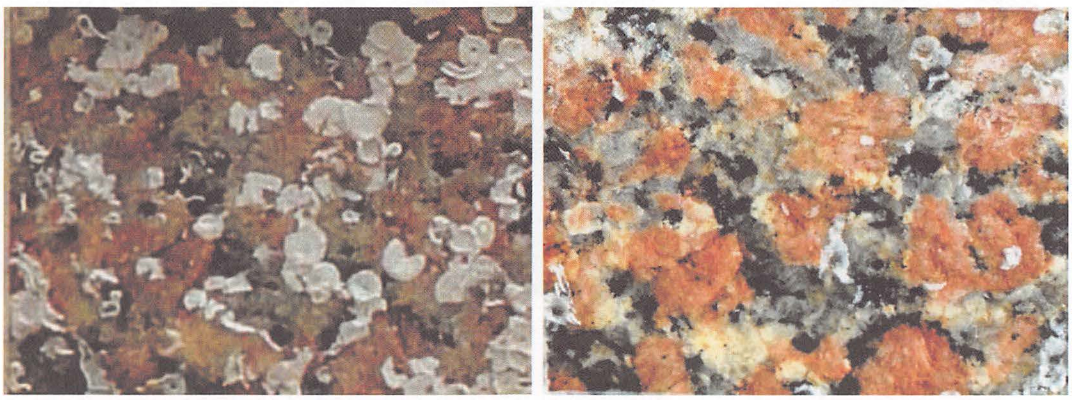

Fig. 15 Results of AB57+EDTA 20% after seven days

Fig. 16 Results of EDTA 10% after seven days

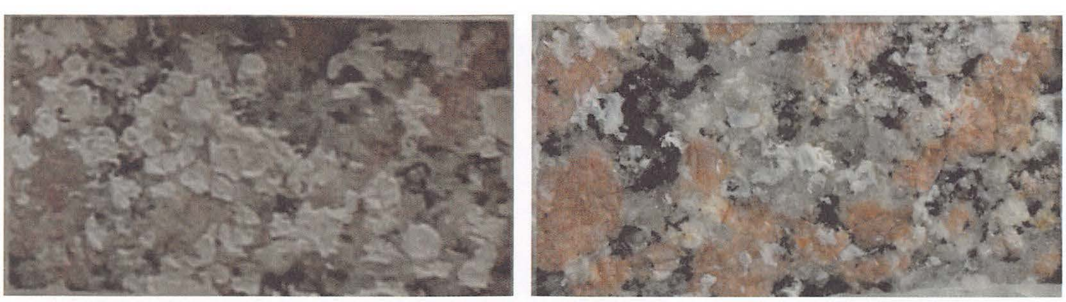

Fig. 17 Results of AB57+EDTA 10% after seven days

Fig. 18 Results of EDTA 5% after seven days

Fig. 19 Results of AB57+EDTA 5% after seven days

From the results discussed in this paper, it can be concluded that the tests of the different cases for cleaning the white deposits were very successful in giving a decreasing view of removing the deposits by increasing the concentration of EDTA over time. Both of the two groups of EDTA and AB57+EDTA gave relative results. The best results were from EDTA 20% and from AB57+EDTA 20%. On the other hand, EDTA 5% and AB57+EDTA 5% showed poor results. The cleaner agents worked on the surface of the insoluble incrustations by etching and decomposing their upper layers. By using the brush and/or fiberglass the decomposed layers were easily removed. In the different cases of cleaning processes the deposits were removed layer by layer. Some of the deposits are round in shape where the core is thinner than the rim. As a result, the center is completely removed first, followed by removal towards the outside depending on the thickness of the deposit. At the end of the test, the different tested areas were washed with desalinated water and natural soap.

In sum, cleaning by using EDTA di sodium salt 20% in the form of a poultice with the help of brushes and/or fiberglass is a successful and safe method for removing the white marine deposits accumulated on the monumental granitic objects.

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