

**“DETERIORATION LEVELS OF EXCAVATED METAL OBJECTS: A
CASE STUDY OF FORT JESUS MUSEUM.”**

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DEDICATION

“ Let us suppose an ichthyologist is exploring the life of the ocean. He cast a net into the water and brings up a fishy assortment. Surveying his catch, he proceeds in the usual manner of a scientist to systematise what it reveals. He arrives at two generalizations:

- i) No sea-creature is less than two inches long.*
- ii) All sea-creatures have gills.*

These are both true of his catch, and he assumes tentatively that they will remain true however often he repeats it” ... (Sir Arthur Eddington, 1882-1944)

I dedicate this work to my mother, Mrs. G. Chowe (nee Kamuda) for her continuous encouragement and support for my education. I am deeply indebted to her. May God bless her a million times.

Gideon Chowe.

DECLARATION

© Gideon Chowe 2003.

I, Gideon Chowe, do hereby declare that, this research is my original work and is a result of my own study except where acknowledged. This work has never been submitted to any University or institution for any type of award whatsoever.



Candidate's signature.....

Date..... 26 JUNE 2003

This research was supervised by Dr. E. Wahome of the University of Nairobi.

Supervisor's signature.....

Date.....

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Gideon L.A. Chowe (BSc.Ed. Mal.)

ABSTRACT

Fort Jesus in Mombasa (Kenya) is located on the coast of Indian Ocean.(Appendix A). In 1967, a Portuguese warship was sunk in this harbour below the fort. The term Mombasa Wreck Excavation was used to describe the expedition that intended to salvage objects from the sunken ship between 1977-1980.

The excavation revealed a lot artifacts that needed immediate conservation. A conservation laboratory was set up and a storeroom was identified. To date, the objects excavated from the ship are still in the storeroom while some are on display in the museum gallery. The conservation laboratory is being used to look after the objects.

Fort Jesus was chosen as a site of study because of the uniqueness of the objects in its custody and because of the concerns that the objects are in bad shape. This study was intended to find out the general condition of the objects. It also aimed at establishing the prevailing conditions in the storage for the past 15years to determine how these are contributing to the deterioration of the objects. The assessment of the condition was done only on metal objects.

Samples of metal objects were taken from the storage and assessed. Microscopes and handlens were used to obtain the fine details of deterioration not visible to the naked eye. Data sets were combined to interpret the extent of damage of the objects.

Most objects are stable and in good condition. Apparently, most of the previous treatments are intact. The fluctuations of the environmental conditions have almost stayed the same. The deterioration of some of the objects can be related to poor storage building. Improvement on the roofing, walls, drainage system and the floor will reduce damage to the objects.

Chapter one

1.0 INTRODUCTION

1.1 Background information

A Portuguese warship which was later identified as the 42 frigate, Santo Antonio de Tanna, sunk in Mombasa harbour in 1697 below Fort Jesus whilst trying to break the prolonged Oman siege. In 1960 two local divers discovered the remains of the hull which was about 15 meters down the ocean to the north of the Fort. A few artifacts were found and were handed over to the curator of Fort Jesus. (Wazwa, M. 1996)

The operation to salvage objects in the sunken ship was known as the Mombasa Wreck Excavation. Excavation of the Portuguese frigate was undertaken by American Institute of Nautical Archaeology (AINA) in collaboration with National Museums of Kenya and it revealed a lot of artifacts which required immediate conservation treatment in order to survive the change of environment from salty marine to fluctuating terrestrial climatic influences.

A conservation laboratory to cater for the needs of the objects recovered from the shipwreck was set up and as a result, many objects were conserved. Some of the treated objects were put on display and the rest of the artifacts that were treated, were put up in a room that was once used as a hospital, during the Portuguese occupation of the Fort (Appendix B). This room was later referred to as the Mombasa Wreck Store. In 1986, some renovations were made to the store so that it could accommodate the treated artifacts. Since then, the Mombasa Wreck collections and some of the Fort Jesus museum collections have been stored here although originally on a temporary basis while plans to put a more conducive environment for the collections were being sought. The Mombasa Wreck

storage area has an irregular shape with dimensions of 9.22m x 6.24m x 6.09 x 8.535m. All metallic objects which are presently in the storage were treated except very few which were being monitored to come up with the right type of treatment. This research, therefore, aimed at finding out the overall condition of these objects since there are fears that the objects have deteriorated to a great extent since recovery and a majority of them need active treatment.

1.1.2 Metal objects in the collection

The Fort Jesus conservation storage houses metal objects made of copper, iron, lead, pewter and alloys. Records on the methods used in treating different objects are available at Fort Jesus laboratory.

1.1.3 Storage technique

The shelves in the storage facility are wooden and objects made of similar metals are stored in same wooden cases. Presently, the storage is air-conditioned. Thermohygrographs are used to monitor the climatic conditions in the room. Small individual objects such as copper, iron and lead pieces are stored in plastic bags in which preconditioned self-indicating silica gel is added (Plate 1.1). Shelving units are covered with plastic sheets. Hygrometers are placed in different cases to monitor RH variations.



Plate 1.1 Pieces of pewter frags in a plastic bag containing silica gel.

1.1.4 Sensitivity of metals to relative humidity and temperature.

Many excavated metals are only stable in extremes of Relative Humidity (RH), whether desiccated or saturated or in very constant conditions. Where RH is particularly high, even active conservation treatments may not be able to prevent chemical reactions occurring, an obvious source of water for such reactions being condensation. However, physical problems caused by unsuitable or fluctuating RH are mainly confined to organic artifacts, even if treated, and to shelving made of wood.

The temperature of the post-excavation environment is always higher than that of the archaeological environment. It is raised still further by heating systems, sunshine, light etc. and is more subject to variation than the temperature of deposits. Metals such as lead feel long-term effects of excessively high temperatures. But generally speaking, metals are much more stable and are not easily affected

by temperature and RH variations except in extreme cases where high RH promotes corrosion of metals.

1.1.5 Fort Jesus – A brief historical background

Fort Jesus museum is located in the historic Fort Jesus monument. According to Kirkman, J. (1974), Fort Jesus was built by the Portuguese in the years 1593-6 in Mombasa, Kenya. It was designed by an Italian, Giovanni Battista Cairati, a leading architect of those days. Since its first occupation, it has only been abandoned once between May and August 1632. The original use as a barracks and fortress was continued by the Oman Arabs after they had captured it at the end of 1697, and was only terminated when the British Protectorate was proclaimed in 1895. It was then used as a prison for over sixty years until 1958. In that year it was declared a historical monument.

The building material of the fort is coral, either coursed coral blocks or coral rag set in red earth and lime mortar with plastered face. It was built about a mile away on the seaward side so that any ship entering the harbour would come within point-blank range of the Fort guns. The direction of the harbour is roughly south to north and the coral ridge on which the Fort is built runs into it at right angles. The plan of the fort was quadrilateral with a wide bastion at each corner and rectangular projections between the two seaward bastions. (See appendix A and B)

The Fort Jesus Museum, located within the Fort, was established and opened to the public in the 1960's. Since then, Fort Jesus Museum and the fort itself have become an important national treasure. The storage of archaeological material is located in what used to be a hospital in the fort (See appendix B).

1.2 Statement of the problem

1.2.1 Deterioration of metal objects at Fort Jesus Museum

The rate of deterioration of archaeological objects is variable, depending as much on the conditions of storage as in the inherent stability of the materials they are made up of. It was believed for sometime that some metallic archaeological objects at Fort Jesus Storage were displaying signs of deterioration. However, the extent of deterioration had not been verified comprehensively through research. Concerns were raised over resources allocated to the care of the archaeological collection in the Fort Jesus Museum storage. As such, part of the collection was said to be at risk of being lost because the level of deterioration of metallic objects was supposedly acute.

There were also speculations that most of the collections were damaged when the storage had no air-conditioning system. This study will investigate the level of deterioration resulting from lack of proper conservation techniques.

1.1.2 Research questions

- Are the deterioration levels of excavated metals at Fort Jesus really high than normal?
- Do environmental control systems stop deterioration of objects in the storage?

1.3 OBJECTIVES

1.3.1 Overall objective

The purpose of this research was to find out whether there is justified cause for alarm as far as the deterioration of excavated metallic archaeological objects at Fort Jesus museum is concerned. This research aimed at establishing the extent of deterioration of the objects in the storage in order to establish the general level of deterioration.

1.3.2 Specific objective

The research also aimed at assessing the prevailing environmental conditions in the storage to determine whether environmental control system has halted deterioration of objects in the storage.

1.4 Rationale

There has been some good work in the field of health studies ascribing distinct 'health states' to humans with increasing degree of disability or illness. Different health states can be ranked to give a type of value that can then be used in cost-benefit analysis. One of the systems that has been used by the UK National Health Services is QUALY, Quality Adjusted Life Year (Ashley, 1999). This system uses information about health states and life expectancy (Soby and Ball, 1991). When applied to objects the two parameters are of crucial concern to museums.

When one talks of conservation of objects, s/he actually implies control of undesirable changes taking place within or outside the object. However, the changes to be controlled are varied, ranging

from a change in colour to a change in strength. The changes may adversely affect the life expectancy with very little visible signs.

This research was therefore crucial because it provides an insight into the level of deterioration of the objects. It also serves as a basis on which predictions can be made on the degree that other deteriorating factors can cause as time goes on.

The results of this research will help curators and conservators to become aware of the vulnerable groups of archaeological metallic objects that need regular monitoring. The research will help in future formulation of conservation policies. The findings shall assist curators and conservators to regularly assess and quantify the extent of damage among the objects, and thereby prioritize conservation measures aimed at slowing down the rate of deterioration in these objects. Through this research, a basis on which fair predictions of the future state of the objects can be designed and objects that need immediate treatment isolated.

1.5 Scope and limitations

The research, apart from examining objects' condition, obtained other details which were relevant in categorizing the objects. Such details included the previous function of the objects. The research covered the following metals that are in the storage: Iron, Copper, Lead, Pewter and other alloys that were excavated from the sunken ship.

Errors in describing the deterioration signs might have occurred as the vocabulary for condition terminology was being put into use, however, it was felt important to embark on the research as a starting point for more detailed study.

The photographic documents used in this research might have faded over the years and might not be a true reflection of the original condition of the objects. However, written comments on the condition were used for complementary information in the use of the photographs.

Because the research was undertaken within a limited period of time, only a small number of objects could be assessed. However, it is hoped that the sample is representative and reliable.

Chapter two

2.0 LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

Generally, artifacts from underwater excavations are extremely fragile and are quite difficult to treat compared to those from terrestrial sites. Without the immediate attention and intervention of a conservator, many kinds of artifacts recovered from under the sea will be damaged or completely destroyed.

Artifacts from underwater environments can come to the museum in several ways. One of these ways is when divers or fishermen find the objects and bring them to the museum. Another way is when archaeologists embark on excavations of shipwrecks. Artifacts may also reach the museum through useful scientific excavations of shipwrecks.

Conservation of artifacts from shipwrecks is laborious, difficult and expensive. It is, therefore, advisable that excavation of shipwrecks be undertaken only if there are sufficient resources for conservation and if artifacts are not at risk of being destroyed. (Hall and Oron : 2001).

2.2 Literature review

In explaining deterioration of metals, Cronyn, (1990) observes that the most important type of deterioration in metals results in chemical rather than physical damage. Cronyn contends that, except for gold, the metals used in antiquity are not particularly stable and in most natural environment they tend to react with other components to form more stable compounds. He says this is not surprising since the raw material for these metals is ore, that is, stable chemical compounds of metals which can be extracted by the process of smelting, the reverse of corrosion. He recognizes two types of corrosion namely 'dry' corrosion, usually taking the form of thin surface patination or tarnishing; and 'aqueous' corrosion, where the metal is attacked more vigorously because of the presence of moisture. (Cronyn, 1990: 165-166)

Archaeological conservation is a means by which the true nature of an object is revealed and preserved. The true nature of an archaeological object includes evidence of the technology and materials used in its original construction and any subsequent pre-burial modifications, its usage and the circumstances and nature of its burial environment. The United Kingdom Institute of Conservation (UKIC) recommends that repairs or alterations made to materials after excavation is also significant to the object's history, in which case they should be fully recorded and/or preserved. UKIC goes on to state that the general obligations regarding all professional actions of archaeological conservators are supposed to be governed by respect for the physical, historic and aesthetic integrity of the object. It asserts that the responsibility for the welfare of the object is supposed to begin when the object is removed from its burial environment and continue through the post-excavation stages. Concern for the future should include protection against further deterioration, damage and loss (UKIC: 1981).

Blackshaw and Daniels (1978) observe that conserved antiquities would be in an unchanged state forever in an ideal world. It seems plausible, therefore, to ascertain that in museums, collections in general will deteriorate because their storage conditions are not ideal. In this same vein, therefore, one might jump to conclude that because conditions in different storages are different, then even the rate of deterioration and damage of objects after excavation is a function of particular storage conditions.

Looking at change of objects in museums over time, Ashley (1995) observes that there arises a problem of finding ways of deciding when this change should be called damage or deterioration and whether damage or deterioration can ever be accepted. He contends that curators, conservators and conservation scientists all have different ways of documenting change and may therefore have different definitions of what damage and deterioration are (Ashley, 1995: 100).

Valuable clues come out when the different perceptions and wisdom of curator, conservator and scientists complement one another. Where priorities are to be considered in the treatment of objects, a comparison of different views of urgency is involved. There is the urgency dictated by the timetable for presentation and interpretation, there is the urgency that is based on predictions of future damage and deterioration (Ashley, 1995.Pp 99-118).

Ashley (1995) continues to say that the state of the whole collections involve an assessor, usually a conservator, placing the observed conditions of individual objects into one of the several categories of which, according to Keene, the most frequently used ones are Good, Fair, Poor and Unacceptable (Ashley, 1995:111).

might as well not exist. Ashley goes on to say that if the object is to be used, we have to be prepared to go down this road and we have to choose a totally arbitrary number for the acceptable limit to damage, somewhere between 0 and 100%.

Ashley (1995) says the number doesn't have to be totally random, it could be arrived at by discussion amongst a group of experts, conservators for instance, who agree that at a certain level the object will no longer demonstrate those qualities for which it was acquired. He goes on to demonstrate this argument by assuming that this number be 75% of the original value. Then at our present rate of use or storage conditions, the object will have suffered an unacceptable degree of damage after, say, X years. He, however, assures us that this is not inevitable. We can exercise some control. Either by reducing the intensity of each exposure to damaging influence or by reducing the duration of exposure, or both. This, he says, will make the slope of the graph less steep. This way, we can increase the object's useful life two times, three times, in fact, as many times as we like.

However, the object will always eventually reach that 75% line. So if we want to say there will only be one allowable rate of damage, then there can only be one acceptable slope for this line. In essence, the attempts to define a maximum annual dose of lighting for sensitive objects or maximum acceptable relative humidity levels for metallic objects is such an attempt to fix the slope of this line. And to fix that slope, we need to define another number. Ashley has termed this number the service life of the object. He says guardians of the valuable and vulnerable artifact have to declare in advance how long they think the artifacts should be allowed to function in the future. Bearing in mind that this is just an arbitrary line, we may choose this as guidance rather than restriction.

In 'Risk Assessment for Object Conservation', Ashley observes that the most useful definitions of damage are related to changes in utility. In other words, his emphasis is on the change in utility and

not in value. He goes on to define 'state' as everything that can be defined or discovered about an object by observation, measurement or analysis. Further, he says, using the experience of the conservator or the blind impartiality of instrumental analysis, we find that there is a direct linear relationship between state and time. This might also be a picture of state versus hours of light exposure, or cycles of relative humidity or number of trips in the museum van. With the appropriate units this is a relationship of state to accumulating dose of damaging and deteriorating events (Ashley, 1995: 333-348).

For specific object types such as photographic material, the accurate scientific investigation of the rates of deterioration may be possible. But because of the complexity of many collections and the complexity of their environments it may never be possible to have anything other than the general views of rates of change (Ashley, 1995). He points out that an area where conservators and scientists could work together for mutual benefit would be in the design of and interpretation of collection condition surveys. He says full conservation surveys to a standard format are the potential basis for epidemiological studies of deterioration. If there are enough similar objects with the same environmental history then information about susceptibilities to particular agents can be derived from the survey data. If objects have entered a specific environment at known times there is the possibility of using the survey data to derive a form of damage function. This can be used to predict future states of the collection. However, other people have argued that roughly, similar objects inscribed with the date of entry remain in approximately the same environment for considerable periods.

Agrawal (1977: 61)) has observed that metals are more durable than organic material but they are not totally immune to deterioration. He maintains that the main metals from ancient periods are gold, silver, copper, iron, lead and their alloys. Brass, an alloy of copper and tin, and bronze, an alloy of

copper and zinc, were the most popular alloys in ancient times. Describing the deterioration of some of these metals, Agrawal continues to say that silver can rarely change to silver chloride in a museum atmosphere, but it often tarnishes, indicating formation of silver sulphide. Copper and its alloys corrode easily especially when buried in the earth. Soil contains many salts which change the metal into its various salts. The main corrosion products of copper are its oxides, carbonates, chlorides and sulphates which attack the surface and make the metal friable and weak. Copper corrosion products, with chloride in them, have the capacity to continue converting fresh metal into salt, even after it is no longer in contact with the soil. This continued corrosion of copper, because of the presence of chloride, is ultimately destructive.

Climatic conditions also affect the deterioration of objects in museum environment. The extent to which these factors cause damage varies mainly depending on the material in the museum and the museum itself. High humidity accelerates the development of bronze disease. Iron and steel rust easily in a moist climate. Agrawal (1977: 63) recommends that when coins are found during excavation covered with soil and corrosion products, they should be conserved only by a specialist and be kept in an appropriate environmental condition.

To maintain constant recommended environmental conditions poses some problems. As Thomson (1985: 85) writes, where as the moisture-absorbent materials must be neither too damp nor too dry, all metals benefit from dryness, particularly iron and its alloys and copper and its alloys. Since most museums form mixed collections, it is indeed unfortunate that the very level chosen as the lower safe limit for moisture-absorbent materials (40-45%RH) should also be the upper limit, not to be exceeded, for unstable iron and bronzes with traces of chloride.

In his book, 'Environmental Management: Guidelines for Museums and galleries,' Cassar (1995) explains the interaction between the external and internal environments. She explains that the weather affects ventilation and, consequently, the air quality, environmental stability and energy consumption within buildings. The driving mechanisms are wind speed, wind direction and temperature. Air enters the building through windows, doors, ventilation grills and other openings.

She recognises the fact that museum buildings are naturally ventilated so that uncontrolled inward and outward flow of air pass through open doors and windows, and the many cracks and gaps in the building's outer structure, that is air infiltration. The air flows in and out because of pressure differences generated across gaps by the action of wind and temperature. She goes on to advise that position of doors and windows affects internal airflow, so knowledge of a building's orientation will make it easier to decide where to locate them in both new and modified buildings. Generally, older and poorly maintained buildings will probably have a high air infiltration rate. The consequences of this may be an unacceptable level of fluctuations in indoor RH and temperature and significant energy losses (Cassar, 1995: 36-38).

The building acts as a buffer with the outer shell of the building being the main line of defense against external weather conditions. It protects the internal environment for objects by separating the changing external climate from the relatively stable internal conditions. Various measures can be taken to reduce air infiltration and enhance thermal stability, both of which are required to achieve humidity stability.

Cassar explains the role of the building in acting as first line of defense. She says that the performance of buildings is affected by weather conditions. A better understanding of the mechanisms that drive weather changes can help in the planning of a new museum in a number of ways, including the selection of the site, the orientation of the building and the internal layout of the

rooms. In case of existing buildings, Cassar (1995) says, knowledge of the prevailing weather conditions and their effects on the building allows environmental measures to be applied in more subtle ways- for example, when deciding the use of different rooms. (Cassar, 1995: 36-38). She goes on to emphasise that for museum staff, it is important to always monitor external relative humidity and temperature as part of the overall monitoring programme.

Another important observation Cassar has made is that it is often difficult to upgrade the fabric of an existing building to improve its environmental performance. She observes that some buildings are simply not appropriate for housing museum collections since conditions are not suitable and in this case mechanical systems can be used to control the conditions. She concludes by saying if all these fail, the only solution may be to move to another site.

Some objects in the museum collections are actively deteriorating. As Bradley (1994: 54) has observed, this is not because the environment in the museum is bad compared with the other places but because the objects themselves are unstable. She goes on to say it is not uncommon to hear people say that an object has lasted hundred years or even thousands of years and is now actively deteriorating in a collection. The explanation she gives to this is that the rate of deterioration may have been slow until a critical point was reached when equilibrium was disturbed and the reaction gathered momentum.

Bradley (1994:55) observes that reactions involved in the corrosion of metals and deterioration of natural organic polymers are well documented. They can be slowed by controlling environmental conditions to reduce the amount of water in the air and to stabilise the temperature.

A recognition is made by Bradley (1990:55) that there are no categories of materials from which objects are made which can be specifically identified as stable. She gives examples of flint being stable stone while soft limestone being prone to deterioration because of their clay and salt content. Gold being a stable metal but other metals, such as bronzes from soils of Western Asia being particularly unstable and often suffers from bronze disease. Iron objects, especially those from archaeological digs, suffer from active corrosion and lamination following excavation. Lead corrodes and silver tarnishes in museums due to presence of corrosive gases in the atmosphere which, she says, are largely derived from man-made pollution.

Apart from designing an appropriate sampling technique for study of archaeological objects, there is need for teamwork if better results are to be achieved. Researches in archaeological storages are meant for several reasons, one of which is for conservation when materials are found to be in poor condition. As Cronyn (1990) has observed, collaboration in conservation is the only ethical approach; without it information is lost and time is wasted. The collaboration must be between all those who have an interest in the excavated treasures, who in the main are excavators, field specialists, curators, analytical scientists and conservators.

2.3 Theoretical framework

Most metals do not occur as pure elements in nature but must be produced through the application of energy. According to the laws of nature, a system strives to attain the lowest possible state of energy, which for metals means that they tend to return to their oxidized natural state and thus to their stable energy form. That, under certain conditions iron corrodes is therefore as natural as that a stone falls to the ground when it is thrown up. The laws of thermodynamics state that order must decline to chaos.

Whilst there are numerous factors in the environment that affect unconserved objects, it should not be assumed that conservation inevitably renders materials immune to the effects of these. Conservation attempts to slow down deterioration but sometimes even this is not possible. My hypothesis, therefore asserted that although the objects at Fort Jesus were treated upon excavation, the levels of deterioration are still high. This was based on the fact that some conservation treatments may include new materials into the objects which themselves are subject to decay.

If materials have survived burial or submersion, it is usually only because they have come into equilibrium with their environment. When they are excavated, suddenly this equilibrium is profoundly disturbed as the artefacts are introduced into the atmospheric environment. Deterioration will begin again and may be obvious after as little time as a few seconds but may not be apparent for a year or more. If within a short space of time, a second equilibrium is not reached, deterioration to destruction will follow. Conservation seeks to ensure that this second equilibrium is reached as soon as possible. Excavation reactivates many of the agents of deterioration apart from disrupting the conditions for preservation in the burial environments of the materials.

2.4 Hypotheses

- The level of deterioration of excavated metallic materials at Fort Jesus museum is high than normal.
- Environmental control systems in the storage have halted deterioration of objects.

2.5 Definitions of terms

Active treatment: Direct removal of agents of deterioration from an object.

High deterioration: Object requires active treatment.

Passive treatment: Preventing agents of deterioration from coming into contact with an object.

Relative humidity (RH): The ratio of amount of water vapour actually present in a unit volume of air to the amount of water vapour required to saturate the same volume of air at the same temperature.

Humidity: The amount of water vapour in the atmosphere.

Microclimate: Condition in a confined space.

Chapter three

3.0 METHODOLOGY

3.1 Introduction

In an effort to come up with reliable results from any research work, sampling method becomes crucial. Champion (1980) has defined sampling as a process of selecting part of the evidence from a study as a basis for generalizing about the whole. She says that methods are also being developed for sampling of large groups of artifacts and that it has been shown that it is necessary to study only a small sample of the whole population to obtain a reliable estimate of its character (Champion, 1980). The samples for the research were only metallic archaeological objects in the Fort Jesus storage, which were excavated from a Portuguese ship that sunk in the ocean below the fort. In this research only the objects that were accessioned on excavation were studied.

3.2 Study site.

The research was carried out inside Fort Jesus monument where the conservation storage is located. It also houses the museum in which some of the excavated materials are displayed.

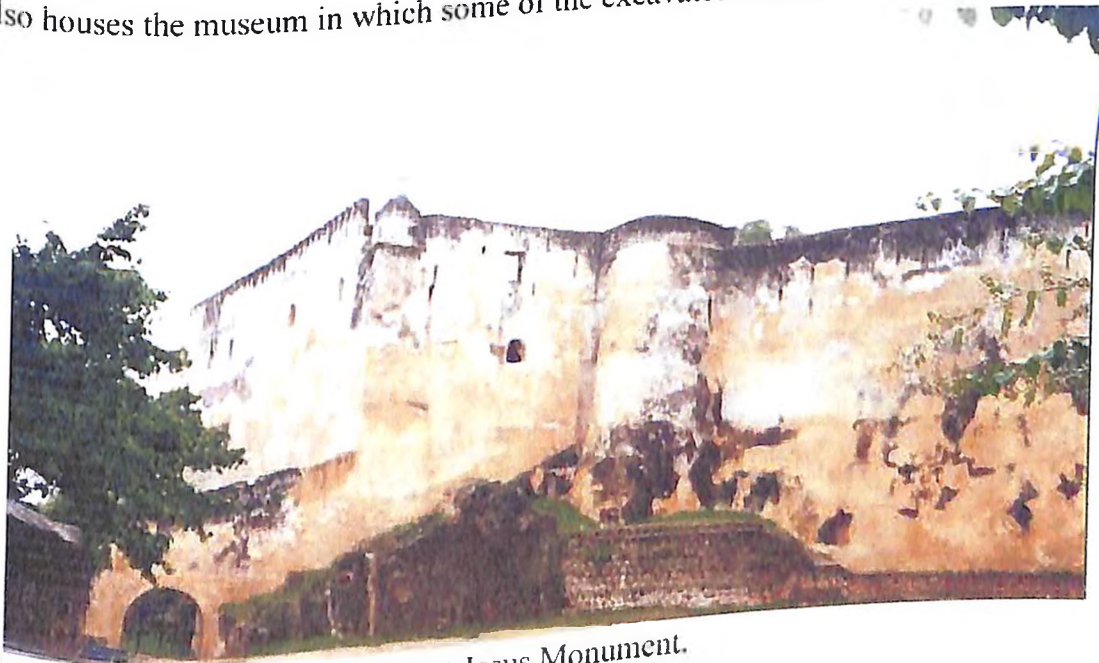


Figure 3.1 A general view of Fort Jesus Monument.

3.3 Study design

On the onset of the research, a series of decisions was made as to the structure of the research design. These decisions were based on the characteristics of the objects in the storage as they were already known, on the data requirements of the research questions being asked, and on the general sampling procedure. Basically, I decided (1) to do my intensive research within the storage area, (2) to select such object 'cases' at random within the clusters, in this case, the shelves, (3) within a selected cluster, to stratify the sampled objects into iron, copper, lead, pewter, brass etc. (4) to select the objects within the stratification at random for condition assessment. Levels of deterioration were scored on a scale of numbers and analysed.

3.4 Population

The research was conducted to assess all metallic objects in the conservation storage at Fort Jesus museum. It also included some objects that were being treated in the laboratory.

3.5 Study sample

All metal objects that were excavated from the shipwreck formed the population and using random sampling, a sample of 35 objects was obtained. All types of metals available in the storage were represented in the sample. An average of six objects from each metal type was sampled.

3.6 Sampling procedure

Cluster sampling was adopted using storage locations as primary units (see Appendix C). However, in each cluster, systematic random sampling was used. Purposive sampling was used in the case of the toolbox which is out doors.

3.7. Data collection methods

The researcher involved the conservation staff in assessment of the objects to avoid a biased categorization of the real condition of the objects. The objects were looked at in closer detail from a conservation point of view. This involved using a conservation assessment form for identifying those objects that can be conserved and those that has deteriorated to a point where conservation might not be cost-effective (Appendix H). This assessment was based on the need for conservation and the type of conservation required. The objects that were examined were only those that are accessioned from excavation. All available records were consulted for information on history of the objects, including earlier treatments. The metallic condition assessment form (Appendix I) was used to place objects in categories according to their general condition and priority. Initially, an assessment was conducted where high-priority objects included those that are published or of national or local importance. Those of negligible importance were objects thought fit to be deaccessioned.

The first stage of the survey involved selecting a representative group of objects showing various stages and signs of deterioration. These were examined both with the naked eye and with the aid of microscopes and hand-lens, and then they were photographed and recorded. This assisted in becoming familiar with the diversity of the signs and to establish a consistent method of describing them.

The environmental conditions in the storage and in individual cases were monitored and measured during the period of study. This involved measuring both temperature and relative humidity in the storage using thermo-hygrographs (Appendix D and J). The data for prevailing weather conditions in Mombasa region was obtained from the meteorological department (Appendix K)

For uniformity of the data collected, standardized condition terminology of object deterioration was adopted. Again standard definitions of the terms were used (See Appendix E).

The range of factors assessed is given in Appendix F and the team involved in the survey was briefed on these before the assessment. Categories for object condition grading is given in Appendix G. Then a trial assessment was undertaken to determine the viability of the methodology in the collection of the data. Background information was gathered before the actual research was carried out. This included finding out about the accession register, card catalogue, index files photographs, sketches, arrangement of shelves, plan of the floor and the building and so on.

The above documents were used to gather information on the original condition of the objects, the time they were excavated and also the type of treatment given to individual objects.

3.8 Methods of data analysis

The condition assessment of metallic archaeological objects placed each object in a condition category that took numerical values, the values were converted to percentages. The percentages in each category were compared (Table 4.1a and 4.1b). Graphs were drawn for easy visual comparison.

Deterioration trends of two selected objects were plotted. Gradient calculations were used to determine the rate of deterioration and predict the expected life span of the objects. (fig.4.3)

Variations in RH and temperature were calculated for the years 1995 and 2003. The values were plotted on logarithmic graphs (Fig. 4.4.1a and 4.4.1b).

The average condition of the objects using 'treatment requirements' was calculated and from this, the average condition of the whole metallic collection was estimated. Then a confidence interval, that the estimated average condition of the collection is approximately equal to that of the sample, was calculated at 95.44% level of confidence using probability computation.

3.9 Problems encountered and solutions

Not many problems were encountered during the research since all the relevant documents and instruments were available. In instances where electronic documents failed to be retrieved, manually written documents of the same were used. Again, it was not easy to generalise about different signs and stages in the deterioration of metals since no two objects displayed exactly the same conditions. The agreed generalized terminology, however, was used to ensure uniformity (Appendix E).

3.10 Ethical issues

No attempt was made to tamper with the condition of the objects and all the recommended guidelines for handling of the same were adhered to. Examination of the objects was governed by a respect of the physical, historic and aesthetic integrity of the objects. Again, no attempt was made to clean or treat objects in any way during the study.

Chapter four

4.0 Condition of objects

The assessment of the objects' condition was done using two forms. The first one was based on the objects' need for conservation and the type of treatment they need. (Form 1)

4.1 FORM 1: CONSERVATION ASSESSMENT FORM FOR METALLIC ARCHAEOLOGICAL OBJECTS.

Conservation needs score: 1- treatment essential for object survival

2- treatment desirable but not essential

3- object stable, no need for intervention

Treatment:

1- active treatment required

2- minimum passive treatment for stability only

3- no treatment required

| Accession No. | Item description | Treatment Need 1-3 | Conservation Need 1-3 | Comments | Location in storage |
|---------------|------------------------|--------------------|-----------------------|--|---------------------|
| MH 4585 | Copper Handle | 2 | 2 | Abraded and cracking. Greenish in colour | 108 Id |
| MH 342 | Brass bowl | 2 | 2 | Greenish growths and Chipping (acidic) | 202 Id |
| MH 3864 | Pewter jug | 2 | 2 | Warty surface due to salts | 116 Id |
| MH 240 | Copper coin Or seal | 1 | 2 | Black stains | 202 Id |
| MH 2111 | Copper alloy Metal can | 3 | 2 | Already treated but showing signs of corrosion | 116 Id |
| | | | | | |
| | | | | | |

| | | | | | |
|---------|---------------------------|---|---|--|----------|
| MH 2339 | Copper handle | 3 | 3 | Showing signs of recent corrosion | 108 Id |
| MH 3167 | Metal frag (iron) | 1 | 1 | Active corrosion but has slowed down | 104 Id |
| MH 1172 | Iron piece from tool box | 1 | 1 | Active corrosion taking place | 104Id |
| MH 6599 | Iron washer | 2 | 2 | Breaking from inside core of the metal | 104 Id |
| MH 6560 | Metal bolt (Iron) | 2 | 2 | Showing corrosion slow taking place | 104 Id |
| MH 6595 | Part of chain pump (Iron) | 2 | 2 | Showing corrosion slow commencing | 104 Id |
| MH 4221 | Lead piece | 3 | 3 | Very stable | 25ABe |
| MH 181 | Piece of lead | 2 | 2 | Salts busting out on the surface | 25ABe |
| MH 4859 | Lead sounding weight | 3 | 3 | In good condition | Id |
| MH 3145 | Pewter frags (Porringer) | 1 | 1 | Broken in piece due to active deterioration | Id |
| MH 58 | Pewter | 1 | 2 | Surface bursting out forcing breakages | Id |
| MH 2439 | Pewter bottle | 1 | 2 | Greenish and whitish products. Presence of salts | Id |
| MH 4421 | Metal ring (Iron) | 1 | 2 | Cracking on the surface | Tray 331 |
| MH 1076 | Copper rod | 2 | 2 | Slight rusting showing up | 331 I |
| MH 164 | Brass syringe | 2 | 3 | Minor structural damage and patina | 46 I |
| MH 3631 | Pewter | 1 | 2 | Very fragile | 46 I |

| | | | | | |
|---------|-------------------------|---|---|---|----------|
| MH 54 | Brass tea pot | 2 | 3 | Major Structural damage- body below rim eaten away | 46 I |
| MH 82 | Sword Scabbard (Lead) | 3 | 3 | Very encrusted, lower end missing | 331 I |
| MH 1832 | Large iron cannon ball | 1 | 1 | Almost completely corroded - parts loose | Store |
| MH 582 | Copper pot | 2 | 2 | Pieces flaking and feeble | 107 AC |
| MH 8318 | Nail box concrete | 1 | 2 | Active corrosion going on. Accumulation of salts seen | |
| MH 8051 | Pewter | 1 | 1 | Greenish powder on the surface | 115 IC |
| MH 6615 | Pewter top | 1 | 2 | Coating flaking off | 115 IC |
| MH 1238 | Small tray (Copper) | 1 | 1 | Concretions and active corrosion | 106 IC |
| MH 661 | Key lock (Copper alloy) | 2 | 2 | Stable but stained | 106 IC |
| MH 695 | Pewter (lid) | 1 | 2 | Very fragile. Whitish powder on the surface | 106 IC |
| MH 1137 | Copper alloy top | 1 | 1 | Surface chipping. Edges fragile | 106 IC |
| MH 4854 | Copper buckle | 1 | 1 | Blue-greenish colourations | 106 IC |
| MH 4280 | Copper buckle | 1 | 1 | Evidence of corrosion | 106 IC |
| MH 7845 | Tool box (Composite) | 3 | 3 | Very stable | Open air |

Assessed by: Gideon Chowe and Brian Nyambu

Using form 1, a number of objects in each category was compiled for easy calculation of percentages

(See table 4. 1a and 4.1b).

Table 4.1a: Totals in different categories of condition

| Name of material | Total no. in conservation Need category | | | Treatment requirement Category | | | Total |
|------------------|--|----|---|-----------------------------------|----|---|-------|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Copper | 5 | 4 | 2 | 4 | 6 | 1 | 11 |
| Brass | 0 | 3 | 0 | 0 | 1 | 2 | 3 |
| Iron | 4 | 3 | 1 | 3 | 4 | 1 | 8 |
| Lead | 0 | 3 | 1 | 0 | 1 | 3 | 4 |
| Pewter | 7 | 1 | 0 | 2 | 6 | 0 | 8 |
| Tool box | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| TOTAL | 16 | 14 | 5 | 9 | 19 | 7 | 35 |

Table 4.1b: Percentages in different categories of condition

| Type of material | % in the group for Conservation need | | | % in the group for Treatment requirement | | |
|------------------|---|------|-----|---|-----|------|
| | 1 | 2 | 3 | 1 | 2 | 3 |
| Copper | 46% | 36% | 18% | 36% | 55% | 9% |
| Brass | 0% | 100% | 0% | 0% | 33% | 67% |
| Iron | 50% | 38% | 12% | 38% | 50% | 12% |
| Pewter | 88% | 12% | 0% | 25% | 75% | 0% |
| Lead | 0% | 75% | 25% | 0% | 25% | 75% |
| Tool box | 0% | 100% | 0% | 0% | 0% | 100% |

Using Table 4.1a and 4.1b, the graphs below were drawn

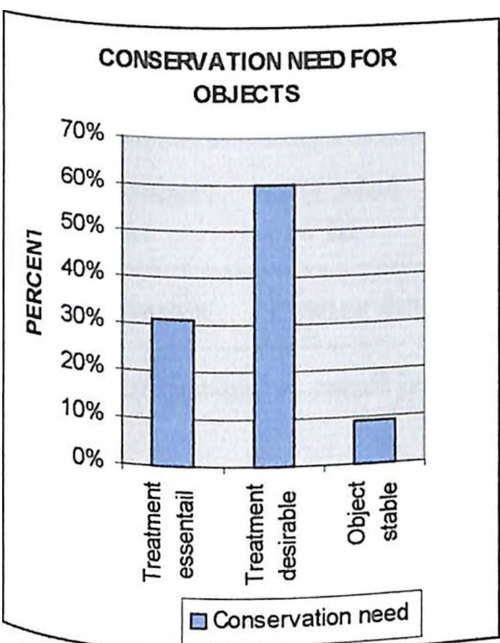


Figure 4.1a Conservation need

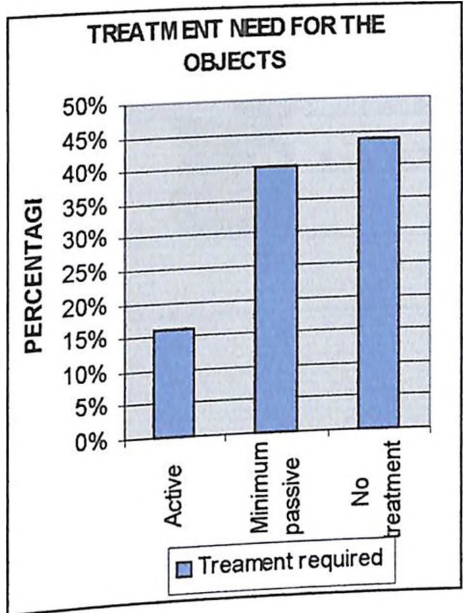



Figure 4.1b. Treatment need

The results above indicate that the majority of the objects sampled have a score of 2 for the conservation need (60%). This means that intervention on the object is desirable but not essential at the present time and for 31% of the objects, treatment is essential for object survival. A sizable number of the objects are completely stable and needs no form of intervention (9%).

In terms of treatment requirements, a great majority of the sampled objects does not require any active treatment (44%). A good number of them (40%) require minimum passive treatment to just make them more stable, while 16 % of them need active treatment.(fig. 4.1b)

A form was designed so that each object showing signs of deterioration could be noted together with a diagram, brief description and some comments. All forms were completed in detail with accompanying photographs.

Sample is given below. (Form 2)

| 4.2 FORM 2: METALLIC OBJECTS CONDITION ASSESSMENT | | |
|---|--|--|
| Date: | 28/3/03 |  Lab 353/466 |
| Acc. Number: | MH 3864 | |
| Location: | 116 Id | |
| Simple name: | Pewter Jug | |
| Brief description: A small juglet with hinged lid | | |
| Damage: <ul style="list-style-type: none">• Major structural damage• Minor structural damage• Surface damage• Disfigurement• Chemical deterioration• Biological deterioration• Repairs/previous treatment• Accretions | Tick Yes Yes ✓ | Comments: Handle with care, jug is fragile. Need to remove traces of salts. |
| Condition: C1 Good C2 Fair ✓ C3 Poor C4 Unacceptable | | |
| Work required: None Very little ✓ Little More | | |
| Priority: 1 ✓ 2 3 4 | | |

Recorder...Gideon Chowe Date...5/4/200

Using Form 2, percentages were calculated for both the objects condition and work needed on the objects. The following tables show the results.

Table 4.2a: CONDITION OF OBJECTS

| CONDITION OF OBJECT | NUMBER OF OBJECTS | % OF TOTAL |
|---------------------|-------------------|------------|
| Good | 10 | 29% |
| Fair | 21 | 60% |
| Poor | 4 | 11% |
| Unacceptable | 0 | 0% |

Table 4.2b: WORK NEEDED ON THE OBJECTS

| WORK NEEDED ON OBJECT | NUMBER OF OBJECT | % OF TOTAL |
|-----------------------|------------------|------------|
| None | 4 | 11% |
| Very little | 21 | 60% |
| Little | 7 | 20% |
| More | 3 | 9% |

The above results were then used to draw the graphs below:

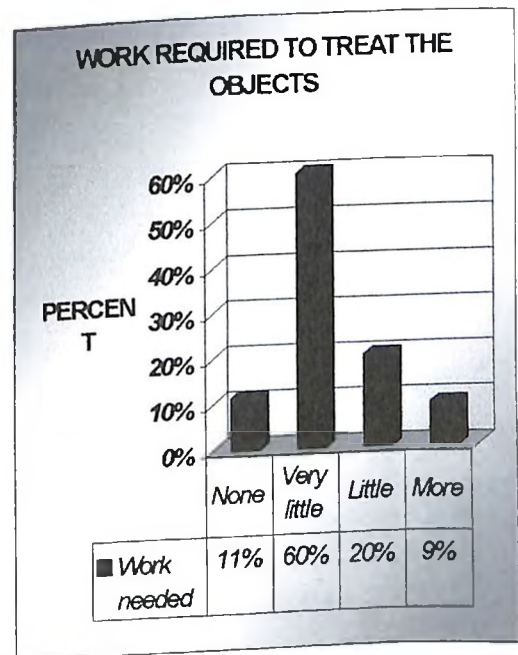
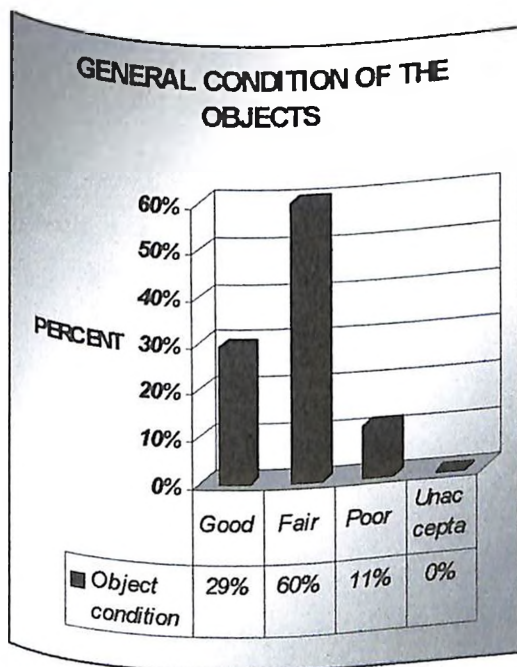


Figure 4.2a: General condition of objects

Figure 4.2b: Work needed on objects

As evident from the above graphs, a reasonable number of the objects are in Good condition (29%) while the majority of them are in fair condition. A small proportion of them is in poor condition. However, it can be seen that no object is worth deaccessioning due to worse condition hence none of them are in an unacceptable condition.

Looking at Fig. 4.2b, it is clear that very little work is required as far as actual interventions on individual objects is concerned. Of course there is some work required to be done on the objects for their stability and survival. Similarly, it is seen here that the work required to treat them is not much and about 1 out of 10 instances indicate that no work is needed at all on the objects (11%).

4.3 State of preservation

There are written and photographic records of the state of the Mombasa Wreck excavation metal collection before they were brought to the storage. These documents were used to compare the present condition of the objects to their past. This was done in order to determine the extent of damage that has occurred in between (See Plates below).

Plate 4.1 A pewter jug



Plate 4.1a: Original condition (1980)



Plate 4.1b: Present condition (2003)

It might be difficult to differentiate the conditions by looking at the plates above. In the first instance, it is difficult to assert that the condition of the photographs themselves have not changed over time. It is possible that the storage of the photographs has affected the authenticity of the original condition whereby some details are lost. However, written documents on the original condition were used to supplement the photographic details.

A summary grading of each object's condition was agreed by the team as the main means of assessing and quantifying preservation. Four grades were used because it was felt that if a fifth grade was allowed, it would mean that the majority of the objects would be assigned the middle grade which is indeterminate, and does not give very useful information. Three grades were thought to be too few to reflect the real condition of the objects.

It was found that, with the exception of very few cases, most objects in the sample are almost in the same condition as they were brought to the storage room. Minor structural damages are present on some of the objects and this can be attributed to improper handling when they were being brought from the conservation laboratory to the storage. A good number of the objects are extremely fragile minor fractures, but note should be taken that fragility is not deterioration.

It was discovered that the major cause of deterioration were salts present on the objects and chemicals left on the objects, such as acids, after treatment. In terms of urgency in as far as different metal objects are concerned, copper and pewter need immediate attention followed by iron. Few objects among these require no treatment at all.

4.4 Deterioration trends

Using the available written and photographic records, the research established deterioration trends of some of some the metal objects. For Example, the conditions of the pewter jug and the nailbox were followed from 1980 to 2003. The conditions of the objects were scored on an arbitrary numerical scale of 0 to 4, then, they were plotted against time at a ten year interval. The figure below illustrates the plot of trends in deterioration of the toolbox and the nailbox.

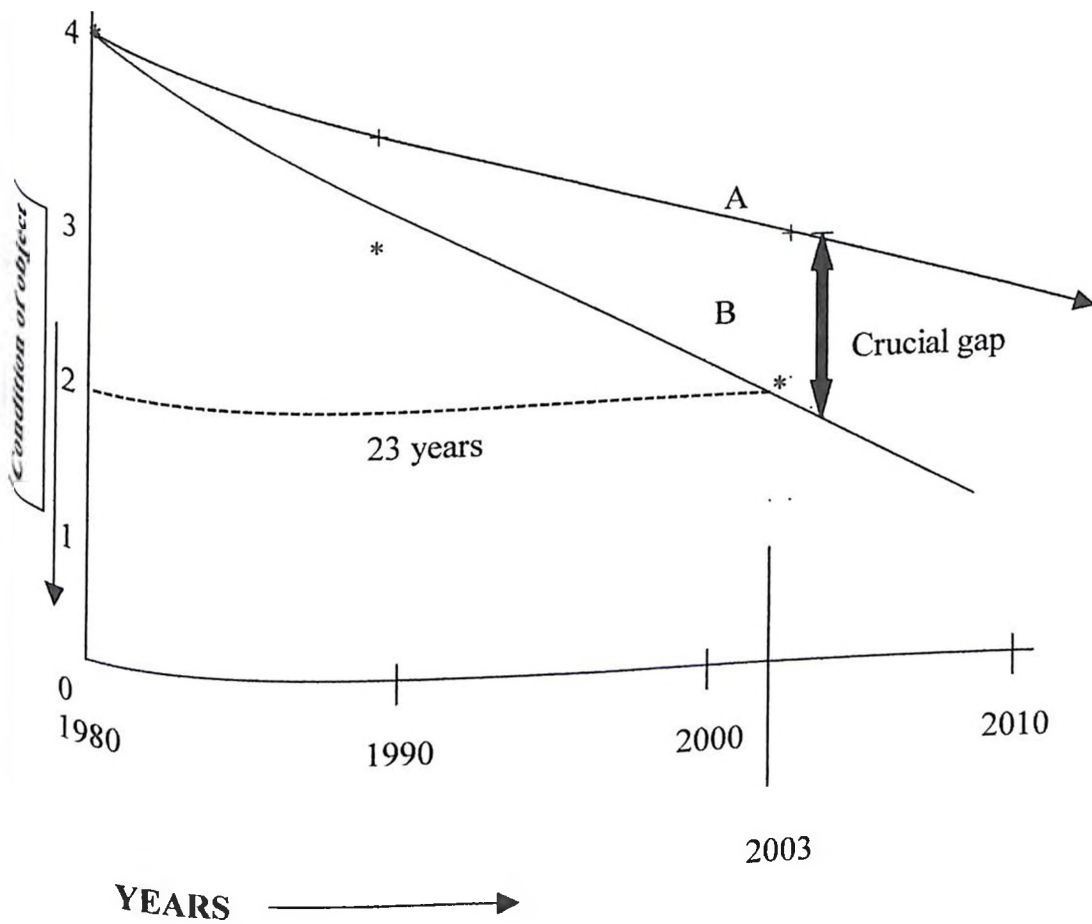


Figure 4.3 Comparative analysis of deterioration trends in two metal objects.

Key to object condition

- 0 = object has no value
- 1 = object in unacceptable state
- 2 = object in poor state
- 3 = object in fair state
- 4 = object in good condition

Key to graph lines

A  = Tool box

B  = Nail box

One thing that is obvious from the above figure is that the condition of an object decreases as time increases. In other words, there is an inverse relationship between time and state of object with time being an independent variable. It is, therefore, paramount that conservation should ensure that the rate of deterioration is slowed as possible.

From the two objects in figure 4.3, it is clear that the nailbox is deteriorating at a faster rate than the pewter jug. In 23 years, the nailbox has gone through two stages of deterioration while the pewter jug has gone through one stage only in the very same period of time. If we extrapolate these graphs, we discover that in about 20 years time from now, the nailbox will have lost value while the pewter jug will take about 50 years from now to reach this stage. If this rate of deterioration is maintained, the life span for the nailbox in the storage can be predicted to be about 40 years and that of pewter jug being about 70 years.

The differences observed here can be attributed to a number of factors. These include the treatment methods used on the objects and the inherent stability of particular metals from which the objects are made of.

For example, records at Fort Jesus indicate that most iron objects, including the nailbox, were washed in 5% Na₂CO₃ (Sodium Carbonate) for a period of 4-6 weeks to reduce chlorides. (Wazwa,

M: 1996). It is possible that complete removal of the chlorides failed in some objects and this could be the case with the nailbox. The chlorides are then inducing active corrosion on the metal.

Pewter is an alloy of tin and lead. Lead is known to be highly resistant to corrosion even in salty environments. This fact can be used to explain the observation made on the pewter jug. Only minor structural damages and accretions are present. The damages can be attributed to the previous repairs not done properly, but there is no evidence of corrosion.

The conservation work, needed, therefore, is supposed to decrease the slopes of these graphs especially that of the nailbox and the other objects in similar condition. That is to say, there is need to reduce the rate of deterioration. This can be achieved either by reapplication of the treatment or improvement of the storage condition for particular objects.

The gap between the two graphs is crucial especially when one takes into account the fact that both objects have the same origin, they were brought to the storage the same year and they are being kept in the same environmental conditions.

As previously pointed out, the condition scale is arbitrary but it was felt that it is important to briefly illustrate how some objects are deteriorating with time. A more detailed study in this aspect is, therefore, needed.

4.5 Prevailing environmental conditions

Weekly variations in temperature and relative humidity were recorded using thermohygrograph charts. These recordings were compared to those of 1995 for the same months of the year. The records for 1995 were used because of the availability of a comprehensive data for the readings. The

Tables below show the results. Samples of thermohygrograph for the years 1995 and 2003 are given in Appendix C.

Table 4.3a: (2003 recordings) Weekly variations in RH and Temperature.

| Relative Humidity (%) | | | | Temperature (°C) | | |
|-----------------------|------|------|------------|------------------|------|------------|
| Week | Max | Min | Variations | Max | Min | Variations |
| 1 | 49 | 38 | 11.0 | 24.5 | 19.5 | 5 |
| 2 | 49.5 | 37.5 | 12.0 | 25 | 23.7 | 1.3 |
| 3 | 58.5 | 44.5 | 14.0 | 26 | 21.7 | 4.3 |
| 4 | 56.5 | 43.5 | 13.5 | 30.5 | 25.2 | 5.3 |
| 5 | 50.0 | 40.5 | 9.5 | 29.0 | 23.5 | 6.5 |
| 6 | 60.1 | 49.9 | 10.2 | 28.5 | 22.6 | 5.9 |
| 7 | 61.0 | 48.0 | 13.0 | 28.7 | 22.8 | 5.9 |

Table 4.3b: (1995 Recordings) Weekly variations in RH and Temperature.

| Relative humidity (%) | | | | Temperature (°C) | | |
|-----------------------|------|------|------------|------------------|------|------------|
| Week | Max | Min | Variations | Max | Min | Variations |
| 1 | 80.0 | 69 | 11.0 | 29.5 | 25.5 | 4.0 |
| 2 | 78.0 | 68.5 | 9.5 | 26.4 | 24.5 | 1.9 |
| 3 | 86.0 | 70.0 | 16.0 | 30.0 | 25.0 | 5.0 |
| 4 | 85.0 | 67.0 | 18.0 | 31.0 | 26.5 | 4.5 |
| 5 | 66.0 | 50.0 | 16.0 | 31.5 | 26.5 | 4.0 |
| 6 | 62.0 | 50.0 | 12.0 | 31.7 | 26.5 | 5.2 |
| 7 | 67.0 | 54.0 | 13.0 | 31.5 | 26.0 | 5.5 |

Looking at the RH and temperature variations in Tables 4.3a and 4.3b, it is clear that these factors were extremely high for 1995. For instance, the RH could reach up to 86% while the temperatures were reaching up to about 32°C. The minimum RH that was once recorded in 1995 is 50% and that of temperature was about 25°C.

Taking the average of the maximum and minimum values of RH and temperature, it can be shown that the RH range in the storage was $68 \pm 18\%$ for that year, while the temperature range was $28.5 \pm 3.5^\circ\text{C}$.

The 2003 RH and temperature figures look friendlier as far as a conservator is concerned. The maximum RH recording is only 61% with a minimum recording of 41%. The highest temperature recorded is about 29°C . Similarly, taking an average of the maximum and minimum readings, we find that for this year, the RH range is $51 \pm 10\%$, and the temperature range is $24.5 \pm 6.5^\circ\text{C}$.

The logarithmic values of RH and temperature variations were used to plot the following graphs:

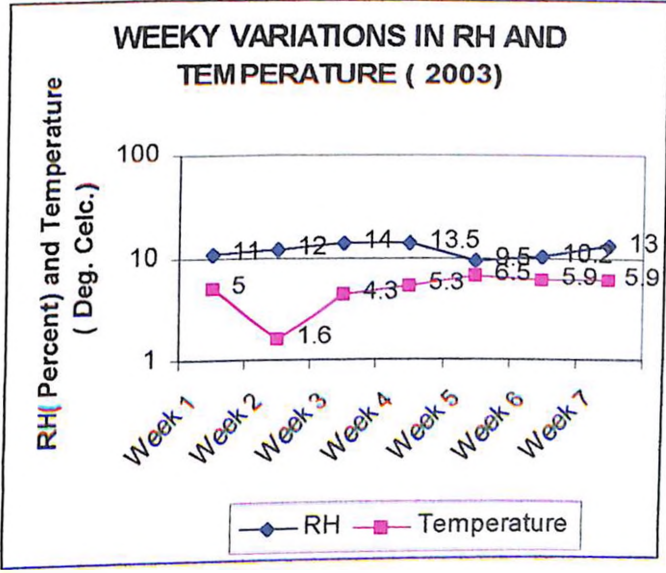
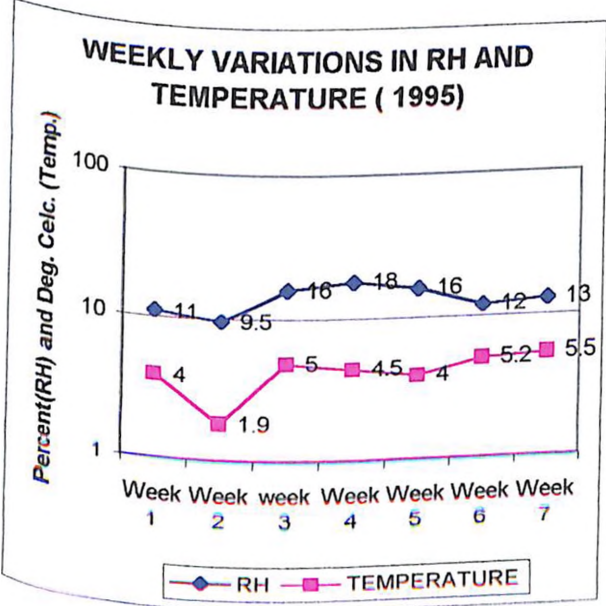


Figure 4.4.a: 1995 RH and Temperature Variations.

Figure 4.4.b: 2003 RH and Temperature Variations

Plotting of logarithmic values of variations for RH and temperature, it seems there is no big difference between 1995, when there was no air-conditioner and 2003 when the room was air-conditioned. As far as these parameters are concerned in the storage room, they have almost stayed

constant with respect to their fluctuations. If this sample of the environmental conditions is representative enough, then one might conclude that the prevailing conditions have been the same in the storeroom from 1995 to date with respect to variations.

Average daily relative humidity readings from different locations within and outside the storage area were taken for a period of five months. Below are the readings for one week taken from April to May. And using the readings, a graph (Fig. 4.5) was drawn.

Table 4.4. A WEEK'S RH READING FOR DIFFERENT LOCATION AS READ FROM 29 APRIL 2003 TO 5 MAY 2003.

| Date | Storage | Lead Case | Iron Case | Copper, Brass, Pewter case | Mombasa region |
|---------|---------|-----------|-----------|----------------------------|----------------|
| 29/4/03 | 60% | 60.3% | 60% | 61.5% | 77% |
| 30/4/03 | 60.5% | 59.5% | 61.5% | 60.6% | 78% |
| 01/5/03 | 60.5 | 58.5% | 63.5% | 60.5% | 77% |
| 02/5/03 | 65.5% | 59.2% | 63.8% | 60.6% | 81% |
| 03/5/03 | 68.5% | 59.5% | 62.5% | 61.3% | 79% |
| 04/5/03 | 63% | 58.6% | 62.5% | 61.6% | 79% |
| 05/5/03 | 64.5% | 59% | 63% | 61.5% | 83% |

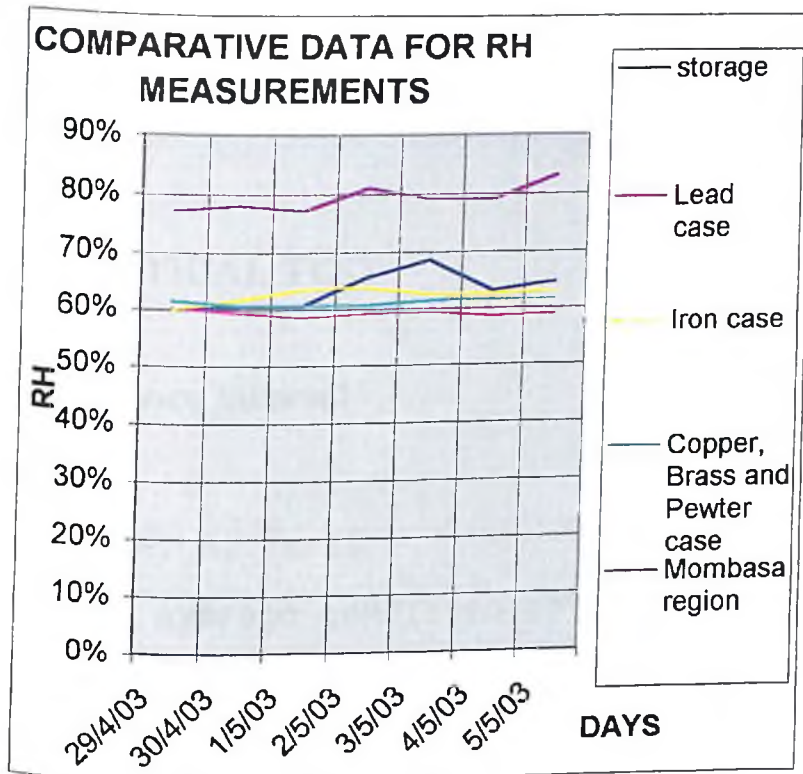


Figure 4.5: RH Measurements for different locations

The figures in table 4.4 indicate a relatively stable RH in both the storage and in the individual cases. *The outside RH is very high. Comparatively, the case containing iron experiences high RH than the other cases.* This could be due to the fact that the case for iron is close to a window and door with gaps between the frames and the walls. (See Appendix C). This then allows inflow of air from outside which in turn influences the RH in the case. This is also true for the whole storage. There is interaction between the external and internal environments and the external conditions being so harsh, exert a big change in the internal, controlled and relatively stable conditions.

Figure 4.5. shows the fluctuations in RH in different locations on a daily basis. Apart from the outside conditions and the RH variations in the storage, the fluctuations in individual cases are not great. This explains why most of the metals are stable. The use of plastic sheets on the shelves and

plastic bags with silica gel to keep metal pieces helps to buffer the changes to a greater extent. This is why the storage RH variations have little effect on the objects' condition and most of the, in general, have stabilised.

4.6 STATISTICAL TEST

4.6.1 Confidence interval

Sample size, n , is 35

Calculated average condition of the objects was 1.94

1.94 is my point estimate for population mean.

Assumption 1

Average condition gotten from the sample is approximately equal to that of the whole collection (population)

i.e. $\bar{x} = \mu$

\bar{x} = sample mean

n = sample size

μ = population mean

σ = Population standard deviation

sample mean = 1.94

sample size = 35

population mean = 1.94 (estimated)

population std. = 0.67 (calculated from sample mean)

Assumption 2

Since $n > 30$, then sample mean is normally distributed with sample mean equal to population mean and sample standard deviation equal to population standard deviation.

Probability of the above assumption is therefore:

$$P(\mu\bar{x} - 2\sigma\bar{x} < \bar{x} < \mu\bar{x} + 2\sigma\bar{x}) = 0.9544$$

And since population mean is equal to sample mean, and the sample standard deviation is equal to population deviation

Then

$$P \left(\mu - 2 \frac{\sigma}{\sqrt{n}} < x < \mu + 2 \frac{\sigma}{\sqrt{n}} \right) = 0.9544$$

hence

The probability that the population mean lies between two standard deviations of the sample mean is 0.9544

i.e.

$$P \left(\bar{x} - 2 \frac{\sigma}{\sqrt{n}} < \mu < \bar{x} + 2 \frac{\sigma}{\sqrt{n}} \right) = 0.9544$$

so, it means that about 95.44% of the interval

$$\bar{x} - 2 \frac{\sigma}{\sqrt{n}} \quad \text{to} \quad \bar{x} + 2 \frac{\sigma}{\sqrt{n}}$$

will contain the population mean.

Since

$$n = 35$$

$$\bar{x} = 1.94$$

$$\sigma = 0.67$$

then

$$\bar{x} - 2 \frac{\sigma}{\sqrt{n}} = 1.94 - 2 \frac{0.67}{\sqrt{35}} = 1.7$$

$$\bar{x} + 2 \frac{\sigma}{\sqrt{n}} = 1.94 + 2 \frac{0.67}{\sqrt{35}} = 2.2$$

hence

$$1.7 < \mu < 2.2$$

I am, therefore, 95.44% confident that the condition of most objects in the storage is between 1.7 and 2.2.

That is to say, I am 95.44% confident that the condition of most of the metal objects has a score of 2 in both conservation need and treatment requirement. Most metal objects in the collection, therefore, need only minimum passive treatment and the treatment is only desirable not essential at present condition.

Chapter five

5.1 Discussion

The research work carried out on 35 objects has provided an insight on the general condition of metal objects at Fort Jesus museum. What was more apparent is that, generally, the objects are in good condition and there is no cause for alarm as far as their present condition is concerned. The research has shown that very few objects require active treatment. There are a number of factors that can be attributed to this observation.

Environmental conditions in the storage have stayed almost constant with respect to fluctuations (Fig.4.4.1a and 4.4.1b). This, therefore, has resulted in the objects stabilizing to the prevailing conditions. Although the RH and temperatures were high in the past than now, it is worth remembering that most metals are least affected by the values of these factors, except in extreme cases. Rather, it is fluctuations of RH and temperatures that cause metals much damage. If objects are able to stabilize quickly to these variations, deterioration is slowed down to very low levels. This could be the case with objects at Fort Jesus.

Secondly, post-excavation treatment is meant to prevent deterioration resulting from the abrupt change of the environment by the objects. When an object is excavated, it will tend to try to adapt to the new environment. This process of adaptation results in the deterioration of the object. Treatment is, therefore, intended to either catalyse this process so that the object stabilizes as quickly as possible or to keep out conditions that harness the process of deterioration. It also involves removing deterioration agents that are already on or in the objects. About 90% of objects at Fort Jesus were

treated upon excavation. This explains why the majority of them have stabilized and are in good condition.

However, it should not a rule of thumb that all excavated objects should be treated for them to survive in the new environment. In fact, some excavated objects are better preserved without any treatment. This research has proved the above argument.

There is a toolbox at Fort Jesus that was not chemically treated in any way. Additionally, this toolbox is not in the storage room, rather, it is outdoors. However, it is in a perfect condition compared to those objects that were treated. This observation underscores the point that the most important thing for excavated objects is the rate of stabilization. This toolbox stabilized quickly to the post-excavation environment, and hence, rate of deterioration is very low. It is, therefore, important to allow a period of observation after excavation, depending on the condition of objects, where monitoring of the post-excavation condition should be done, after which a decision on whether to treat them or not shall be reached.

The temperature within the storage is not as high. The thick walls of the building act as a buffer to the effects of temperature increase inside the building.

Access to the storage at Fort Jesus is strictly monitored and controlled. The custodians of the storage have maintained high standards as far as storage access is concerned. No person is allowed to go into the room without being accompanied by a conservator. Even during this research, the researcher was, at no point in time, allowed into the storage alone to assess the condition of the objects. This has, therefore, contributed to minimizing the unnecessary handling, vandalism and all similar acts that could contribute to the damage of the objects.

The use of plastic papers to cover the objects in shelves and the storing of small pieces of metal objects in plastic bags has assisted in preventing the deteriorating agents from coming into contact with the objects.

However, the conclusion that *most* objects at Fort Jesus are in good condition means that *some* are in poor condition. In fact, a good number of them have deteriorated so much that *active treatment is a must*. (See Plates 5.1 and 5.2)

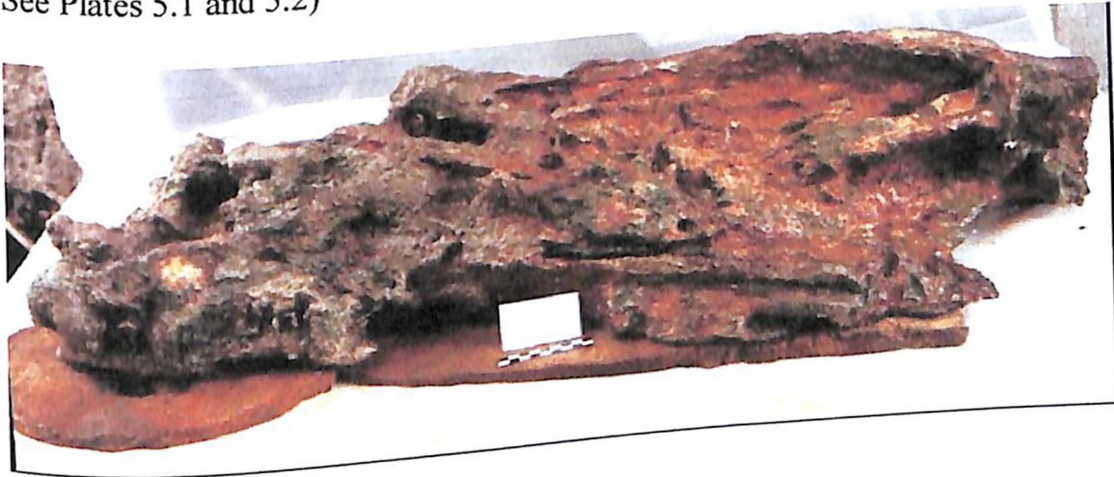


Plate 5.1 A highly corroded nailbox.



Plate 5.2. Pieces of corroded iron

One cause of deterioration of these objects is the treatment applied after excavation. In the first instance, no treatment is perfect, or rather, it is extremely difficult to achieve a perfect treatment.

When objects are excavated, some look sound or like in good condition while the deterioration process is taking place inside them. When such objects are treated by, say, putting a coating on the surface, the coating only serves to mask the invisible deterioration. As time goes on, the deterioration becomes apparent to the naked eye. This explains why some objects at Fort Jesus were treated more than once after excavation.

Similarly, some chemicals used in treatment of objects are themselves decaying agents e.g. acids. This is where the issue of reversibility of treatments comes in. It is possible, though not fully verified, that some of the chemicals used at Fort Jesus are catalyzing the damage of the objects. Even pure water increases deterioration of some artifacts and complete desalination (removal of salts) of other artifacts is at times not possible. The presence of salts increases the rate of corrosion in metals.

However, this research has found no concrete direct correlation between the presence of air-conditioning system and the reduction of damage on the objects. This was not the main object of this research though, and there is need for further study in this aspect.

Other objects showed presence of salts on them. The source of these salts can be traced to the sea. This observation can be explained by the storage's closeness to the sea and its open vents that allow sea air to gain access into the building. Salts like sodium chloride (common kitchen salt) are highly abundant in sea-derived air, and that might explain the presence of the same on the objects.

The design of the building has great influence on the climate inside it. The orientation, plan, shape, thickness of the walls, ventilation system and other aspects of the building have an influence on the microclimate inside. The roof has a slope that slants to one side and as it rains, not all the water

drains off from the roof. Some water seeps into the walls thereby causing dampness, and as a result, plaster flakes from the walls inside the storage. (Plate 5.3)



Plate 5.3 A flaking wall showing cracks and traces of salts.

The flaking products from the plaster could also be one source of salts since the walls are built of coral. The flakes also tend to stain the objects.

The storage building has a leaking roof which allows rainwater to get into the building directly. Apart from the presence of water itself, which causes damage to only those objects it has come into contact with, water also results in a rise in the RH of the room, thereby affecting more objects. The table below might assist in explaining the sensitivity of metals to different conditions of RH:

Table 5.1. SENSITIVITY OF METALS TO RH.

| Condition of metal | Sensitivity to RH (%) | Aspect of damage |
|--------------------------------------|-----------------------|------------------------------|
| Sound metals (in good condition) | High | Will corrode |
| | Low | Will be stable |
| | Fluctuating | Increase risk of corrosion |
| Corroding metals | High | Accelerate corrosion |
| | Low | Will be stable |
| | Fluctuating | Accelerate corrosion |
| Metals from the sea with chloride | High | Accelerate rate of corrosion |
| | Low | Reduce rate of corrosion |
| | Fluctuating | Greatly increases corrosion |

There are standards set for different types of collections. For example, the tolerance range of archaeological metals is 20 percent (RH) maximum, and that of historical metals is 40 per cent (RH) maximum, and 50 per cent (RH) and 19°C temperature for mixed and stable collection, (Cassar, 1995: 20). The term 'ideal' condition is usually used to describe these standards. But strictly speaking, these 'ideal' values of RH and temperature are not universally ideal. They may be ideal for a particular collection in a particular location and not ideal for that same collection in a different setting. These values should therefore be just a frame of reference, a starting point so to say, in the creation of a conducive environment about any collection. To whatever levels of RH and temperature the objects have acclimatised, they should be left but monitored continuously.

What is more important in this regard is the environmental consistency. The actual values are of no great importance. This is the case with objects at Fort Jesus. There has been continuity in the environmental conditions and hence the objects have reached equilibrium with the existing environment so that any abrupt change can enhance more deterioration.

Mombasa is a coastal area and the RH is high. This is because the temperature differences between land and sea create air mass movement. By day, the direction of airflow is towards the land; by night, the direction of airflow is towards the sea. This explains why humidity is high in the storage during the day. This is crucial because it is during the day when people work and therefore the opening of doors and windows poses a big threat to the stability of the conditions in the storage. The openings in the building render a non buffer zone between the internal and external conditions. There is competition between the internally controlled conditions and the harsh external natural conditions making the total control of the internal conditions with coolers impossible, hence the continual fluctuations of RH and temperature.

The floor of the building has cracks. These allow dust into the storage room. Dust increases corrosion even if it does not contain corrosive substances, rather, it tends to retain water and salts on the metals for a lengthy period of time. And in between the wall of the fort and the storage, there is an open space where water settles if it rains. This is a potential source of moisture which contributes to the increase in the RH of the storage.

Chapter six

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The groundwork achieved by the research has provided a realistic indication of the level of deterioration of metal objects within the collection at Fort Jesus museum and has highlighted particular problem areas. The research work aimed at establishing the levels of deterioration of metal objects and whether environmental control systems have helped in stopping the deterioration. It was hypothesised that the deterioration levels of metal objects at fort Jesus museum are high than normal and that the environmental control systems have halted deterioration of the objects.

The research has revealed a number of aspects on metal objects at Fort Jesus storage. It has been found that most of the objects do not require active treatment. In fact, about 60 per cent of the objects assessed in the study are stable and show no signs of deterioration in the 10 to 15 years of storage. Almost without exception, about 35 per cent of them show signs of deterioration, though minor ones, like tiny spots of iron corrosion. About 5 per cent of them need direct intervention for their survival. Most of the treatments applied to the objects are still intact and show no evidence of the same falling out within the next ten years.

The findings of the study have helped to highlight vulnerable groups of metal objects which should be monitored regularly. From the sample obtained, lead, pewter and iron have been found to be the group that is affected most by deteriorating agents.

No relationship was established between the condition of objects when the storeroom had no air-conditioning system and the condition of them when one was installed until now. As far as the environmental condition variations in the storage and within the individual cases are concerned, there is no pronounced difference between the two periods.

The major contributing factor to the deterioration of the objects has been found to be poor storage facility. There are a lot of flaws in the building itself which is allowing agents and factors to come into close proximity with the objects. The harsh conditions from outside are influencing the climatic variations in the storage due to the same problem of poor storage building.

The research has also established that some excavated metal objects are better preserved without any kind of treatment. Post-excavation observation of objects is, therefore, important before deciding on why and how to treat objects.

In essence, the results of the research are encouraging. The findings of the study have led to both hypotheses being rejected as they are proved to be false. This is so because it has been shown that the deterioration levels of metal objects at Fort Jesus are not high than normal. Again, no relationship could be established between condition of objects in the presence of environmental control systems and the condition in the absence of these.

The research should not be taken as complete and the results should not warrant complacency on conservation work since hidden deterioration might have not been detected during the study. There is scope for further detailed study. Updating and adding to the available data should allow discovery of ways to prevent deterioration to a larger extent.

6.2 Recommendations

Although curators and conservators have been aware of deterioration of metal objects at Fort Jesus museum for some time, no attempt had been made to assess and quantify its extent until this research.

The rate of deterioration of excavated metal objects depends primarily on the composition of the metal, manufacturing process and the surrounding environmental conditions. While it is the responsibility of the craftsmen to modify their formulae to maximise the durability of metal, curators and conservators can work towards slowing down the process of deterioration by controlling the environment in which the object is stored, using suitable storage supports and cases constructed of suitable materials, a proper storage building and by instigating a programme for regular cleaning of the objects.

The results of the research have prompted the researcher to make some recommendations to ensure that deterioration of objects is slowed down. Thomson (1986: 84) has observed that whereas the moisture-absorbent materials must be neither too damp nor too dry, all metals benefit from dryness, particularly iron and copper and its alloys. He contends that since most museums form mixed collections it is indeed unfortunate that the very levels chosen as the lower safe limit for moisture-absorbent materials (40-45% RH) should be the upper limit, not to be exceeded, for unstable iron and bronzes with traces of chloride.

Thomson (1986: 88) recommends RH level of 40-45 per cent as ideal for metal-only collection and RH of 45-50 per cent as a compromise for mixed collections and where condensation may be a

problem. Fort Jesus storage has a mixed collection and hence a compromise in RH levels is essential to ensure the survival of all objects in the collection.

With reference to the present condition of the objects and RH readings within the storage room and in individual cases, the researcher recommends the RH of 55-60 per cent as ideal for this collection. To achieve this, the vents on the walls and openings in the windows and doors should be sealed completely. The roof should be more slanted to allow all rainwater to drain off the roof when it rains. The holes in the roof should be sealed with wax or any other suitable sealant. Drainage system around the building should be improved to avoid water from settling around the building premises which could be a source of moisture through evaporation and rising damp. Cases should be constructed from glass and metal as opposed to the wooden ones which are being used presently. Objects should always be handled with cotton gloves to prevent transferring sweat and body oils that might enhance deterioration on the objects.

It is possible to achieve a dust-free environment by removing the old floor and replace it with a tiled floor. With well-constructed cases and sealing of open vents in the building, it should be possible to restrict air-exchange rates thereby reducing dust entry and circulation, and also maintaining a stable relative humidity. The use of conditioned silica gel should be continued and instead of putting it in individual plastic bags, the silica gel can be put in the cases with a good access for its maintenance. This should be possible when the design of the cases is appropriate.

From a practical point of view, it would be an obvious advantage to keep all objects that are undergoing active deterioration together. While this would apparently disrupt research and historical interpretation of the collection, it might be possible to highlight the severity of the problem of excavated metal deterioration by keeping the unstable objects as a didactic storage unit.

The effects of deterioration felt by the objects resulting from the flaking walls can be eliminated by scrapping off the old plaster and replace it with new and durable plaster. Once this is done, regular repairs should be done where signs of plaster flaking are observed. There is need, therefore, for regular monitoring of the general condition of the building.

Since this research focused on metal objects only, there is need for further research on the condition of all types objects in the collection and find out how the storage environment and facilities are affecting their survival.

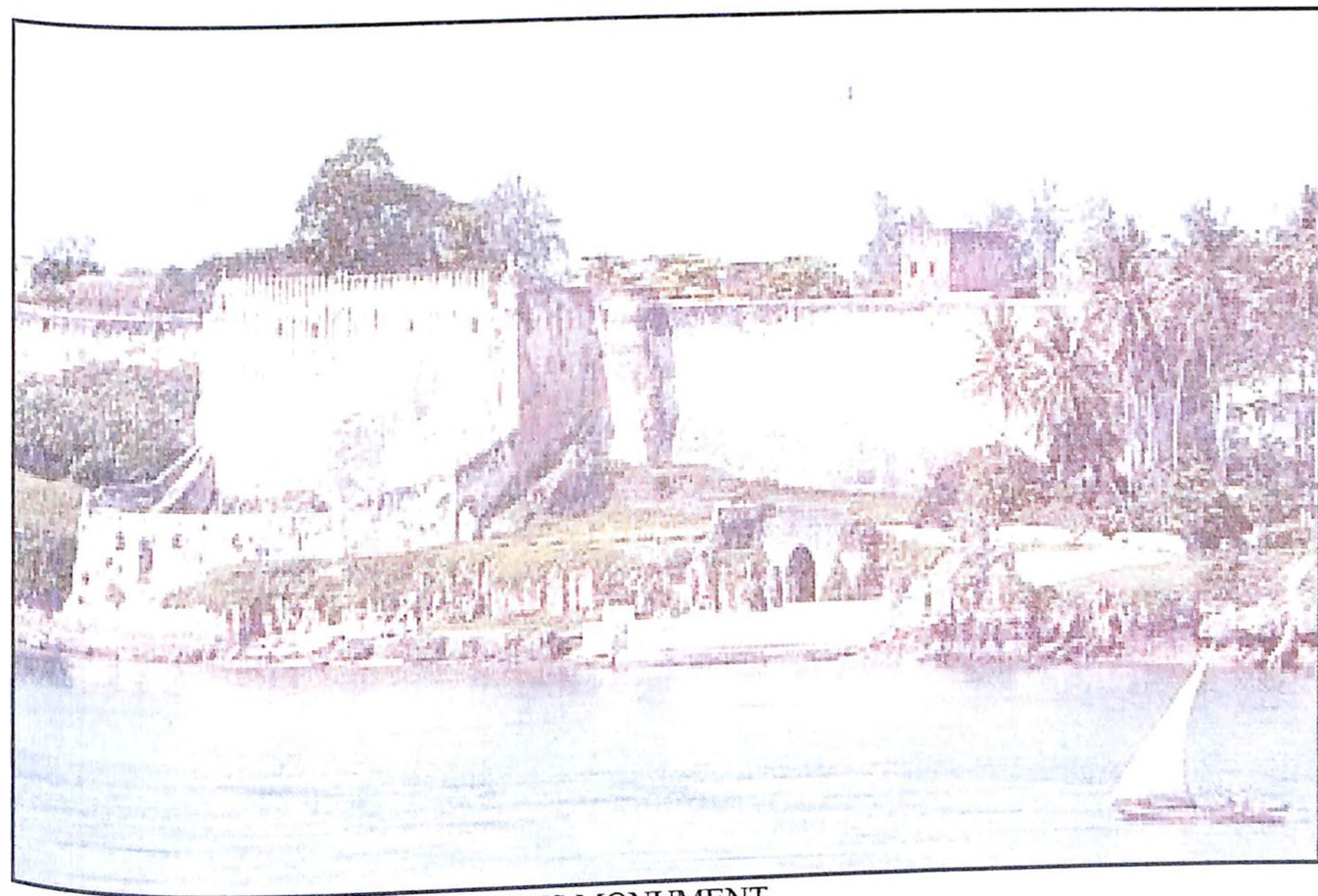
REFERENCES:

- Agrawal, O.P. (1977) A handbook for the use of museum curators. National Research Laboratory for Conservation of Cultural property. New Delhi
- Blackshaw, S.M. and Daniels, V.D. (1978). *Selecting materials for use in the display and storage of antiquities*. 5th Triennial meeting. Zagreb. Icom Committee for Conservation.
- Bradley, S.M. (1994) *Do objects have a finite lifetime?* In Care of Collections. Routledge. London.
- Cassar, M. (1995). *Environmental Management: Guidelines for Museums and galleries*. Routledge. London.
- Cronyn, J.M. (1990). *The Elements for Object Conservation*. Routledge. London.
- Hall, K and Oron, A. (2001). *Conservation of Marine Finds*. The International Institute for Conservation of Historic and Artistic Works. (IIC). England.
- Ashley, J.S. (1995) *Risk Assessment for Object Conservation*. Butterworth. Woburn.
- Keene, Suzanne (1994) *Audits of Care: a framework for collections condition survey* In Care of collection. Routledge. London
- Keene, Suzanne. (1996). *Managing Conservation in Museums*. Butterworth- Heinemann in Association with Science Museum. London.
- Muller, J.W. (1979). *Sampling in Archaeology*. University of Arizona Press. Tucson. Arizona.
- Oakley, V. (1990). *Vessel Glass Deterioration at the Victorian and Albert Museum: Surveying Collection*. The Conservator. Number 14.
- Thomson, G. (1985) *The Museum Environment (2nd Ed.)*. Butterworth. London
- Thomson, G. (1978). *The Museum Environment*. Butterworth and Co. (Publishers) Ltd. London.
- UKIC, (1981). *Guidance for Archaeological Conservation Practice*. Archaeological section. UK.
- Stone, Thomas G. (1996). *Artifacts Revisited: The Evaluation of Old Treatments*. ICOM-CC.11th Triennial Meeting. Edinburg, 1-6 September, Pp. 643 –649.

- Sarah, Champion. (1980). *Dictionary of Terms and Techniques in Archaeology*. Phaidon Press Limited. New York.
- Sease, C. (1994). *A conservation Manual for the Field Archaeologist*. University of California: Los Angeles.
- Torfs, K et al. *The Cathedral of Bari, Italy; Evaluation of environmental effects on stone decay Phenomena in Studies in Conservation*. Journal of the International Institute for Conservation of historic and artistic work. Volume 42. Number 4. (1972) Pp. 193-203.
- Weiss, N.A. and Hassett, M.J. (1991) *Introductory Statistics* (3rd Ed). Addison- Wesley Publishing Company. New York.
- Wazwa, M. *The Conservation of Movable Cultural Property from Underwater sites; The Case of the Mombasa Wreck* in Recent Trends in Conservation of art Heritage. Shashi Dharan. 1996.

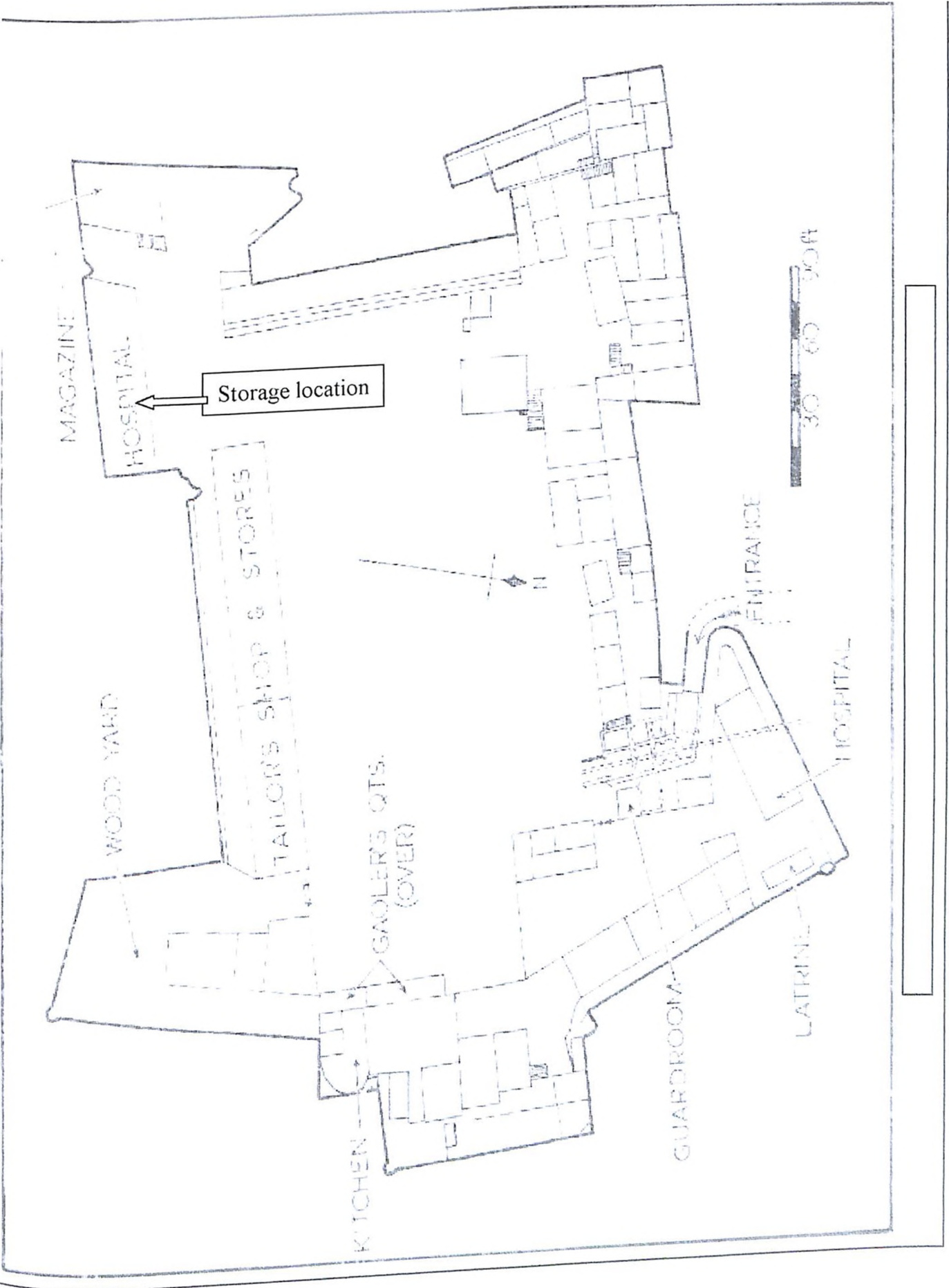
APPENDIX

APPENDIX A: Fort Jesus Monument.

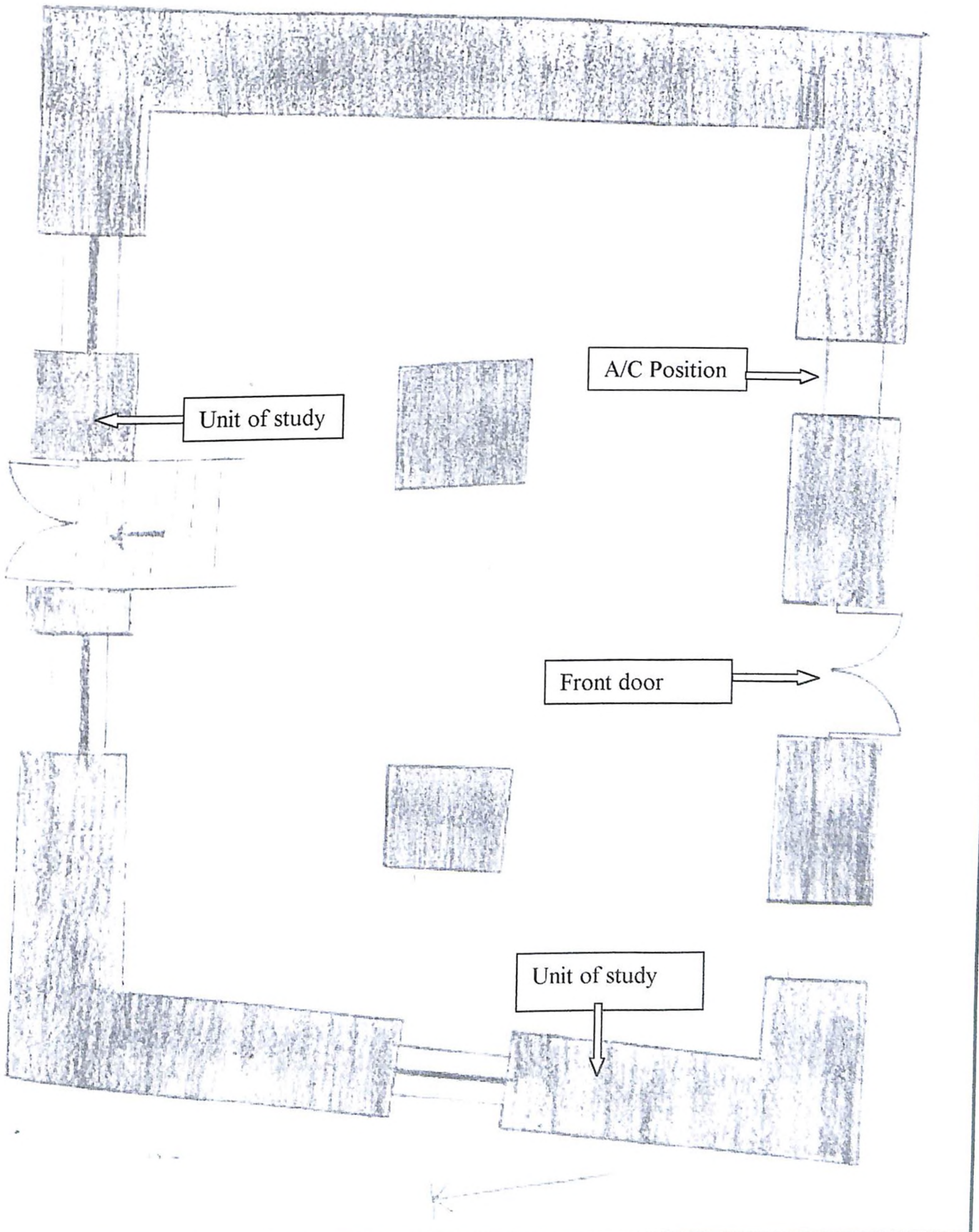


OCEAN SIDE OF FORT JESUS MONUMENT

APPENDIX B: FLOOR PLAN FOR FORT JESUS



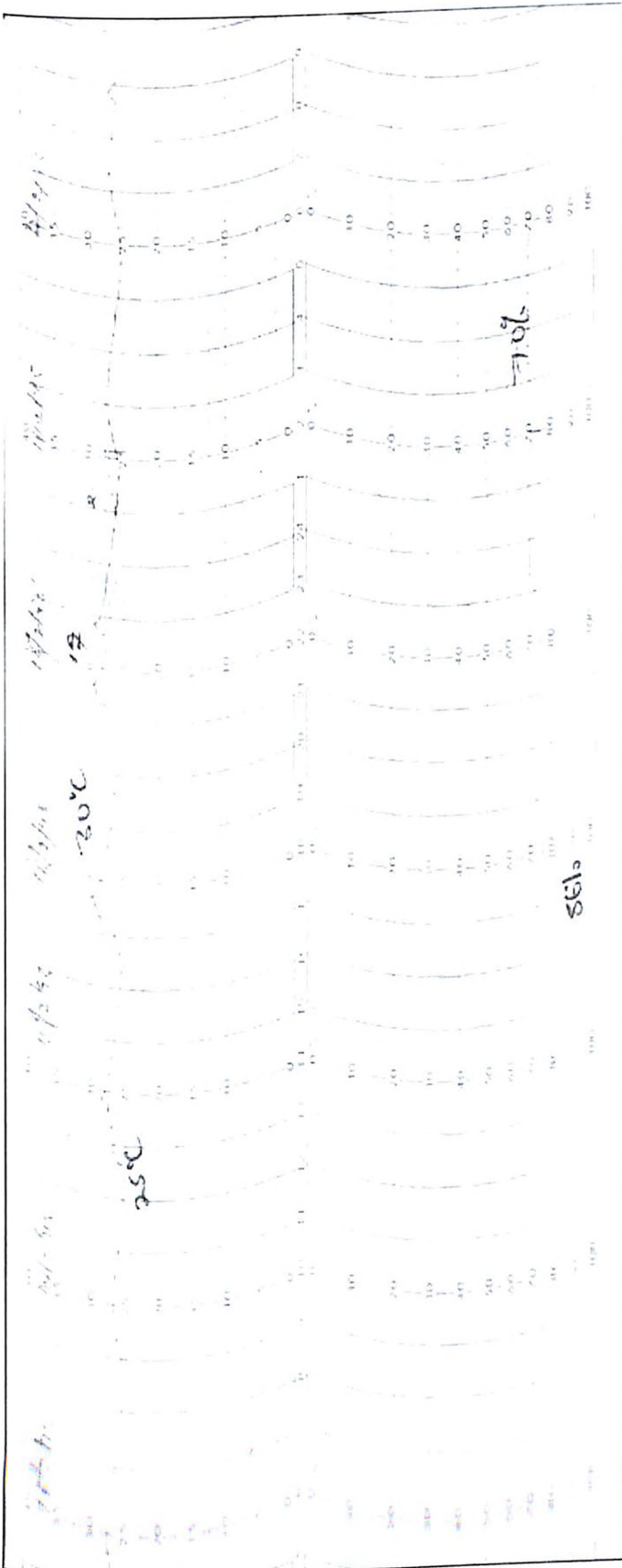
APPENDIX C: Floor plan of the storage.



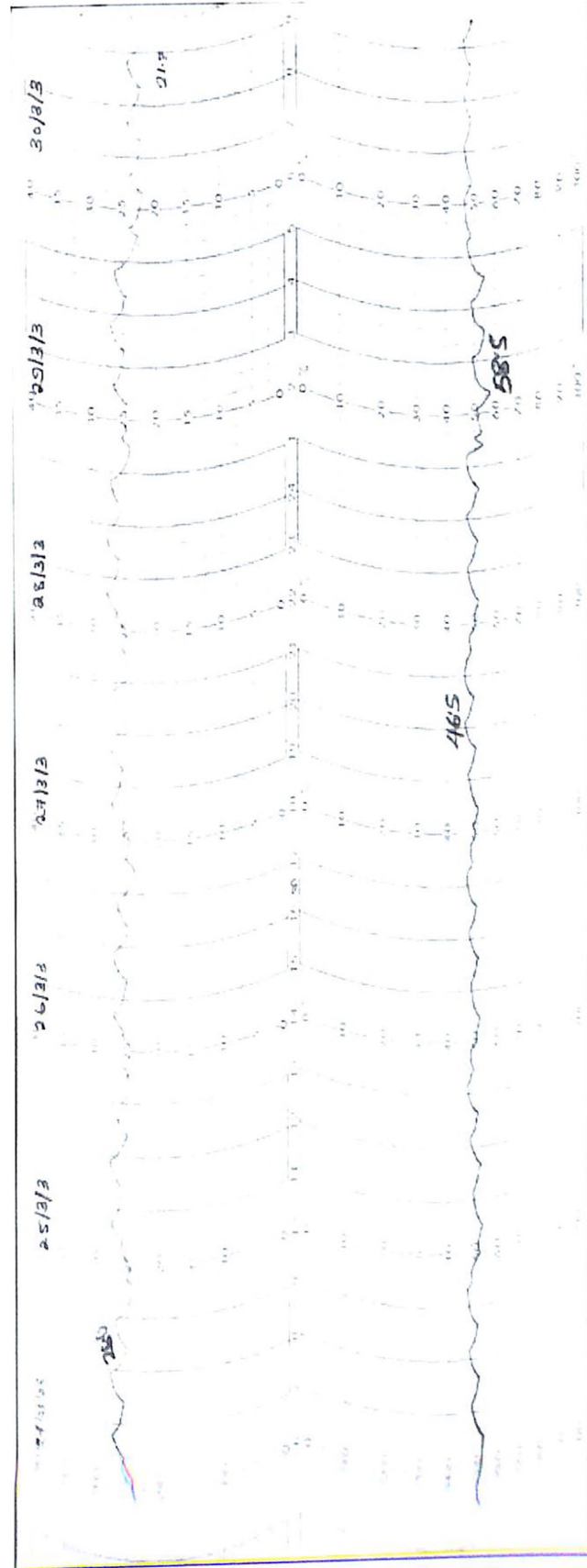
Scale: 2.0665cm: 1m

APPENDIX D: Thermohgograph recordings.

1995



2003



APPENDIX E

OBJECT CONDITION TERMINOLOGY

| | |
|-------------|---|
| ABRADED | Surface eroded by rubbing action resulting in loss of surface/ surface details. A superficial injury caused by rubbing or scraping resulting in an area of denuded surface. |
| ACCRETION | Discrete material formed by the adhesion of separate particles present on the surface of an object obscuring surface detail. |
| BENT | Physical distortion of rigid material resulting from application force |
| CHIPPED | Loss of small flattish fragments of an object surface as a result of sharp blow |
| CONCRETION | A hard solid mass of discrete material deposited on the surface of object |
| CORRODED | Significant chemical conversion of object material, usually metal to new chemical compounds. The degradation of metals or alloys due to chemical reactions with their environment, accelerated by the presence of acids or bases; for example, the rusting of metal surfaces exposed to moist air or to impure water. |
| CRACK | Visible partial fracture in the object material surface/structure that extends through the thickness of the layer, with parts remaining in contact. A fissure or fracture caused by the effects of stress on weak or weakened parts of a material |
| CRAZED | Irregular open network of interconnected cracks on the surface of an object material |
| DELAMINATED | separation of layered elements on an objects surface/structure |
| FLAKING | Thin sheets of material that are loose and liable to become detached as a discrete layer |
| TARNISHED | A thin film of corrosion overlaying metal surface, usually made up of sulphides, that discolours the surface of a metal |

APPENDIX F

CONDITION ASSESSMENT OF ARCHAEOLOGICAL METALLIC OBJECTS

RANGE OF FACTORS TO BE ASSESSED.

- Major structural damage
- Minor structural damage
- Surface damage
- Disfigurement
- Chemical deterioration
- Biological deterioration
- Poor repairs/previous treatment
- Accretions which are not part of the object of its history

(Keene, 1996.p145)

APPENDIX G

CATEGORIES FOR OBJECT CONDITION ASSESSEMENT

GOOD: Object in its context is in good conservation condition or is stable (likely to be displayed with no or little work.

FAIR: Fair condition, disfigured or little damage but stable, needs no immediate action, needs no work for safe storage.

POOR: Poor condition, and/or restricted use and/or probably unstable. Action desirable (a conservation priority)

UNACCEPTABLE: Completely unacceptable condition, and/or severely weakened, and or highly unstable and actively deteriorating, and/or affecting other objects. Immediate action should be taken.

Elizabeth Pye. Lecture Notes.

APPENDIX H: CONDITION ASSESSEMENT FORM

FORM 1: CONSERVATION ASSESSMENT FORM FOR METALLIC ARCHAEOLOGICAL OBJECTS.

Conservation needs score: 1- treatment essential for object survival
 2- treatment desirable but not essential
 3- object stable, no need for intervention

Treatment: 1- active treatment required
 2- minimum passive treatment for stability only
 3- no treatment required

| Accession No. | Item description | Treatment Need 1-3 | Conservation Need 1-3 | Comments | Location in storage |
|---------------|------------------|--------------------|-----------------------|----------|---------------------|
| | | | | | |
| | | | | | |

APPENDIX I

| 4.2 FORM 2: METALLIC OBJECTS CONDITION ASSESSMENT | | | |
|--|-------------|------------------|--|
| Date: | | | |
| Acc. Number: | | | |
| Simple name: | | | |
| Brief description: | | | |
| Damage: <ul style="list-style-type: none"> • Major structural damage • Minor structural damage • Surface damage • Disfigurement • Chemical deterioration • Biological deterioration • Repairs/previous treatment • Accretions | Tick | Comments: | |
| Condition: C1 Good C2 Fair C3 Poor C4 Unacceptable | | | |
| Work required: None Very little Little More | | | |
| Priority: 1 2 3 4 | | | |
| Recorder..... Date.....2003 | | | |

METEOROLOGICAL DEPARTMENT

APPENDIX ^{MOMBASA} Temperature readings for Mombasa area.

Station

JANUARY (0600Z)

2003
19

Reading of TEMPERATURES / RH

For

JANUARY 2003
TEMP RH

FEBRUARY 2003
TEMP RH

MARCH 2003
TEMP RH

APRIL 2003
TEMP RH

MAY 2003
TEMP RH

| Date | AV. 26.2 | AV. 83 | AV. 27.6 | AV. 81 | AV. 28.2 | AV. 79 | AV. 27.2 | AV. 76 | AV. 28.0 | AV. 72.4 | | | |
|------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-------------|--|--|--|
| 1 | 25.6 | 77 | 26.6 | 82 | 26.0 | 88 | 27.8 | 77 | 28.2 | 67 | | | |
| 2 | 26.0 | 80 | 27.2 | 82 | 27.2 | 84 | 26.9 | 81 | 27.0 | 74 | | | |
| 3 | 25.3 | 85 | 25.7 | 92 | 27.7 | 74 | 27.4 | 79 | 27.2 | 71 | | | |
| 4 | 26.3 | 79 | 27.6 | 82 | 28.0 | 78 | 27.2 | 79 | 28.2 | 65 | | | |
| 5 | 26.8 | 74 | 26.9 | 87 | 26.0 | 74 | 26.1 | 83 | 26.9 | 73 | | | |
| 6 | 24.4 | 94 | 27.9 | 78 | 26.7 | 84 | 27.4 | 77 | 28.5 | 70 | | | |
| 7 | 25.4 | 88 | 26.7 | 87 | 27.1 | 83 | 26.8 | 78 | 28.1 | 72 | | | |
| 8 | 26.3 | 82 | 27.0 | 80 | 27.4 | 83 | 27.6 | 73 | 26.7 | 82 | | | |
| 9 | 26.0 | 86 | 27.4 | 80 | 28.5 | 78 | 26.8 | 76 | 28.1 | 66 | | | |
| 10 | 26.8 | 78 | 27.2 | 79 | 27.8 | 82 | 27.6 | 72 | 27.7 | 75 | | | |
| 11 | 26.8 | 78 | 27.1 | 83 | 27.7 | 79 | 26.5 | 81 | 28.1 | 67 | | | |
| 12 | 26.4 | 77 | 27.8 | 79 | 27.7 | 78 | 25.2 | 90 | 28.0 | 71 | | | |
| 13 | 25.8 | 82 | 27.7 | 80 | 29.5 | 73 | 25.4 | 79 | 27.2 | 76 | | | |
| 14 | 26.0 | 82 | 27.5 | 84 | 28.6 | 78 | 27.5 | 68 | 27.3 | 77 | | | |
| 15 | 24.8 | 86 | 27.2 | 82 | 28.6 | 80 | 25.9 | 82 | 28.7 | 66 | | | |
| 16 | 27.3 | 74 | 28.2 | 78 | 28.3 | 78 | 26.2 | 82 | 28.6 | 70 | | | |
| 17 | 27.1 | 75 | 27.6 | 83 | 29.0 | 78 | 28.0 | 68 | 28.6 | 71 | | | |
| 18 | 25.5 | 89 | 28.2 | 78 | 29.6 | 74 | 28.0 | 74 | 27.0 | 82 | | | |
| 19 | 26.2 | 79 | 28.0 | 80 | 29.8 | 67 | 27.0 | 79 | 28.2 | 71 | | | |
| 20 | 27.3 | 77 | 27.0 | 85 | 29.3 | 68 | 27.8 | 71 | 28.4 | 71 | | | |
| 21 | 27.2 | 79 | 27.4 | 84 | 28.0 | 80 | 27.4 | 70 | 28.6 | 73 | | | |
| 22 | 25.0 | 95 | 28.0 | 75 | 28.6 | 77 | 28.2 | 65 | 27.8 | 76 | | | |
| 23 | 26.6 | 85 | 28.5 | 77 | 28.6 | 77 | 28.3 | 76 | 29.2 | 65 | | | |
| 24 | 27.0 | 83 | 28.2 | 78 | 28.6 | 81 | 26.2 | 81 | 29.0 | 70 | | | |
| 25 | 26.5 | 81 | 29.2 | 75 | 28.7 | 78 | 27.8 | 71 | 28.8 | 73 | | | |
| 26 | 26.8 | 83 | 29.0 | 78 | 28.7 | 75 | 27.4 | 76 | 28.6 | 75 | | | |
| 27 | 25.5 | 92 | 27.0 | 92 | 28.6 | 77 | 28.6 | 66 | 27.7 | 80 | | | |
| 28 | 26.2 | 90 | 28.0 | 78 | 26.3 | 91 | 27.7 | 78 | 27.7 | 78 | | | |
| 29 | 27.2 | 84 | 28.0 | 79 | 28.5 | 77 | 26.4 | 76 | | | | | |
| 30 | 26.7 | 83 | 27.6 | 82 | 27.6 | 78 | 27.5 | 67 | | | | | |
| 31 | 25.1 | 96 | | | 28.2 | 73 | 27.2 | 71 | | | | | |

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REPUBLIC OF KENYA