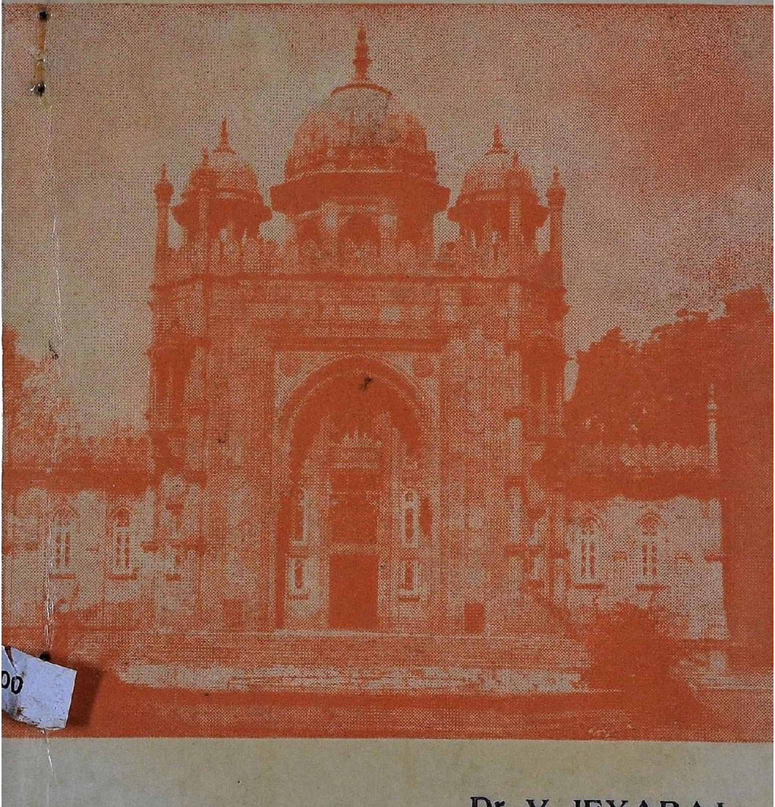
Hand Book

on

CONSERVATION IN MUSEUMS



Dr. V. JEYARAJ

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CONSERVATION IN MUSEUMS

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M. Ramu, I.A.S.
Commissioner of Museums

Government Museum,
Madras - 600 008.

FOREWORD

This publication on "Conservation in Museums" brought out by a devoted Conservation Scientist, Dr. V. Jeyaraj of the Government Museum, Madras fulfils a long felt need of the curators, museologists and specialists as well as learners in this area of work. It is hightime that we realise the importance of conservation measures right earnest to preserve museum objects on scientific lines starting from collections, storage and display of these pieces. As here are attendent gaps inherent in the areas of preservation of specimens, there is greater need for a package of guidelines for applying various techniques in preserving these objects.

The major constraints in the area being availability of funds, it is still important to build up a shelf of projects and fix up priorities so that sectoral projects could be taken up in a phased manner with the financial assistance from Government and institutions specially working for the development of museums.

The Chemical Conservation Laboratory of this museum established in the year 1930 is one among the well known laboratories in our country comparable with the Delhi National Museum and Government Museum and Art Gallery, Baroda.

The author, Dr. V. Jeyaraj with his vast experience in this field for nearly two decades has combined his scholarship with practical experience in bringing out this unique publication.

I am sure this book will serve the cause of conservation of museum objects in a substantial measure besides a source material for the curators, archaeologists and all those who are working in this vast and expanding discipline.

Madras - 600 008
22.6.1995

M. RAMU
Commissioner of Museums

PREFACE

Museums, galleries, archives, libraries, temples, churches, mosques etc., play a very important role in preserving our art and cultural heritage. Out of them museums top the list as they engage themselves in the collection, preservation, display of the objects, cataloguing them doing research on them, bringing out publications on them etc., as a routine affair besides public relations, outreach programmes, conducting training programmes, etc. Museums add their collections through various means like field collection, as treasure-trove finds, gifts. The preservation of these collections cause great concern among the curators, conservators, collectors etc. Natural and manmade agencies pose mainly conservation problems. Therefore proper maintenance and conservation guidelines to safeguard the objects are essential. Government Museum, Madras is a multipurpose museum which established a chemical conservation laboratory in 1930 to preserve the metallic antiquities. Then in the later years, its scope was extended to the conservation of all types of museum objects. There was a great demand for publication of a book in conservation as a guide and source book for those who are engaged in the preservation of art and cultural objects. Therefore, this handbook on 'Conservation in Museums' has been written by me with the experience I gathered as a conservation chemist in this department over 11 years and as a curator of multipurpose district museums for about 8 years. My recent visit to various museums in the United Kingdom, Germany and France has added up my expertise to this book. I hope this handy book will be a source book for those interested in preserving our art and cultural heritage for posterity as well as those who are interested to learn conservation.

I would like to thank Mr. S. P. Elangovan, I.A.S., Secretary to Government, Tamil Development and Culture Department, Government of Tamil Nadu for his encouragement and his acceptance to release the book on 30.6.95 during the valedictory function of the 21st Refresher course on "Care of Museum objects" at the Government Museum, Madras. I am thankful to Mr. M. Ramu, I.A.S., Commissioner of Museums I/C who was instrumental for writing this book and for his foreword to this book.

I am thankful to the Assistant Directors of Museums Mr. S. Thangavelu and Dr. N. Devasahayam for making available all the facilities to bring this publication through the DTP unit of this museum. I thank all the technical and ministerial staff who were helpful in this task. I will fail in my duty if I do not thank Mr. J. D. Jagannathan, Laboratory Assistant and Mr. B. Saravanan, Technical Assistant who assisted in all the activities in the laboratory. I am grateful to all those who encouraged me to bring out this publication as a publication of this department.

Madras - 600 008.
22.6.95

V. JEYARAJ
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Part I
General

INTRODUCTION

A museum was considered as a temple of the muses - *mousein* (Greek) upto 15th Century. In the 15th Century museum was considered as a building used for the storage and exhibition of historic and natural objects. In Venice, for the first time museum was made available for visitors in 1523. In 1625 a collection of biological specimens and artefacts by John Tradescant and his son at Lamberth, London was available for public. In India the first museum was started at Calcutta in the beginning of this Century. The first museum in Tamil Nadu was started in 1851. The museum movement took a shape in the 1950's and now in India over 400 museums are present which are of various categories like National Museums, Regional Museums, State Museums, District Museums, University Museums, Local Authority Museums, College and School Museums, Private Museums depending upon the agencies which run the museum. Depending upon the activities of the museums they are classified as Multipurpose Museums, Archaeological Museums, Science Museums, Transport museums, Personalia Museums etc.

Nowadays, museums are institutions which preserve the hoary and glorious past through the original materials for posterity besides making the visitors to understand them and enjoy. Most of the earlier day museums were established because of the bequest of rare objects by individuals . Nowadays state governments are taking keen interest to establish museums. The Department of Museums, Government of Tamil Nadu is keen in opening museums in the district headquarters in order to make the people of the district to know about their past and the materials of the state besides giving information and enjoyment to the visitors. At present there are 13 museums run by the Government of Tamil Nadu.

Museums are actively involved in increasing their collections through field collections, gifts and exchanges, purchases and treasure-trove finds. The major archaeological collections like bronze icons, coins, jewelleries are through the treasure-trove act of 1878. Acts like Treasure-trove Act of 1878, the Antiquities (Export Control) Act 1947 help the museum to preserve the precious antiquities for posterity. The important roles of a museum are collection, preservation, documentation, display, research, publication, outreach, public relation, training etc. Among the various activities of the museums conservation is the most important one.

The museum objects are varied both material-wise and subject-wise. Objects of daily use, utensils and tools, paintings and decorations, folk art, ethnographic, tribal, cultural and contemporary art, natural history etc., are not having similar properties. Many of us think that once an object enters the museum the responsibility of the curator is over. Those objects before their entry to museum attained an equilibrium with the surroundings. But most of the objects try to deteriorate as soon as they reach the museum as the new environmental factors start to interact with the objects.

Infact conservation of cultural property means remedial measures to be taken to eradicate the defects already present in the objects and protecting them from further damage by maintaining certain conditions for their better preservation. To remedy the defects present in an object and to remove the unwanted materials, one has to examine the object, diagnose the defect, documenting its condition and the type of treatment needed and then treat it. The custodians should know, therefore the properties of the objects, their chemical behaviour and the effects of environment and other causes of deterioration.

In the European countries most of the museums have classified their collections areawise not materialwise and so the head of the collections has to know much about all the materials. The objects are better preserved when custodians, conservators, designers and administrators co-ordinate. In India most of the museums are headed by a curator who may be a specialist in a particular subject. Very few museums have the conservation facilities with them. Proper house keeping will help the objects to be in a good environment. If the custodian is aware of the dangers involved and precautionary measures to be taken against them, he can preserve them better. He should know the deteriorating factors, the symptoms of deterioration, methods of handling the objects, display techniques, storage principles, packing devices, transportation, safety measures, vandalism, neglect etc., for better maintenance of his collections.

Conservation is the term nowadays spelt in the museum quite often as a profession. There is also a widespread term called *restoration*. Restoration is any action taken in order to bring the object, as far as possible, to its original state. But, conservation is the action taken to determine the nature or properties of materials used in any kind of cultural holdings or in their housing, handling or treatment; any action taken to understand and control the causes of deterioration; and any action taken to betterment the condition of such holdings. Therefore conservation includes preservation and restoration.

ACTS FOR PRESERVING ANTIQUITIES AND MONUMENTS

In order to preserve the antiquities and monuments, the Government of India enacted acts. i) Indian Treasure-trove Act No.VI of 1878 (ii) Ancient Monuments Preservation Act, 1904 and (iii) Antiquities (Export Control) Act 1947.

Indian Treasure-trove Act No. VI of 1878:

As per the Indian Treasure-trove Act No.VI of 1878, whenever any treasure exceeding in amount of value ten rupees is found, the treasure should be handed over to the District Collector and the Collector after necessary enquiries with the finder, land-owner etc., and in consultation with the Director of Museums, fixes the value of the treasure and hands them over for preservation in the museums. The finder and the land owner get a suitable compensation (in cash) which is calculated from the existing metal value and 20% antique value.

ii) Ancient Monuments Preservation Act 1904:

The ancient monuments preservation act, 1904 has three parts. 1) protection of ancient monuments, 2) arresting the movement of movable objects of historical importance and 3) protecting historically important sites and prohibiting excavations.

Under this act historic, artistic monuments are declared as protected monuments. It restricts removal of any artistic sculptures etc., without the written permission of the district Collector. It restricts the excavation of historical sites also.

iii) Antiquities (Export Control) Act 1947:

In order to prevent the export of antiquities and art objects the Government of India enacted Antiquities (export control) Act of 1947. According to this act, coin, sculpture, manuscript, epigraph or other work of art or craftsmanship, and article, object or thing detached from a building or cave, any article, object or thing illustrative of science, art, crafts, literature, religion, costumes, morals or policies in bygone ages, articles, any object or thing declared by the Central Government by notification in the official gazette to the antiquity for the purpose of this act, which has been in existence for not less than one hundred years.

CLASSIFICATION OF OBJECTS

Any object representing culture, art etc., preserved in a museum qualifies itself to be a museum object. They vary from one to the other due to nature, type, property etc. Their vulnerability to damage and their control measures also differ.

Depending upon the type of treatment to be given to the objects they can be classified as follows:

1. Metals
2. Organic objects
3. In-organic objects
4. Paintings.

Metals:

Metals and alloys form a major portion of museum collections. They are bronze icons, bells, vessels, weapons, jewelleries, coins etc. They are affected by corrosion. The corrosion products should be removed and stabilised avoiding further corrosion.

Organic Objects:

Materials derived from living organisms are organic objects. Wooden objects like temple cars, doors, vahanas, clothes, palmleaves, leather objects etc., are prone to climatic changes. The environment should be stable and the objects should be attended to carefully as they are easily affected by insects also at large.

In-organic Objects:

Inorganic materials are very stable. They are complex in nature. Stone pillars, sculptures, inscriptions, terracotta objects etc., are some of the inorganic materials. They are mostly exposed to the atmosphere and are affected both by rain and weathering takes place. They should be treated and preserved.

Paintings:

Whatever may be the medium, type and variety, the paintings are multi layered and therefore, they require special study and treatment.

ATMOSPHERIC FACTORS AFFECTING MUSEUM OBJECTS

Conservation refers to the whole subject of the care and treatment of museum objects both movable and immovable. The two aspects of conservation are the control of the environment to minimise the decay of museum objects, and their treatment to arrest decay and to stabilize them where possible against further deterioration. Therefore one who is interested in the conservation of museum objects must know the damaging effects of the environment on them such as light, humidity and air pollution, sound and vibration and what to do to minimise this damage.

Light:

Light is a form of energy. It can change colours, can bring about deterioration on the surface; where surface is the very essence of exhibits like paintings, drawings, textiles and can bring down the strength of the object. Stone, metal, glass and ceramics are not affected but all organic objects such as cellulosic and proteinaceous are affected. Light is much more potent than heat as far as art objects are concerned. The spectrum of radiation from museum light sources such as day light, fluorescent and incandescent lamps etc., can be divided into three regions, by wavelength. They are ultraviolet radiation (300-400ηm), light or visible radiation (400-700ηm) and infrared radiation (beyond 700ηm). The light of wavelength upto 500ηm brings about degradation on materials by photochemical reaction. Therefore the light should not directly fall on the objects, but only reflected light from a surface painted with zinc oxide or titanium oxide should be allowed. These chemicals absorb the ultra-violet radiations from the light.

All textiles are subject to damage by light, as many of the colours used in miniatures, water colours and art on paper, natural history specimens are sensitive. Oil paintings change more with light. The paint medium whether oil, egg, gum or glue, is certainly damaged by light.

Both the ultraviolet and the visible radiations are absorbed by the colours of the materials and they deteriorate. Day light has the highest proportion of UV radiation and therefore, it must be filtered. Fluorescent lamps have less UV radiation than day light but they need to be filtered. Light from incandescent lamps need not be filtered as they do not emit UV radiation. The illuminance of light is measured in terms of lux. Digital lux meter is used to measure the intensity of light. Different papers like

Rhodamine B paper, to monitor the visible light and litharge paper, to monitor ultra-violet radiation have been developed. By the change of colour the corresponding intensity of various lights can be inferred. The rate of damage depends on the exposure. The exposure is the simple product of illuminance and time. Therefore in order to reduce damage to objects by light, we have to reduce both illuminance and time. When we want to control the illuminance it is better to have artificial lighting upto 50 lux. In order to avoid glare and have a good look of objects, the light should be partly directional and partly diffused. Fibre optics are nowadays used in the European museums.

The problem of day light in museums is not yet solved.

There are many ways of reducing exposure in particular circumstances that the most that can be done are as follows:

1. Limited exhibition materials should be brought out from stores.

2. Illumination should be given only during opening hours.

3. Illumination may be provided only while on view.

4. Use of replicas may be thought of.

5. Curtains over desk cases are a best conservation measure which should be followed.

Heat:

A small change in temperature can have several effects. But temperature change is not as important as humidity change except when it, in effect, causes humidity changes by drying.

Storage at low temperature can be of benefit to archival materials and textiles. Excessive radiant heat must be avoided, but there should be no problem at 50 or 200 lux of light. Rise in temperature influences the rate of deterioration by light.

Humidity:

The moisture content of air is humidity. Objects originated from plants and animals have water in them. If the moisture is taken away from wood, ivory or bone, they contract and very likely split and warp. The absorption of moisture makes objects to swell and vice-versa. In changing size they also may change shape or warp. Many museum objects are made of composite materials. The humidity is measured by a scale of relative humidity (R.H.).

$$\text{Relative humidity} : \frac{\text{Amount of water in a given quantity of air at a given temperature}}{\text{Maximum amount of water which the air can hold at that temperature}} \times 100\%$$

There are various instruments to measure the R.H. They are sling or whirling hygrometer or sling psychrometer, hair hygrometer, recording hygrometer, electronic hygrometer etc. Use of a reliable electronic hygrometer with self-checking device or of a wet-and-dry-bulb instrument is essential for calibrating other R.H. recording instruments.

Various classes of museum materials respond to R.H. The different modes of deterioration which are influenced by R.H. are physical, chemical and biological modes. All moisture absorbent materials, such as wood, bone, ivory, parchment, leather, textiles, basketry and matting, and adhesives swell when the R.H. rises and shrink when it falls, causing warping, dislocation between parts, splitting, breathing of fibres, etc., especially at low R.H.

Most insect pests flourish at higher humidities. Very low humidity would be a preventative measure but impracticable. Insect damage may be discouraged but cannot be prevented by humidity control.

Humidity Control:

Air-conditioning is the best way as it not only controls humidity but also removes dust and gaseous pollutants from the air. One single equipment cannot humidify and dehumidify. Therefore, humidifier or dehumidifier can operate but with a humidistat, which maintains a constant R.H. by switching a heating system on and off.

There are electrically operated humidifiers of atomising and evaporative types and dehumidifiers of desiccant and refrigerant types. For humidification, an evaporative type of humidifier should be chosen because of its convenience. For dehumidification in warm climates a refrigerative type of dehumidifier and in cold climates a desiccant type should be used.

In the show cases a buffer can be used. A buffer is a moisture - containing solid which, when the R.H. rises, absorbs moisture and gives it out when the R.H. falls. The best buffer is silica gel, not in its dry form, but brought into equilibrium with air of the required R.H. 20 kg silica gel per cubic metre of case volume is suggested for best result.

In the closed cases a bowl of specified solutions may be kept in which the water will evaporate and gives R.H. depending on the salt. At 20°C magnesium nitrate gives, in practice, about 50% R.H. and sodium bromide about 58% R.H.

High R.H. in museum buildings are due to flood and high monsoon floods are rare, but dampness in buildings is the main cause for humidity. Dampness in buildings may originate from roof, foundation, exposed wall, plumbing failure, toilets or drinking water facilities etc. It may also be carried in by visitors. This dampness may be brought to control in the event of no humidity control system by ventilating the outside climate through windows, dry conditioning by electric immersion heaters and fans.

In the event of dry weather bowls of water may be kept at spots. The window *cus-cus* curtains may be moistened to allow cool air inside the galleries.

Air Pollution:

Air pollution is one of the serious dangers posed to museum objects. The various means by which air pollution created are, particulates, gaseous pollutants, salt sprays, sound and vibration. Air pollution, therefore, is the contribution of various factors.

Particulates:

Particulate matter in the atmosphere is due to expulsion of smoke in the factories, due to fuel combustion, vehicular traffic, salt spray from the sea, etc. The normal level of particulate matter in a clear weather is 0.9 to 1.5 microgram per cubic metre. In a highly industrial area or a foggy weather it goes upto 5 microgram per cubic metre. The walls of new concrete buildings give off dust of alkaline in nature inside the buildings.

Removal of Particulates:

Particulate matter can be avoided to certain level by well made closed show cases in exhibition rooms and polythene bags in storages, providing screens to windows, foot-mattresses at the entrances, regular vacuum cleaning etc. Removal of particulates involves full ducted air-conditioning so that air passes through the filters. Disposal of waste by firing should be avoided in the campus as it creates particulate matter in the campus.

Gaseous Pollutants:

Like the particulates, gaseous pollution is caused at large by the burning of fuels in power-station, factories, domestic buildings and automobiles. There are various pollutants in the atmosphere. They are oxides of sulphur, nitrogen and carbon, ozone, hydrogen sulphide etc.

Oxides of Sulphur:

When the fuel is burnt the sulphur combines with oxygen in the air to form sulphur dioxide. Sulphurdioxide further combines with oxygen to form sulphur trioxide. As soon as this is formed it combines with water to form sulphuric acid. Sulphuric acid is a very strong and corrosive chemical and it cannot be removed by cleaning the air because of its involatility. The chief materials to suffer from sulphur dioxide pollution are calcium carbonate containing materials like marble, limestone, frescoes; cellulosic materials like paper, cotton, linen; proteinaceous materials like silk, leather, parchment and wool, other organic materials; metals etc.

Oxides of Nitrogen:

There are various oxides of nitrogen; among them nitrous oxide and nitrogen peroxide are harmful to museum objects. But nitrogen oxide has a concern in the museum environment. It is soluble in water and forms a strong acid, nitric acid. It is more dangerous than sulphuric acid.

Carbon dioxide:

The oxides of carbon are carbon monoxide and carbon dioxide. Carbon dioxide dissolves in water in the atmosphere to form carbonic acid. Even though this acid is weak it affects all organic materials.

Ozone:

Ozone is a poison found at high concentration in polluted areas. Ozone can enter the museum from three sources; by the natural production in the upper atmosphere, by the effects of sunlight on automobile exhaust gases and from certain kinds of lamp and electrical equipments which are used inside the museums.

Ozone affects unsaturated organic compounds. Ozone also increases the rate of oxidation of silver and iron and sulphidation of silver and copper.

Salt Sprays:

The salts which may be present in dust in the air are chlorides, silicates, carbonates, ammonium sulphates etc. The chlorides are the most dangerous contaminant which affects metals. Droplets of sea water are thrown into the air, and they may evaporate to form sodium chloride crystals which are carried by the wind inland. Infact only coastal museums will be affected most. Research has indicated that a level of upto 5 micrograms per cubic metre of chloride may be found anywhere, even far inland.

Pollution from the Materials of Display and Storage:

Even though we are able to eliminate all outside pollutants there is a problem from within the show cases and storages, contributed by the materials used. Some types of rubber, composite board, wood used in the display cases and storages give off organic vapours such as organic acids, volatile sulphides and they affect metals especially, lead, silver and photographic materials. The adhesives used give off certain harmful gases. Cellulose nitrate gives off nitrogen oxide vapours, poly vinyl chloride gives off hydrogen chloride. Materials used for display and storages are subjected to Oddy's test (finding out the increase of weight of a polished copper foil after exposing it to sulphide atmosphere) to find out their suitability for the display and storage purposes in the museum.

Removal of Gaseous Pollutants:

It is essential to keep the museum objects out of the contact of the gaseous pollutants. There are two well known methods for removing the gaseous pollutants in the museum environment. They are (1) water spray methods and (2) activated carbon filter method . In the water spray method air is passed through a water spray in the air conditioner by which the soluble oxides of nitrogen, sulphur and carbon are absorbed. But ozone is not absorbed by this system.

Activated carbon filters and copper impregnated activated carbon are used to absorb the gaseous pollutants. They have to be replaced periodically. Copper impregnated activated carbon filters are replaced once in 5 years. Disposal of waste materials by firing should be avoided to cut off the oxides in the campus.

Sound and Vibration:

Sound and vibration affect weak museum objects. Sound affects museum objects and therefore a specification is suggested for maximum allowable back ground noise from traffic and local machinery in an exhibition or storage area. Vibrations caused by building work, traffic, ventilation equipments and other machineries affect weak museum objects. High frequency sound and vibration should be avoided in the galleries and storage areas. Rubber cushioning may be provided for weak objects on display and storage.

BIODETERIORATION

There are various agencies like light, heat, humidity, pollution, micro-organisms which have deteriorating effects on the materials of museum objects. Of these agencies biological agencies like microorganisms and insects of various kinds are the most devastating. Almost all classes of museum objects such as stone sculptures, metal objects, cellulosic and proteinaceous objects, paintings are damaged by these agencies.

Biodeterioration is any undesirable change in the properties of the materials effected by the activities of the living organisms. Tropical climate favours biodeterioration. Temperature between 25°C to 35°C and relative humidity above 70% favour biodeterioration.

Symptoms of Biodeterioration:

The activities of the biological agencies can be noticed only by a close examination of the objects regularly. As soon as some changes are noticed on the objects they should be investigated seriously.

Stains and Discolouration:

Because of the biological activities stains are formed in the objects. *Foxing*, a brown spot formation, in paper is due to microorganisms. Excreta of the insects, dead insects create stain on the objects. Because of the excreta of insects, the pigments are dissolved and discolouration takes place.

Erosion:

Because of the frequent passage of certain insects erosion occurs on the object.

Disfigurement:

Insects eat away portions of the objects and permanent disfigurement is created. eg. photographs are eaten by silverfish, wooden objects are eaten by termites.

Pitting:

The surface of objects are pitted and become rough; metals by corrosion; stone by sulphate reducing bacteria.

Tunnelling:

Insects eat the materials and tunnel through them leaving holes.

Firbillization:

Because of the action of the biological agencies composite materials become fibrous.

Powder Formation:

Even though the insects are not visible, their action will be revealed by the powder falling from the objects.

Development of Odour:

Distinct smell will be emanated when fungal growth is active. The death of rodents etc., will be inferred from the bad smell.

Changes in Properties:

Mechanical and chemical properties arc lost. For example, materials become weak.

Insect:

Organic objects like wooden objects, leather, textiles, books, biological specimens etc., are worst affected by insects. Insects bore holes into the materials and eat voraciously. The insect menace is high due to high temperature and humidity.

Some of the most common insects attacking materials are silverfish, cockroaches, termites, moths, beetles, book-lice and crickets.

Silverfish:

Both the young ones and adults cause surface damages to paper, eat away glue, paste etc., from books and documents, herbarium specimens, photographic plates, paintings of the Tanjore style as they involve, paper, textile and paste. In order to eradicate them 5% D.D.T., B.H.C. or Pyrethrum in kerosene is sprayed.

Cockroach:

Both the adults and young ones damage wool, leather, paper, herbaria, ethnographic and natural history materials, palmleaves. 5% D.D.T., Chlorodane, B.H.C. or Pyrethrum in kerosene as a spray, sodium fluoride, gypsum (1:1) as poison powder, Baygon Bait are the effective insecticides.

Termite:

There are two main categories of termites. They are dry-wood termites and subterranean termites. The subterranean termites maintain a link with the earth, whereas the dry-wood termites live in wood. Adults bring about irreparable loss or damage to wooden objects, furniture, showcases, panels, books, textiles and other cellulosic materials . Structural timbers may be coated with creosote, zinc chloride or sodium fluoride. AsCu (Dichromate - 4 parts, copper sulphate-1 part, arsenic pentoxide-1 part and water 100 parts). Sprays of Dieldrin, Aldrin, Dursban TC, D.D.T., B.H.C., Chlorodane eradicate termites. Subterranean termites may be eradicated by treating the soil of the affected area by drilling pits and filling them with the solution of insecticides. Fumigation with ethyl bromide or carbondisulphide is good for small wooden artefacts.

Book-lice:

Adults of book lice cause surface damages to paper, herbaria, leather, gelatine of photographic plates, Tanjore panel paintings, water colour paintings etc. Such materials are fumigated with paradichlorobenzene. Naphthalene balls are also used. A spray of 5% D.D.T. in kerosene may be given to the object.

Clothes Moth:

The active stage of the insect pest, clothes moth is the larval stage. It destroys woollen fabrics, hair, fur, feather, stuffed mammals and birds. Fumigation may be done with 1% penta chlorophenol in alcohol. Arsenical paste (arsenic trioxide, alum, soap) is used in stuffing mammals and borax in case of birds. Fumigation may be done with paradichlorobenzene. Naphthalene balls may be used.

Beetle:

The larval stage of the beetles are active in damaging objects. The carpet beetles feed on hair, wool, feather, leather, etc. The hide beetle damages leather, stuffed birds, dried fish etc. The wood-boring beetles bore into wooden objects, also book bindings and palm-leaf manuscripts. The book-worm beetles tunnel into books, palmleaves etc. Fumigation with methyl bromide, ethyl bromide or carbon disulphide is an effective measure to control the beetles. 5% solution of pentachloro phenol, Pyrethrum, D .D .T . in kerosene may be sprayed.

Insect Trapping in Museums

In pest control treatment in museums, insect trapping is becoming a favour means of early warning and monitoring of insect pest infestations. Insect traps normally consist of two components. They are an attractant and a killing and retention system. The attractants are food baits, light, coloured surfaces etc.

The insects attracted to the traps are killed and retained until they can be disposed off. Common systems are like electrocution by a high voltage grid, drowning them in the attractant solution, fumigation with a vapour phase insecticide, exhaustion of the insect in a closed container from which it cannot escape, adhesion to a sticky surface, as with fly-paper and sticky traps.

Most types of insect traps are not suitable for use in museums because of their damaging effects on objects.

Most traps used in museums are sticky type ,where the sticky surface forms the base of an open-ended box. In this construction the sticky surface does not get accidentally attached to objects, visitors or staff and is protected from dust and particles which would reduce its efficiency. Small triangular prism shaped traps typically with a base size of 2.5 x 3.0 cm using a synthetic sticky materials of inert poly butenes will be of much use . Window-traps are nothing but a corrugated plastic with a central sticky well, have been found useful in catching larval forms of some pest insects. Owing to their see-through window over the sticky well, the window traps are valuable in show-cases etc., where any catch can be seen without opening the case or disturbing the trap.

General Treatment for Insects:

There are two main methods of treatment of museum objects with insecticides. They are:

1. Fumigation and
2. Dusting or application in solution form or fogging.

Fumigation:

Fumigation is nothing but keeping the insect infested objects for few hours in an airtight chamber where volatile fumigants are kept. Paradichlorobenzene, carbon disulphide, methyl bromide, ethylbromide, carbon tetrachloride, Nifol, naphthalene balls, etoxide are some of the fumigants used in the eradication of insects from the infested museum objects of organic nature especially ethnographic, natural history specimens, documents, textiles etc. Even if there is no infestation on the objects, the insect prone objects should be fumigated prior to monsoon. The choice of fumigants is very important as some are toxic and some affect certain materials.

Ethylene oxide has an adverse effect on leather, wet paper, paint, varnish, resin etc. Methyl bromide has an adverse effect on rubber, leather, woollen materials, paper, photographs, feathers etc. Fumigants will not have lasting effect on the objects and therefore periodic fumigation should be done.

Even though the application of insecticides in the solution form either by brushing, injecting or spraying is having certain health hazards, it has long effect on the objects. 5% solution of insecticides like DDT, BHC, DDVP, pentachlorophenol, mercuric chloride are most suitable. Storage, cupboards, drawers, shelves etc., should be treated with the insecticides in the solution form.

Cryptogamic Plant Growth:

Bacteria, fungi, algae, lichen, liverworts and mosses constitute the cryptogamic plants which affect museum materials. Among these, only fungi generally pose very high threat to museum objects. Bacteria are found to flourish only when the moisture content of the medium is very high. Organic objects like wood, textiles, paper, leather musical instruments, certain paintings are disfigured and destroyed to a considerable extent on account of mould growth. Moulds, by reason of their ramifying mycetia, which can seek out moisture from a distance and transport it from one point of growth to another, can grow in atmospheres of little more than 70% relative humidity. Fungi are unable to photosynthesise their own food and hence damage the materials on which they grow. Usually they are aerobic (need air to grow) but some species are an-aerobic also. Fungal spores are present in the atmosphere all the time, but remain dormant. They become active and start developing as soon as conditions of humidity and temperature favourable for their growth occur.

Damages by the Cryptogamic Plants:

Bacteria:

There are various species of bacteria. Sulphate reducing bacteria affects iron objects, stone and sulphur containing objects.

Fungi:

There are various species of fungi like aspergillus species, niger. Paper, cotton, textiles, ethnographic objects, wood, leather, outdoor stone objects, herbaria etc., are affected.

Fungus degrades organic materials like paper, leather, textiles and also causes stain on them. It disfigures paintings, stone objects and wooden materials and chemical and mechanical properties are changed. Oil paintings which have rough surface also found to be affected by fungi at high humidity conditions.

Control Measures:

Control of bacterial and fungal growth on museum objects are two fold. viz, preventive and remedial or interventive. Since moisture is the very important requirement for the growth of bacteria and fungi, humidity control is the best preventive measure. Since most of the museums cannot afford to have air-conditioning facilities, proper air circulation and ventilation may be provided. Cleanliness is essential to avoid bacterial and fungal growth. Therefore organic materials should be dusted using a fine brush or vacuum cleaner.

Fungal infested objects should be brushed off and fumigated. Thymol is a very good fumigant. 5% thymol in rectified spirit spray will be an effective check to fungal growth. Fungicidal paper is prepared by treating filter paper with 10% p-chloro-m-cresol solution or 1% phenyl mercuric acetate solution and then drying it. Panacid is also a good fungicide.

MISHANDLING, NEGLECT AND VANDALISM

Much of wear and tear, as well as accidental damages to museum objects can be significantly reduced by the judicious application of collection care management and adapting certain basic conservation principles. Many damages to the museum objects are attributed to poor handling, lack of training to staff, neglect and vandalism.

Mishandling:

Human factors such as poor handling and lack of training to staff to tackle objects result in serious damages to the objects either in the storage, transportation or in museums.

Careless handling of the objects results in soiling, dents, scratches, abrasions etc.

Damage occurs when objects are dropped, objects tear or break when outsize or heavy objects are hand-carried instead of being transported on trollies. Objects break when they are lifted from points of weakness. Surfaces of objects get damaged when surfaces of objects are dusted or cleaned with coarse or soiled cloths, brushes or vacuum cleaners carelessly.

Neglect:

Neglect of museum objects results in various problems. Areas where any type of work on art objects is done must be kept absolutely clean. Very often it is noticed that perspiration and grease of hands stain art objects. The natural oils from hands, deposited on objects, attract dust which is chemically harmful. It is advisable to wear clean cotton gloves when handling objects of art, or to use a clean cloth between hands and the object. Hands should not touch painted surfaces, as in the case of miniatures or manuscripts, photographs or slides and negatives.

Vandalism:

Vandalism is a deliberate act by which damages are made on the museum objects. Acts of true vandalism are fortunately few. The visiting public are generally respectful of the works of art on display. The motivation of the deranged individual to damage the objects take place in crowded galleries. The defacement of paintings or sculptures with graffiti by pencils, felt pen, etc., particularly on nudes and female figures have moral and behavioural connotations which require study by psychoanalyses. Other instances of willful damage can be attributed to political, religious or racial fanaticism.

In the majority of situations the conservation and security precautions in museums are sufficient to prevent accidental damage, negligence and to inhibit the less determined vandal. These measures include physical or psychological barriers, such as floor elevations, ropes and stanchions or the total encasement of the objects in show cases. These barriers will deter many visitors from approaching too close and touching, marking or accidentally scratching the objects. However, mischievous visitors will find ways to outwit the guard. Other means of security protection depends on the guard's perception of deviant behaviour in visitors. Close circuit TV scanning of queues of visitors can often pinpoint strange behavioural patterns and the guard on duty can be alerted to be more watchful of the individual spotted. Another method is to pass the visitors through airport style security electronic barriers and remove potentially harmful devices.

Whether it is mishandling, neglect or vandalism, it can be reduced to the minimum by the close monitoring of the duties of all the staff and by imparting training to the concerned staff who preserve the museum objects for posterity.

TRADITIONAL CONSERVATION METHODS IN INDIA

The study of the history of various traditional conservation methods in India is much interesting. Parts of plants were used for preserving the cultural heritage, both as insecticides and fungicides.

Metal Icons:

The ancient metal icons are images of gods, goddesses and others created by our ancient craftsmen for worship. Since metals are prone to deterioration, various preservation treatments were done by using naturally available materials like oils, flour, ash, sandal powder etc. The various preservation treatments were oil preservation, flour preservation, sandal preservation etc. These were done on a regular basis. This technique is nothing but the present day poulticing.

Stone Objects:

Stone was used for making sculptures for worship. These stone images were applied with oil as well as milk with an idea of preserving them. The oily accretions were removed regularly by tamarind, which is acidic in nature. By this act the images were protected from all environmental damages. The accretions on stone surfaces are removed by various poulticing methods such as oil preservation, flour preservation, sandal preservation regularly in temples.

Palmleaf Manuscripts:

Palmleaves were used for writing purposes. In the preparation of the palmleaf manuscript itself preservative methods were adopted. Turmeric powder was used to avoid insects and fungi. They were cleaned and bundled by cloths keeping natural materials like dry neem leaves, vettiver, pepper, turmeric powder etc. The palmleaf bundles were normally stored in the lofts of the kitchen. Annually they were cleaned and fumigated on certain festive occasions specially meant for this purpose.

Wood Carvings:

The wood-carvings of the temple cars were coated with *mahua oil* to preserve them. They were annually cleaned by applying curd on them followed by flushing with water. The application of oil and curd kept the wood carvings free from deterioration and drying.

Environment Treatment:

The temple areas and even houses were fumigated with camphor which drove away insects, bacteria, fungi etc. Moistened *Cus-Cus* curtains were used to send cool air into the rooms. Trees were grown around buildings to absorb dust. Trees are natural air-conditioners. Brooming of floors was done only after wetting the floor to avoid flying off of the dust and resettling.

Most of the traditional methods of conservation are practiced even today in temples and villages. They are considered to be better methods even today as they do not introduce any new problems.

HISTORY OF CONSERVATION AND CONSERVATION LABORATORIES

Evolution of Conservation:

The application of chemistry to study the decay and conservation of antiquities is not new. In the middle of 19th Century Michael Faraday studied the deterioration of easel paintings and others were already applying the methods of chemical analysis to determine the composition of objects particularly those made of metal. The first scientist to have been employed in a museum, however, appears to have been Friedrich Rathgen, who headed the laboratory in the Royal Museums in Berlin from 1888 to 1927. Rathgen published his methods as a book which was subsequently translated into English. Also in the mid 19th Century, the National Museum in Copenhagen, faced, in particular, with the problem of preserving an increasing number of waterlogged wooden objects found in Peat bags, employed its first conservator, V.F. Steffensen, in 1867. In 1896 he was joined by Gustar Rosenberg who also left a testament to his career in book form.

A new laboratory, named after Rathgen, was founded in Berlin in 1975. The first world war, however, can be credited with initiating the scientific conservation of antiquities in the UK, because when British museum objects were unpacked in 1919, after war-time storage the underground railway tunnels, some of them were found to have noticeably deteriorated. As a result, the Department of Scientific and Industrial Research appointed Dr. Alexander Scott, FRS as a consultant to the British Museum and in 1926 Dr. Harold Plenderleith, M.C. was recruited as a full-time Conservation Scientist. His career is well known, culminating in the establishment of the International Centre for Conservation in Rome.

The positive emergence of Conservation as a profession can be said to date from the foundation of the International Institute for the Conservation of Museum Objects (IIC) in 1950 and the appearance soon after in 1952 of the Journal, Studies in Conservation. The role of the conservator as distinct from those of the restorer and the scientist had been emerging during 1930 with a focal point in the Fogg Art Museum, Harward University, which published the precursor to Studies in Conservation, Technical Studies in the field of the fine arts (1932 - 42).

UNESCO, through its Cultural Heritage division and its publication, had always taken a positive role in conservation and the foundation, under its auspices, of the International Centre for the Study of the Preservation and the Restoration of Cultural Property (ICCROM), in Rome, was a further advance. The centre was established in 1959 with the aim of advising internationally on conservation problems, co-ordinating conservation activities and establishing standards and training courses.

A significant confirmation of professional progress was the transformation at New York in 1966 of the two committees of the International Council of Museums (ICOM) one curatorial on the care of paintings (1940) and the other mainly scientific (1950) into the ICOM Committee for Conservation.

From the early 1960's onwards, international congresses (and the literature emerging from them) held by IIC, ICOM, ICOMOS and ICCROM not only advanced the subject in its various technical specialisations but also emphasised the cohesion of conservators and their subject as an interdisciplinary profession.

British Museum and Victoria and Albert Museum (all types of objects) in London; Freer Art Gallery (Paintings), Getty Conservation Institute in USA; Louvre Museum, Paris, Rathgen Research Institute, Berlin are some of the institutions which do remarkable work on conservation.

Although the number of conservation scientists in the world has increased significantly in the last 30 years it is small in relation to the problems faced in trying to conserve the cultural heritage of mankind.

Evolution of Conservation in India:

The conservation branch of the Archaeological Survey of India was established in 1917 in Dehradun for the conservation and preservation of archaeological antiquities. The beginnings of conservation chemistry in India may be stated to date from the time of its inception in 1917. Madras Government Museum was the first of its kind to establish a conservation laboratory in 1930 with the appointment of Dr. S. Paramasivan and developed by Mr. N. Harinarayana subsequently. National Museum, New Delhi, established its conservation laboratory in 1950. Conservation Scientists like Mr. T.R. Gairola, Dr. O.P. Agrawal, Mr. A.S. Bisht have contributed much to the National Museum. Indian Museum, Calcutta and Salar Jung Museum, Hydrabad, concurrently started their respective laboratories in 1960. It is needless to state that in recent years there has been a rapid growth in conservation awareness in India. Under the guidance of International Organisations such as UNESCO and ICOM (International Council of Museums) several museum laboratories and national institutes have been established. Today, there are over 50 museum conservation laboratories instituted all over India. National Research Laboratory for the Conservation of cultural property was established in 1979 at New Delhi by Dr. O.P. Agrawal, later it was shifted to Lucknow to cater to the national conservation requirements and to carry out research programmes in the conservation of cultural properties. Its branch, the Regional Conservation Laboratory has been established at Mysore in 1987. Recently the Indian National Trust for Art and Cultural Heritage (INTACH) has established the Indian Conservation Institute with the efforts of Dr. O.P. Agrawal the retired director of the NRLC. It has its branch at Bangalore headed by Mr. S. Subbaraman. National Museum in New Delhi has started the National Museum Institute in which conservation is one of the departments which is headed by Dr. I.K. Bhatnagar. Mr. A. S. Bisht is the President of the Association for the Conservation of Cultural Property in India. Dr. R. K. Sharma is serving in the field of conservation as Director (Science) in the Archaeological Survey of India.

GENERAL METHODS OF CONSERVATION

The greatest challenge facing museums is the caring for the collections and at the same time exhibiting and interpreting them for public education and enjoyment. Conservation methods should be known to persons who handle the objects under their possession. There are two types of conservation. They are, a) preventive conservation and b) interventive conservation.

Preventive Conservation:

Prevention is better than cure. If the degradation caused by a poor museum environment can be avoided reducing the need for remedial conservation, the museum objects will be saved for posterity to study and enjoy.

Planning for preventive conservation in a new museum, a museum expansion or renovation involves the proper coordination among museum staff and proper knowledge about conservation so that the needs of the museum collection are met in the brief; and that they continue to be met through the design process in construction, building operation and maintenance.

Preventive conservation involves three broad categories. They are i) environmental standards, ii) fire, security and safety factors and iii) design specifications.

Environmental Standards:

There are four main factors after the conservation of antiquities for which conservation experts have established standards. The role of preventive conservation is to apply the following standards to the specific collections and effectively implement them in museum buildings in order to prevent damages on the museum objects.

Relative humidity	:	50±3% R.H.
Air cleanliness	:	90-95% efficiency in particulate filtration
Light levels	:	50 lux for highly sensitive objects. 150-200 lux for medium sensitive objects. 300 lux for low sensitive objects
Temperature	:	21°C±1°C.

Fire Safety and Security:

Fire is another devastating agency which completely destroys objects such as organic objects and in-organic objects. Even metallic objects like lead will also be damaged. Fire safety is an important aspect to be cared for.

Causes of Fire:

Fire in museums can occur due to various factors.

1. Smoking in the galleries or storages
2. Fire in chemicals which can explode and easily volatilised.
3. Faults in electrical installation.
4. Spread of fire from other buildings
5. Bombing during war times.
6. Vandalism

Precaution Measures:

Protection against fire depends on facilities available to quench the fire if it starts. The building should have exit doors for the easy evacuation of staff and visitors. Plenty of water supply at the nearest point should be available. Sand kept in buckets, which are replaced quite often will enable to throw it on fire when fire starts. But use of water and sand should be avoided in galleries and storage. Since spotlights etc., used in museums produce a lot of heat on the insulations, the wires should be checked often and changed at a specified period of time. Smoking should never be allowed inside the galleries and storages. Open fire lamps, candles, kerosene lit lamps should never be used inside the galleries and storages. Combustible materials, discarded furnitures, waste paper, gunny bags etc., should never be stocked near the galleries nor the storages. The conservation laboratory should be detached from the galleries and storage area as it has the chance of fire due to use of hot plates, stoves, open flames etc.

Detection of Fire:

When fire breaks out at a place in the gallery or storage it should be detected immediately to extinguish it. There are automatic fire alarms available. Most of the European museums are provided with fire detectors and fire alarms. Among the various fire detectors like heat detectors, smoke detectors, flame detectors, radiant energy detectors, laser beam detectors, the last one is sensitive. Fire detective system should be checked periodically to ensure its effective functioning. The security personnel as well as the staff of the museum should be trained in fire fighting to fight against fire.

Fire Extinction:

The break of fire should be intimated to the fire service station at once. Extinction of fire differs from object to object and from one type of fire to the other. One must know the types of fire and the types of objects near the fire so that the type of fire extinction may be decided and fire put off without much damage to the objects. There are three types of fires. They are i) class A fire (fire on ordinary combustible materials like paper, wood etc.) ii) class B fire (fire on inflammable materials like oil, volatile chemicals etc.). iii) class C fire. (Fire in electrical installations)

The fire fighting equipments also vary with the type of fire. The common type of fire extinguishers are soda acid type, foam type, CTC type, carbon dioxide type, dry chemical type, halogenated hydrocarbon type. Soda acid type of fire extinguisher is based on the action of acid on sodium carbonate solution giving out a powerful stream of water with carbon dioxide. It is only useful to extinguish the class A fire. Foam type fire extinguisher is based on the principle that it gives off a thick foam which covers fire and oxygen supply is cut off. It is also effective only for class A fire.

CTC type is based on the evaporation of carbon tetra chloride and cutting off oxygen supply and class B and C fires are extinguished. Carbon dioxide type and dry chemical type fire extinguishers are used to extinguish all types of fire. Halogenated hydrocarbon fire extinguishers are very much in use these days and are very effective.

Extinguishers must be kept in conspicuous places. Their periodic recharging on the dates recommended by the manufacturer is absolutely necessary, as the chemicals inside them do not remain effective indefinitely.

Security measures are also essential in preserving the museum objects for posterity. The security personnel should be vigilant. No object should move without proper entries. All security measures should be taken to protect them from burglary. Burglar alarm or closed circuit television may also help in this case.

Design Specification:

The display and storage areas should be designed in such a way that lighting, environmental controls, building construction are upto the standards. The design of the building for a museum and the materials used for construction of buildings play an important role in preventive conservation. As far as possible, insect proof materials, like steel, should be used for structures. All timbers should be properly treated to make it insect proof, especially against termite attack. While constructing the museum building the ground should be treated for insects. The plants and trees touching the buildings should be trimmed to avoid the passage of squirrels into the buildings. All ventilators should be well weld-meshed to avoid pigeons, owls etc. Some museums have installed mechanical and electronic devices to drive off insects, birds, etc.

Planning for new building for museum is complex; but making an existing building to fit into a museum is more difficult. To reduce the risk of degradation and loss of the collection in a museum over the short and long term, the conservation requirements of the collection need to be met.

The application of the environmental standards and the fire and safety and security measures will go a long way towards preserving the collection for posterity.

Interventive Conservation:

Interventive conservation is the conservation intervening the natural and physical decays taking place in the objects. The three important facets of chemical conservation are a) removal of accretion b) stabilising and arresting damages and c) consolidation and protection.

a) Removal of Accretion:

Museum objects are prone to various accretions like corrosion, surface adherents; unless these accretions are removed the objects loose their aesthetic look and the details cannot be legible. These accretions may be removed by physical and chemical means electrochemical and electrolytic reduction means in the case of metals.

Physical Method:

When objects are received at the museums either through treasure-trove, field-collection, excavation, purchase or gift they may have accretions on the surface hiding all the details even giving an ugly look. Accretions like silicious materials on metallic objects may be removed by means of chisel, knife, vibro-tool etc. Accretions found on ceramics, beads etc., may be removed by brushing and by the application of soap solution etc. In case of prints, paintings etc., superficial dirt may be removed by rubbing with an eraser. Soot and biological accretions on stone objects may be removed by erasers, air abrasion, steam cleaning and laser cleaning. Since we do not introduce any chemicals in this method no side effects are noticed.

Chemical Method:

The unwanted surface accretions may be removed from the surface of the objects by chemicals by dissolution. When chemicals are used less strong chemicals with low concentrations should be used. In the case of metals the corrosion products may be removed by dissolution. Alkaline Rochelle salt solution removes chlorides and carbonates, citric acid solution removes the oxides from copper based objects. Formic acid, ammonia remove the black tarnish and white chlorides from silver objects. Lead carbonate from lead objects are removed by acetic acid. Oxalic acid and glycolic acid remove rusts from iron objects.

Solvents like acetone, benzene, rectified spirit etc., remove the oily accretions from stone objects. The brown varnish layer from paintings and other objects are removed by organic solvents very carefully by means of cotton swabs. The oily accretions from painted wooden panels, tribal bamboo objects are cleaned by means of rectified spirit, benzene etc.

b) Stabilising and Arresting Defects:

Various defects such as corrosion on metals, warping in wooden objects, flaking and cohesion in paintings, scale removal on stone objects, twisting in palm-leaves, browning in case of papers and textiles, hardening in leather etc., take place. The defects should be arrested and the objects should be properly stabilised.

Metals:

The corrosion in metals is stabilised by chemicals by forming a complex with the corrosion products and are stabilised and thus the corrosion is arrested. eg. Benzo triazole stabilises the bronze disease and arrests it.

Wooden Objects:

The warping in wooden objects is removed by water and glycerine and kept under weight and then wooden objects are protected by polyvinyl acetate in toluene which cuts off water entry thereby the warping in the objects is arrested.

Paintings:

Flaking in paintings and cohesion in the painted layers are stabilised by means of adhesives and inpainted. Paintings are provided with glass front, without touching the painted surface, and a backing to avoid moisture, dust and insects.

Stone Objects:

Stone objects are affected by salt formation in the pores of stones. The salts are removed by poulticing with paper pulp, sepiolite etc. After the removal of salt, the surface should be protected by adhesives like polyvinyl acetate. Scaling is avoided and stone is stabilised. Paraloid B72 is also used to protect stone objects. Silanes are used to stabilise stone objects.

Palm Leaves:

Because of desiccation the palm-leaf manuscripts become brittle and twist. The stuck of leaves are separated by moistening with steam and applied with rectified spirit and citronella oil. This gives the flexibility and proper weight over it keeps it straight.

Cellulosic Materials:

Cellulosic materials such as paper, textiles, because of acidity gets brown colour. These should be deacidified and treated with calcium bicarbonate or barium hydroxide in order to arrest further acidification and as a reserve against acidity.

Leather Objects:

Because of desiccation proteinaceous objects get hardened. Any oil applied on it enters into the cells of the proteinaceous materials and flexibility is restored.

Consolidation and Protective Coating:

Fragile objects need to be consolidated. Consolidation should be done by adhesives which strengthen the objects. Paraloid B72, polyvinyl acetate, wax, acrylic esters are some of the consolidants. The consolidation may be done either by application, immersion, impregnation or by vacuum impregnation. Protective coating may be done with one of the above consolidants.

The consolidants should be transparent, soluble in a solvent, reversible, should not react with the objects but should physically make bonding with objects.

CONSERVATION ETHICS

Conservation is the means by which the true nature of an object is preserved. The aim of conservation is to control the environment to minimise the decay of objects. In treatment, it is arresting decay and where possible, stabilising objects against further deterioration.

General Obligations of Conservators:

One who involves in conservation of museum objects must be aware of his responsibilities to posterity, colleagues, profession and to the public.

One must be aware of his responsibility for the museum objects entrusted to his care.

It is his responsibility to be knowledgeable of possible risks to objects and must protect objects in their custody, against damage and loss.

It is his responsibility to advise those involved in the display, photography, transportation, handling and packing of objects on methods which minimise risks to objects according to museum environmental policy.

It is crucial to maintain records of technical examination, assessment of condition, treatment and any information regarding its original appearance and function.

Highest standards of treatment should be followed irrespective of the value, nature or quality of the object.

No one is expected to know all aspects of conservation and therefore one should seek the advice of other professionals in the field.

By monitoring the handling of objects, their storage and the environment in which they are displayed, the objects can be preserved better at the same time the chemical treatment could be avoided.

Full documentation of any treatment carried out should be made and kept as a permanently accessible archive which will be useful to arrive at future conservation when necessity arises.

Materials and techniques used in the treatment of an object should be familiar to him; they must not cause damage to the object or to its original constituents.

The selected treatment should be effective as long as possible without incurring repetition.

Any residual chemicals remaining after treatment must not impede reversal or prevent further treatment.

There is no obligation to remove old repairs unless they result in the deterioration of objects. Old repairs, if ugly, may be removed without damaging the object.

Over treatment should be avoided, instead minimum required treatment should be given to preserve its originality and aesthetic beauty.

Physical methods should be tried first, if not possible, then chemical methods should be chosen as the residual chemicals damage the object.

When we use chemicals one should try neutral solution. One should proceed from the most dilute solution and the least strong methods to more complex solutions and equipment.

Drastic methods should never be used .

Part II

Metals

FACTORS AFFECTING METALLIC ANTIQUITIES

Metals as materials have more strength and flexibility of manipulation than stone or clay or wooden objects; but when it comes to chemical stability they (except gold and silver) fall far short of the latter. They are susceptible to many factors which bring about their deterioration, resulting in the formation of deleterious compounds conducive for further deterioration and the ultimate transformation into forms (ores/minerals) in which form(s) they occur in nature. Corrosion is the menace that the conservator faces with metallic antiquities.

The principle behind this is that when objects are buried for a long time under certain conditions that are reasonably constant, they tend to attain a state of equilibrium with their surroundings. This will constitute the first stage in metallic corrosion. Soon after excavation these materials are once again exposed to yet another entirely new environment upsetting the earlier equilibrium in which they had been conditioned; and owing to such series of changes, most metallic objects are profoundly affected. Metallic objects buried in salty ground are exposed not only to moisture but also to the action of corrosive salts dissolved in the ground water. In short excavated objects exposed to a new environment may cause a new type of corrosion to break out afresh as they once again tend to adapt themselves to the new conditions.

The deteriorating factors affecting metallic antiquities are: (i) Humidity/ Temperature, (ii) Air/contaminated air (with pollutants) and (iii) Lack of maintenance.

i) Humidity/Temperature:

Humidity is the measure of moisture content in air/soil. Humidity brings about deleterious effects on metallic antiquities. Under excessive wet conditions corrosion on metals is encouraged. In damp and hot conditions bacterial and fungal growth further facilitate corrosion.

In Tamil Nadu the climatic condition is unfavourable for the upkeep of the antiquities. Generally, the relative humidity in Madras is very high, i.e., above 90% during July to January. The humidity is very low down to 27% during the month of June. During May it is comparatively low in the range between 30% to 40%. There is always a difference in the relative humidity and temperature inside and outside the galleries , which are not favourable for the long term preservation of antiquities. Relative humidity between 45%-60% and temperature between 20-25°C is ideal for antiquities under which condition the deterioration will be minimal.

ii) Air/Pollutants:

Oxygen, oxides of sulphur, carbon and nitrogen, hydrogen sulphide, chloride spray, etc., present in the air adversely affect the metal objects forming oxides, carbonates, sulphates, sulphides, nitrides and other complex corrosion products. The chloride salt spray present in the atmosphere along sea shores adversely affect metallic antiquities forming the corresponding chlorides. Hydrogen sulphide tarnishes metallic surfaces to the corresponding sulphides.

iii) Lack of Maintenance:

Prolonged exposure to unoptimised temperature, humidity, etc., mishandling, vandalism, improper package and direction during transit, etc., also affect metallic antiquities to a great extent.

BRONZE ANTIQUITIES

History of Bronze Technology:

Bronze technology seems to have preceded iron in human civilization and had emerged in the near East as early as 3000 B.C. There are historical records of the prevalence of bronze casting technology in India even before 2500 B.C. This is evidenced from the excavated bronze image of the *dancing girl* from Mohanjodaro, which is currently preserved in the National Museum, New Delhi and the *man-like* figure found at the confluence of Ganges and Jamuna in North India which has been dated to be about 1000 B.C.

Bronze technology in Tamil Nadu dates back to the 7th Century B.C. evidenced from the bronze objects obtained from excavations at Adichanallur, Tirunelveli District, Tamil Nadu; these objects are today preserved in the Government Museum, Madras. Recent excavations by the Department of Epigraphy of Tamil University, Thanjavur at Kodumanal, Periyar district, Tamil Nadu, have brought to light a *semi-precious stone-studded tiger* bronze image belonging to circa 200 B.C. Even though the bronze icon-making was in vogue during the Pallava period (close of 3rd to 9th Century A.D.), the Pallavas have left too few of their icons to enable one to evaluate the full potential of the technological achievements prevalent in those periods. In spite of the existence of the bronze technology of the Pandyas (2nd Century B.C. to 17th Century A.D.) the remains of bronze icons of that period are not many. During the reign of the Cholas (9th to 13th Century A.D.), high quality bronze icons have been manufactured. Later, Vijayanagar Kings encouraged the art of bronze icon-making in the 15th and 16th Centuries A.D.

The bronze icons in the Government Museum, Madras, acquired through the Treasure-trove Act of India 1878 are mainly from Thanjavur, Trichy and Pudukkottai districts of Tamil Nadu. Scientific examinations of these objects reveal that traditional casting was the technique in vogue. Bronze icon-casting technology by the traditional method is practiced even to this date at Swamimalai in Thanjavur district and also in few other places in Tamil Nadu.

Generally bronze is an alloy of copper (75-80%) and tin (20-25%). Ancient bronze icons are generally considered to be made out of *panchaloha* connoting a *five-metal alloy* usually a composite alloy of metals – copper, tin, lead, silver and gold in varying proportion. But analysis of South Indian bronzes reveal that they invariably consist of copper, tin, lead, zinc and iron. Trace quantities of arsenic, antimony, bismuth are also detected in a few of them.

Methods of Bronze-casting:

Basically the two popular methods of bronze casting practiced in India are:

1. Solid casting (*cire-perdue* meaning *lost wax* process) and
2. Hollow casting.

1. Solid casting:

The solid casting process is otherwise called *cire-perdue*, a French term meaning *lost wax*. The basic principle of the solid casting is that the image is first fashioned out of wax, then over it are laid in succession sufficiently thick, uniform layers of fine-grained clay ('puthumann') followed by coarse sand with clay. The mould thus prepared is allowed to dry under shade, and then heated to about 80°C to let out the molten wax through openings provided in the clay layer. Finally molten bronze melt is poured into the hollow space thus created in the clay mould kept buried in the soil, taking care to fill every crevice and corner in the mould cast. The mould is allowed to cool and the clay layer is broken to bring out the cast bronze icon. This is then given the finishing touches by the artisan with chisel and hammer to bring out the finer details of the image. The icon is then given a final polish with fine sea-shore sand. By this method, it is possible to cast only one icon at a time. The laborious mould preparations should be repeated for every individual casting of the icon. The famed bronze master-pieces from Tamil Nadu are solid cast pieces.

2. Hollow Casting:

Since this type of casting of icons have an inner core of clay, it is called *hollow casting*. They will be comparatively light in weight. In this process, a slightly smaller sized image is made out of clay. Thread like wax is extruded on to the clay mould and wrapped around it. The wrapped wax thread is flattened out evenly to the contours of the image.

Finally the clay model is covered uniformly and completely with a thin layer of wax. Then the intricate details are worked out on the final wax layer. After the wax figure is fashioned to the required form and size, fine clay is applied over it. During the working of the clay mould, holes and inter connections (runners) are suitably provided to facilitate easy flow of the molten alloy in the hollow space around the inner clay core and the escape of hot gases during the *pour process*. The mould is cooled, and broken up carefully to reveal the image. To get the artistic details required for the image, finishing touches like chiseling, filing, polishing, etc., are effected by the artisans. By this method also only one piece can be made from a mould.

The technique of making a large sized bronze statue is to cast the image in pieces and assemble the separately cast fragments together by welding in the final stage. Several books on ancient technology on metallurgy, detail this art. Work on the 10 foot bronze statue of Dupleix of the 18th Century A.D. at Pondicherry, is a classical example of the *piece-mould hollow casting*.

COINS

Coins are one of the cultural and commercial remnants of the past through which our ancient history can be reconstructed. The coins used by our forefathers were buried for so many reasons and are now exposed through exploration, chance discoveries or excavations. Such coins are preserved in the museums and similar public institutions for posterity. Coins can be preserved better if the curators, coin collectors, numismatists have a rudimentary knowledge on the science of conservation of coins.

Factors Affecting Coins:

Metals as materials have more strength and flexibility of manipulation than sone, clay or wooden objects, but when it comes to chemical stability (except gold, silver) they fall far short of the latter. They are susceptible to many factors which bring about their deterioration, resulting in the formation of deleterious compounds conducive for further deterioration and the ultimate transformation into forms (ores/minerals) in which form(s) they occur in nature.

Relative humidity, temperature, air, pollutants, lack of maintenance, etc., are the factors which affect coins.

Examination of Coins:

In order to conserve coins one must have the knowledge of the metals, alloys, constituents of the coins and their corrosion products. In order to find out the metallic composition non-destructive analysis will be carried out by Weisz ring-oven technique or by non-destructive instrumental means like X-ray fluorescence analysis, electronspectroscopy for chemical analysis. The type of fabrication is revealed by the metallographic studies. The type of corrosion is studied by x-ray diffraction analysis. These studies make one to choose the correct method of conservation treatment.

Metals Used in Coins:

The earliest coins which were in use are punchmarked gold, silver and copper coins. Die struck coins of various metals, are also exposed and preserved in the museums. The following table tells the various metals used in minting of coins in India.

Metals/Alloys Used in Ancient Coins

Name of the Metal/alloy	Constituent Metals	
White gold	Gold 90%	Silver 10%
Red gold	Gold 90%	Copper 10%
Electrum	Silver 70%	Gold 30%
Debased silver	Silver 60-90%	Copper 40-10%
Pewter	Lead 20%	Tin 80%
Coinage bronze	Copper 90%	Tin 10%
Bell Metal	Copper 78%	Tin 22%
Billon	Copper	Silver
Potin	Copper, Tin	Lead, Silver

The following table gives an idea of the physical properties of some of the important coinage metals:

Metals	Gold	Silver	Lead	Copper	Zinc	Tin	Aluminium	Nickel
M.Pt.°C	1063	963	327	1084	419	232	658	1455
Sp.Gr.	19.33	10.1	11.4	8.9	7	7.3	2.6	8.9

Modern Metals in Coins:

Artefacts, coins and medals made of aluminium, zinc, magnesium, nickel etc., and their alloys form a small but significant part of the collections of objects of modern metals.

Zinc:

Zinc was known as a distinct metal in India in the 14th Century. But, knowingly or unknowingly zinc is invariably found in all icons, artefacts and antiquities made of copper alloys even before 14th Century.

At high humidity, zinc is corroded to form zinc hydroxide $[Zn(OH)]_2$ in the absence of carbon dioxide and basic zinc carbonate $[ZnCO_3 . Zn(OH)_2]$ in the presence of carbon dioxide. In the presence of sulphurdioxide it forms zinc sulphate. Zinc corrodes in the presence of oils and plywood.

Aluminium:

Aluminium was discovered in 1820. Aluminium is resistant to corrosion due to the formation of a protective film of aluminium oxide (Al_2O_3). It forms chloride and sulphate. Aluminium corrodes in an enclosed environment containing urea - formaldelyde adhesive, in tropical climate.

Magnesium:

Magnesium was discovered in 1808. Magnesium corrodes and forms hydroxide, $Mg(OH)_2$, basic magnesium carbonates $[Mg(OH)_2 . MgCO_3]$ and sulphates. Acids profoundly corrode magnesium and its alloys. Wood emanates gases which corrode magnesium.

CONSERVATION OF METALS

Conservation of excavated and once conserved museum artifacts may be considered as one of the most important off shoots of Archaeological Chemistry .

Metallic antiquities constitute a heterogeneous though well defined group of materials, almost all prone to corrosion of one type or the other. This phenomenon results in the loss of metallic properties with the formation of mineralised incrustations due to a series of chemical and/or electro-chemical reactions. The resultant disintegration/deterioration may be slow/fast with a subtle or profound change in the appearance of the artifacts. This corrosion disease calls for the immediate attention of the conservation chemist for, the sooner the object is treated the better its chances of survival without loss of characteristics and hence their antique value.

A basic requirement for the right approach for conservation is that a maximum of informations must be made available to the conservation chemist with respect to its chemical combination, physical structure, mechanical stability and last but not the least in importance the nature of corrosion products and the mechanism involved there in of the antiquity. It is only against these informative background, the conservation chemists can approach the problem in the right direction. Conservation chemistry therefore presents a complicated set of problems, both technical and aesthetic and the conservation chemist must never stray away from any one of the following guidelines:

1) The prime object of the chemist is to restore the original appearance to the maximum extent possible.

2) To use such of those conservation technique(s) to protect the antiquities from further deterioration and

3) To record the historic documents of the art and technology of the article to posterity in all its pristine form.

Hence it is of prime importance to choose a conservation technique with a view to take care to the preservation of the authentic, aesthetic and material characteristics of the antiques. In the above context it is often difficult to decide what has to be removed from the corroded objects and what to be left on it in order to restore as much as possible of its original appearance.

Corrosion from the surface to the core of the metallic objects causes considerable destruction to the original surface including its shape, colour and texture and inscription - the first three physical properties determine the aesthetic and antique values of the object. Additionally, corrosion products on the objects often become conglomerated with the minerals around them considerably adding to the general grotesque disfiguration of the artefacts.

As a rule, a detailed examination of all the corrosion and silicious layers is absolutely essential prior to removal of anything from the surface of the objects, because, important features concerning the object and its history may oft' times be inferred from the deposits which are likely to get lost in the treatment processes. More so, knowledge of the structure and properties of deposit helps in the choice of the right approach to conservation method.

After the preliminary examination of the whole corroded object, qualitative chemical analyses are performed on the corrosion products carefully scraped out of the metal antiquities. Results often reveal, that they are closely related to some naturally occurring mineral/ore form of the metal constituents present in the alloy. Oxides, halides, sulphides, sulphates and carbonates are some of the less complex commonly encountered corrosion products formed on metallic antiquities.

Museum objects of priceless antique value on display/preserved in stores are generally left in a relatively stable environment and consequently they are not readily vulnerable to the otherwise destructive corrosion forces of the fluctuating atmosphere. Such of those articles exposed to the atmosphere out of doors are however susceptible to corrosion at a relatively faster rate due to the adverse effects of the sun, rain, wind, etc.

Excavated or treasure-trove objects brought out suddenly to the atmosphere are prone to damage and deformation on account of the sudden disturbances from their state of equilibrium with those prevalent environment in the buried condition. This may result in partial or total mineralisation within a short time depending upon the condition of the excavated objects and the prevailing new environment. Hence conservation is an important stage for all the antiquities received in the museums before display in the galleries or those to be kept in store rooms.

An in-depth knowledge of the chemistry and mechanism of the corrosion products and corrosion respectively on different metals/alloys is essential before one selects a particular conservation method.

Corrosion Products:

Copper:

Beginning with Berthelot, several investigators - Rosenberg, Fink, Polushkin, Collins, Caley, Plenderleith and Rutherford J. Gettens, have described the chemical nature of the layered structure on the surface of ancient artefacts of copper and its alloys and have also suggested chemical and/or electrochemical reaction mechanisms to explain the formation of several mineral products compacted on them. Some of the corrosion products on the copper antiquities are red cuprous oxide (Cu_2O), black cupric oxide (CuO), greenish blue malachite [$CuCO_3.Cu(OH)_2$], blackish green atacamite and paratacamite ($Cu_2(OH)_3Cl$), azurite [$2Cu\ CO_3.Cu(OH)_2$], Chalcopyrite [$CuFeS_2$], etc. The corrosion that occurs on the alloys of copper such as bronze, brass, etc., is dominated by the chemistry of copper, and the major elements present, in the alloy. The main corrosion phenomenon encountered in bronzes and allied materials is termed *bronze disease.* Bronze disease is a form of *pitting* corrosion where, the metal constituent(s) present in the alloy being at the lower side of the electromotive series with respect to the major metal copper is actively dissolved by the corrosive agents and the corrosion products get deposited in the pitted points.

One probable mechanism for the underground corrosion of bronze is described in which, strata of cuprous chloride, cuprous oxide, and basic copper carbonate are found in succession from the metal to the surface. The cuprous chloride is usually present at the interface between metal and cuprous oxide.

Cuprous chloride is known to react in a reversible manner with water to form both cuprous oxide and hydrochloric acid. The hydrochloric acid is then removed from the system by reaction with metallic copper in the presence of oxygen to regenerate cuprous chloride as:

$$2Cu\ Cl + H_2O \text{ ----------->} Cu_2O + 2HCl,$$

$$2HCl + 2Cu + {}^1/_2O_2 \text{ ------>} 2CuCl + H_20$$

The first of these reactions is caused by the second to proceed in a forward direction with the formation of cuprous oxide which will be added to the mass of this mineral which is already present. As a result of the second reaction, cuprous chloride is continuously regenerated ahead of the newly formed cuprous oxide. The copper metal is correspondingly corroded away, with the net result that the layer of chloride moves steadily forward into the metal.

At areas of loose overlying layers of minerals, air and moisture may enter sufficiently rapidly to convert compact cuprous chloride directly to bulky basic cupric chloride which then breaks out, upon the surface and provides an easy-path for the entrance of yet more oxygen. The loose powder formation can also be referred to as *malignant patina.*

It has been noted in the bronze gallery of the Government Museum, Madras, that some bronze icons in high humid conditions (upto 96% R.H.) especially during winter, ooze out a liquid that runs out as a streak and leaves bluish white streaky deposits on drying. This liquid on analysis is found to contain chloride, copper, lead and tin ions, the major constituents being basic copper chloride. This is referred to as *weeping of bronzes.*

If the hydrolysis of cuprous chloride is combined with oxidation to form the basic copper(II) chloride, $[Cu_2(OH)_3Cl]$, as

$4\,CuCl + 4\,H_2O + O_2$ ------> $2\,Cu_2(OH)_3\,Cl + 2\,HCl$, the reaction will proceed spontaneously but the concentration of hydrogen ion cannot increase above approximately $4 \times 10^{-5}M$ over the cuprous oxide membrane since at lower pH values, the dissolution of the basic copper chloride occurs as:

$Cu_2\,(OH)_3Cl + 3\,H^+$ ----> $2\,Cu^{2+} + 3H_2O + Cl^-$.

To explain this observation the following chemical equation postulated by many scientists might be invoked.

Cu-Sn-Pb ----------> $Cu^{2+} + Sn^{2+} + Pb^{2+}$

(leaded bronze)

$Cu^+ + 2NaCl + H_2 + (O)$ -----> $CuCl_2 + 2NaOH$

(Cathodic)

$CuCl_2 + 2NaOH$ -----> $Cu(OH)_2 + 2NaCl$ (Blue gelatinous)

$2Sn + O_2 + 2H_2O$ ------------> $2Sn^{2+} + 4(OH)^-$

$Sn^{2+} + 4NaCl + 2H_2O + 2(O)$ ---> $SnCl_4 + 4NaOH$

$SnCl_4 + 4NaOH$ ------> $Sn(OH)_4 + 4NaCl$

$2Pb + O_2 + 2H_2O$ -----------> $2Pb^{2+} + 4(OH)^-$

$Pb^{2+} + 2NaCl + H_2 + (O)$ ----> $PbCl_2 + 2NaOH$

$PbCl_2 + 2NaOH$ --------> $Pb(OH)_2 + 2NaCl$

Patina Formation:

Under conducive temperature in the presence of atmospheric air, copper reacts with oxygen, an oxidant, to form a layer of cuprous oxide, Cu_2O. The object becomes covered with the familiar *brown patina* of bronzes which constitutes a protective layer conforming to the original contours of the object. This copper (I) oxide may subsequently be oxidised to form copper (II) compounds which are characterised by blue-green colour. Basic copper nitrates, suphates, carbonates are the end products of the continued combined effects of air, water (moisture), carbondioxide and pollutants like oxides of nitrogen and sulphur on copper and its alloys. Such patina once formed is stable for centuries and is called *edel patina* which imparts an aesthetic beauty to the artefacts.

Gold Objects

Gold is a noble metal. If gold is pure, it does not corrode even if gold objects are found buried under the earth for a long time. Red gold, white gold, electrum are some of the important alloys of gold. When such alloyed objects are exposed to corrosive atmosphere the baser metals corrode first and leached out to the surface resulting in the surface enrichment of gold. For example, copper in a gold alloy corrodes first and the corrosion products covers the whole object making it to look like copper. When the corrosion products are removed, gold appears to be bright.

Gold objects which are in contact with copper also appear greenish - blue because of the corrosion products of copper. Such objects are treated with alkaline sodium potassium tartrate and the original appearance is regained.

Gold objects which were buried in lime deposits are found to be covered with calcareous materials. Such objects are immersed in a 1% solution of nitric acid, which removes the calcarious materials.

The dirt on gold objects can be easily removed by a mild detergent or soap like Teepol. Cleaning with an ultrasonic cleaner with a detergent solution cleans the objects very well. Organic remains on gold objects are removed by soaking the objects for a few minutes in a 2% caustic soda solution. Buried gold objects sometimes appear purplish-red in colour giving an aesthetic look. It is a valuable patina worth preserving but it is easily rubbed off.

Gilded objects need care while treating them. If gold coating is found over copper or bronze, alkaline Rochelle salt treatment is rewarding. But, in general mechanical cleaning with needle etc., is advisable. Gilded gold objects found darkened by soot, dirt etc., may be cleaned with the help of 5% ammonia solution.

Pure gold is very malleable. Therefore, crushed objects should be reconstructed only by an experienced conservator.

Silver Objects:

Silver is a noble metal. It corrodes when it is buried or exposed to unfavourable environment. The normal corrosion products of silver artefacts identified are black silver sulphide, lavender silver chloride and pale yellow silver bromide. Silver objects form silver sulphide when buried underground for long time. In a museum atmosphere, they rarely change to silver chloride, but often they tarnish, indicating the formation of silver sulphide. Buried silver objects sometimes are found to be covered with copper corrosion products which is due to the corrosion products of copper alloyed with silver object or due to the transfer of corrosion products from the copper container in which the silver coins are usually hoarded. Mostly silver coins are found buried in a copper container and the treasure-trove coins are usually received in the museum along with the copper container.

Being a noble metal, at ordinary temperature and in dry air, silver remains apparently unoxidised. However, at ambient temperature, combination between metal cations and oxygen ions result in the formation of an oxide. If the oxide assumes a similar crystalline structure to that of the metal upon which it is growing, and if it occupies a volume larger than that of the metal destroyed for its formation, it acts protectively. If the silver oxide film is produced in dry conditions at room temperature, it is in fact outstandingly protective. In the presence of moisture, highly reactive radicals such as .OH and .O_2H are produced which subsequently, react with water and oxygen to yield hydrogen peroxide. The hydrogen peroxide formed promotes the penetration of corrosive agents by introducing irregularities in the oxide structure. Chloride ions easily permeate through the oxide films peptize conglomerates of their molecules and intensify the already existing flaws, leading to the creation of numerous local cells in all crevices and abrasions of the silver layer. The exposed copper present in the object acts as an anode and the silver object acts as a cathode in which copper goes into solution forming copper (II) chloride in the chloride environment. Silver then undergoes attack by copper (II) chloride and dissolve according to the equation.

$$Cu^{2+} + 2Cl^{-} + Ag^{-} \text{----->} AgCl + CuCl.$$

Thus the corrosion mechanism of silver may be explained as detailed above.

The other ruinous change of the silver objects is caused by hydrogen sulphide. It reacts with silver in the presence of oxygen as:

$$2Ag + H_2S + \frac{1}{2} O_2 \text{ -----> } Ag_2S + H_2O$$

The *tarnishing* of silver requires both oxygen and water.

Lead Objects:

Ancient lead objects excavated from the soil are often covered with white incrustation, which is produced by the chemical action of saline matter in the soil. A wide variety of corrosion products have been identified in lead objects. They are, massicot (PbO), platnerite (PbO_2), cerrucite ($PbCO_3$), hydrocerrucite [$Pb_3(CO_3)_2(OH)_2$], cottunnite ($PbCl_2$), phosgenite [$Pb_2(CO_3)Cl_2$], anglesite ($PbSO_4$), galena (PbS), etc.

Leaden objects are normally coated with a thin film of dull grey oxide; this in pure dry air (free from pollutants) acts as a protective patina. However, this film of oxide in contaminated air is discontinuous and non-protective and in course of time, active corrosion breaks out with the formation of basic lead carbonate. This corrosion product is puffy, voluminous and loosely adherent. It is for these reasons that leaden objects often suffer serious disfiguration unless the corrosion is checked in the early stages.

When lead objects are excavated from the ground they are commonly found to be covered with a dull white encrustation which appears to be stable; it is in such an unsightly condition and often as to be unacceptable as specimens for exhibition that the lead antiquities are received in museums. Improper storage affects lead objects.

Lead objects buried under the soil are mostly found covered with corrosion products. Their removal sometimes results in serious deformation and complete crumbling down of the objects. Such objects in near total state of deterioration should be consolidated rather than conserved, at least to restore back their gross details. However, sound objects may be subjected to conservation methods detailed earlier to restore back the hidden details.

Iron Objects:

Iron objects corrode easily, giving rise to unsightly rust that cause swelling and deformation of the decaying objects. The various corrosion products identified on iron antiquities are oxides, sulphites, phosphates, basic sulphates/carbonates/chlorides, hydroxides, oxychlorides of iron etc. Exposed monuments of iron in the atmosphere are in constant contact with oxygen, pollutants, moisture, heat, etc., and hence they are prone to chemical and physical changes. However, the *wonder iron pillars* at Dhar and Delhi have withstood the ravages of time due probably to their high purity iron content of 99.8% and 99.72% respectively.

Many iron objects buried under the ground are heavily mineralised with only a thin metal core. Chlorides play an important role in the corrosion of iron objects. If the excavated iron objects are partially corroded by the chloride bearing corrosive agents, the chloride must be removed completely, otherwise rapid corrosion will completely mineralise the objects.

Depending upon the stage/state of corrosion, the iron objects can be classified under three categories as:

a. slightly corroded

b. extensively corroded but having a thin metal core

c. grossly corroded, mineralised objects,

Conservation Chemistry of Metallic Objects:

The two main objectives of conservation of metals are, i) removal of corrosion products and (ii) arresting further corrosion.

Removal of Corrosion Products:

The deleterious corrosion products on metallic artefacts should be thoroughly removed in order to prevent further corrosion of the artefacts. The removal of corrosion products can be effected either by a) physical, b) chemical, c) electrochemical/ electrolytic methods or d) by the combination of one or more of the above methods.

a) Physical Method:

The corrosion products along with the silicious materials can conveniently be removed physically by simple mechanical tools such as pin, scalpel, chisel, hammer, mechanically operated vibro-tool, etc. The areas exposed after the unwanted corrosion products thus removed are given a final rub with fine emery paper to bring out the inner patina layer to relief adding aesthetic beauty to the objects for certain patina can also act as a protective coat. Mechanical means of removing deposits have the advantage over chemical means in that the former methods do not introduce or leave behind any additional chemicals or products of chemical changes on the metal artefacts. Air abrasion may also be carried out.

Ultrasonic method can be used to remove the extraneous silicious matter by immersing the objects in a detergent solution contained in an ultrasonic cleaner. Vibro-tool may also be used. However this technique calls for extreme care, for lack of it may damage the finer workmanship of the artefacts. Airbrasive and laser cleaning can also be of use.

b) Chemical Method:

Usually chemicals which can dissolve or form soluble complex with the corrosion products are used to remove the deleterious materials from the objects. Only mild chemicals and very dilute solutions are used to remove the corrosion products without affecting the metal beneath.

If chlorides are present in bronze antiquities, the antiquities are soaked for few weeks in an aqueous solution of sodium sesquicarbonate (equal proportions of sodium carbonate and bicarbonate), the completeness of removal of the corrosion products is indicated by the carbonate solution acquiring the faintest blue tinge. By this procedure the metal chlorides get converted into oxides and/or to other harmless yet protective corrosive products and thereby the metallic artefacts are protected and preserved.

Buried bronze antiquities coated with a heavy white deposits of calcareous materials such as calcium carbonate and magnesium carbonate are soaked for about a week in 5% aqueous sodium hexameta phosphate in which the calcareous deposits are soluble.

The bronze diseased bronze or brass or copper objects may be treated with alkaline Rochelle salt solution (15 gms of Rochelle salt i.e. sodium potassium tartrate, 5 gms of sodium hydroxide and 80 ml of distilled water). This removes completely the corrosion products of copper and the oxide layer is exposed. Red copper II oxide is removed by treating with a 10% citric acid solution, but the surface is found to be rough because of pitting of the metal by citric acid.

10% ammonia is used to remove the copper corrosion products as ammonia forms a complex with the copper chloride.

A 5% EDTA solution is used to remove corrosion products.

The black silver sulphide(Tarnish) and the lavender silver chloride are removed by 10% formic acid and 10% ammonia alternatively. The debased silver objects look like copper as they are covered with corrosion products of copper. They are first treated as if they are copper objects.

Lead objects are treated with 5% acetic acid. This removes the corrosion products of lead.

Iron corrosion products are stabilized by the use of tannic acid based products.

Wax coated iron objects may be cleaned by poulticing with sepiolite.

Chemicals such as 5% phosphoric acid or thioglycolic acid can be used for the immersion treatment of the iron objects. Objects retrieved from the sea/saline soil can be boiled in a 10% solution of sodium hydroxide solution which removes the chloride arresting further corrosion.

Ion-exchange resin treatment is yet another approach to treat especially corroded lead antiquities. The corroded lead object is placed in contact with granules of treated ion exchange resin (Amberlite IR120) covered with warm distilled water for about 20-30 minutes. Metallic lead is unaffected, but incrustations of lead carbonate/basic lead carbonate gradually dissolve away and lead cations are removed by the Amberlite IR120. The resin may be regenerated by dilute nitric acid and used again.

c) Electrochemical/Electrolytic Reduction:

The electrochemical reduction involves the reduction of the corrosion products by nascent hydrogen evolved by the action of 10% sodium hydroxide on zinc granules/powder on the affected spots.

The corrosion (oxidation) of metallic artefacts is usually an electrolytic process. The removal of the oxidative corrosion process can be effected through reductive electrolysis. The electrolytic method first developed by Finkener is now widely used. It was Colin G. Fink who put it to extensive use for the restoration of bronzes in the Metropolitan Museum of Art, New York. In 1930, Paramasivan adopted this technique in the Government Museum, Madras for the restoration of large sized South. Indian bronze icons and heavily corroded copper plates with inscriptions. This method continues to be popular even to this date by many conservation scientists for the restoration of coins and inscribed plates.

Reduction is usually carried out in an electrolytic cell keeping the antiquity as the cathode with two strips of iron gauze suspended on either side of the object or a cylinder of the same material enclosing the object all round, as the anode in a 5% aqueous sodium hydroxide/sodium carbonate/ acetic acid or formic acid electrolytic bath. Current is passed from a direct current supply from a 1-50 volts source and an optimum density (2 amps per square foot with respect to cathodic object) for a few to several hours, depending on the thickness of the encrustation. The corrosion products on the antiquity are reduced and removed by alternate brushing and washing until the hidden details are exposed with all its intrinsic artistic details.

Electrolytic Brushing:

In the case of large sized, non-transportable bronze objects (which cannot be easily shifted from the galleries/stores to the laboratory) a localised treatment of a slightly modified electrolytic method is resorted to, with good success. The metal object affected by spot corrosion is kept as the cathode. A steel rod with a sponge head moistened with 10% caustic soda solution is connected to a 12 volt direct current power supply and the electrolyte impregnated sponge is pressed on the affected spot and the circuit completed. Electrolytic reduction takes place and the spots get reduced to the corresponding metal. This process has been very successfully used by the author for local treatment and conservation of bronze icons, iron swords, etc. Lead coins may be conserved with graphite anode successfully.

The bronze icons which are affected by *weeping* are locally cleaned by electrolytic brushing. Since the holes found at the weeping spots are just able to take the finest needle of a syringe, the liquid collected in the holes is first syringed-out. When numerous holes are present in the icon, the surface of the affected object is poulticed with moist neutral paper pulp and the same is removed when dry. This procedure is repeated till the paper pulp removed gives a negative test for chloride.

Treatment of slightly corroded iron objects in fairly good condition with solid core of metal is best done by electrolytic reduction. Spot reduction can be effected by electrolytic brushing or by electrolytic reduction.

Intensive Washing:

Intensive washing is the last step but definitely not the least in importance in conservation of artefacts; unless the treated objects are washed completely free from the residual chemical(s) left behind on the objects, they will once again react with metal and the corrosion cycle will be repeated again. Therefore, washing should be intensive and thorough in the final stages especially with methods involving chemical treatment. The last residual salts in the treated objects is best eliminated by prolonged soaking of the objects in distilled water or the process may be speeded up by using hot water. This process may be repeated to ensure complete removal of chemicals. R.M. Organ has successfully carried out this intensive washing technique with distilled water by alternate heating and cooling.

Consolidation and Protective Coating:

The metallic antiquities which are very fragile and highly mineralised need to be packed up with wax/resin. This process is called *consolidation.* Consolidation can be done with 10% wax dissolved in benzene or by vacuum impregnation. A 2-3% polyvinyl acetate in acetone, toluene or acetone-toluene mixture can either be coated on the object or vacuum impregnated. In the case of fragile bronzes, the missing corroded portions after treatment are filled and modelled with resin like M-seal or Paraloid B72 mixed with suitable acrylic colours.

Arresting Corrosion:

1. Stabilization of Highly Corroded Objects:

In most of the excavated and treasure-trove objects, it is seen that the corrosion has proceeded to an extreme stage where very little metal is left intact. In such cases, objects can best be conserved by stabilising the corrosion products formed.

Spots of bronze disease formed over protective layer of patina may be mechanically removed. The pits found are then filled with a fine paste of silver oxide (in alcohol/water). Insoluble silver chloride thus formed seals off the underlying harmful effect of copper(II) chloride arresting further corrosion. Sodium sesquicarbonate solution dissolves the copper(II) chloride (bronze disease) without affecting the copper (II)) carbonate (protective patina). Zinc dust in place of silver oxide may be used effectively.

Therefore prolonged immersion of the bronze-disease affected antiquity in a solution of 10% sodium sesquicarbonate removes the deleterious chlorides and stabilises the carbonate patina formed on copper alloy antiquities.

Benzotriazole (BTA) in water or alcohol forms a complex with cupric chloride and oxides. This inhibition procedure can also be adopted to arrest further corrosion. Benzotriazole in water is preferred to benzotriazole in alcohol in the cases of antiquities with thick layer of bronze disease as the former slowly but surely penetrates into the core of the metal - the evaporation of water mixture being slow compared to benzotriazole - alcohol treatment. This is the most effective method for the conservation of copper and bronze archaeological antiquities affected with bronze-disease.

One of the methods of preventing "bronze disease" in antiquities is to maintain the antiquity in a dry atmosphere (45-60% R.H.). Under these conditions the spreading of further corrosion is arrested.

Even wood emanates some acid fumes and therefore silver objects displayed inside the cases are affected. Zinc oxide globules are kept in the cases to absorb the hydrogen sulphide vapours thereby tarnishing is averted.

Poulticing is adopted to remove salts from iron objects since iron rusts fast. The rusting may be stopped by applying a water repellant on the surface of the objects. Besides wax, some consolidants like poly vinyl acetate, Paraloid B72 or varnishes can be applied on the objects.

Bidriware

Bidriware is made out of zinc alloyed with copper, tin and lead. The name bidri was derived from a place in South India where a special earth was found, which had a chemical effect on this alloy and was used to make objects. The object, after casting and polishing, is engraved with designs to be inlaid with silver or gold wire or plate and thereafter rubbed with earth. This process gives to the object a beautiful black colour, leaving the silver or gold wire shining.

The black finish is important to bidri objects. This should not be subjected to acidic or alkaline chemicals. If the inlaid silver or gold wire or sheet is separated, it should be fixed in position with adhesives like araldite.

Part III

Inorganic Objects

STONE OBJECTS

Rocks and minerals are in abundant and are consisted with silicate units. The main cations are sodium, calcium, magnesium and aluminium. A linear plymer-like structure of silicate units form the basis of fibrous minerals such as asbestos. A planar structure in which silicate units are linked in two dimensions give rise to soft, slippery minerals, such as talc, mica and soapstone. A three dimensional frame work silicate, as in quartz and feldspars, results in an extremely strong solid.

There are various types of rocks such as igneous, metamorphic, sedimentary etc. Igneous rocks like granite are those which were formed by the cooling of volcanic lava. Sedimentary rocks like sandstone and lime-stone were formed by gradual sedimentation of layers of sand and other inert materials brought by rivers and streams and deposited at the beds of lakes and ponds. In due course of time these layers got petrified and stone formed. Metamorphic rocks, for example marble, were formed by the metamorphosis of either igneous or sedimentary rocks into a new form on account of pressure or heat or some other geological change.

Granites are the basic materials for carving out sculptures in India especially in south India. They have outstanding hardness and strength. They are mixtures of quartz, potash feldspar and mica, formed under intense pressure and high temperature. They have also been chosen as building materials. Most of the cave temples are cut out of these rocks.

Sandstone was also chosen to cut and shape sculptures. Mathura region has this type of stone sculptures. It is composed of quartz grains in a matrix of either more quartz, when it is strong, or limestone, when it more easily, because limestone (calcium carbonate) is readily attacked by acidic solu-tions i.e. even by rain water (pH is 5-6)

Marble was also used in sculpturing as well as facing monuments like Taj Mahal. Marble is non-silicious and is nothing but a compressed lime stone. It takes good polish as it is less porous. The coloured lines are the impurities present.

Dolomite was also chosen as a stone to carve sculptures and as building materials. It is a double carbonate of calcium and magnesium and its properties are similar to marble and limestone.

Laterite are rocks which are very porous and easily affected by moisture and percolation of water.

Deterioration of Stone:

Excavated stone objects are much affected by crystallisation of salts which are absorbed with in stone. Since salts deposited in cavities near the surface, they can impose strains great enough (upto more than 1000 atmospheres) to cause complete disintegration of surface features such as ornamentation.

Outdoor stone objects suffer the damages due to acid rain which is due to the dissolution of oxides of sulphur, carbon and nitrogen in the atmosphere. Leaching away of mobile materials from inside and recrystallisation occurs on the surface as an efflorescent deposit. Further more, substances dissolving in the capillary passages of stone may produce high osmotic potential gradients which can lead to pressure damage. In urban areas black crusts of carbonaceous materials are often present.

Deterioration also occurs due to the growth of algae, fungi, moss, lichen and other micro-vegetation.

Insects and birds' droppings also affect the stone objects and monuments.

Visual examination

In order to decide on the strategy of conservation, the stone objects should be studied and examined very carefully.

Using a magnifier the condition of the stone should be studied. The surface should be watched for the presence of deposits like crust, salts, mould, dirt, pigments, grafiti marks, voids, flaking, powdering etc. The hardness may be tested. The alteration products may be analysed by spot tests and by x-ray diffraction studies. Soluble salts like chlorides, nitrates, sulphates should be removed immediately otherwise they will damage the stone. Pigments, if found, should be preserved as such.

Preservation of Stone Objects:

Most of the deteriorations on stone are due to water. Now, the job is to remove the unwanted dirt and salts from the objects, protecting the surface with a water repelling material, and consolidating the crumbling surfaces.

Removal of Dirt:

Stone sculptures often accumulate dust, dirt and stains. Loose dust can easily be brushed off. Pure water with detergent like teepol is used to remove the dirt accretions. Stains of grease, oil, wax or paint can be cleaned with suitable organic solvents like toluene, acetone, benzene, trichloroethylene, triethanolamine etc., or their mixtures. Whenever paints fall on the objects it should be cleaned before drying. Steam cleaning is also done.

Wishab, a type of pencil eraser, may be used to remove the dirt by rubbing against the dirty surface of the stone object.

Removal of Salts:

Salts that have migrated into the stone is to be removed along with efflorescent deposits on the surface without causing further damage. Smaller objects may be immersed in salt free water. A *poultice* is applied to remove the salts. Porous materials such as cotton wool, paper pulp or sepiolite (hydrated magnesium silicate) are used as poultices.

Removal of Biological Accretions:

Deposits of moss or algae not only make them to appear patchy, green or black in colour but also produce pits in the surface of the stone, thereby weakening the structure. A 5-10% solution of ammonium hydroxide is used for removing algae. Cotton pads dipped in the solution and kept on the affected area for about 15 minutes, brushing and washing will remove the growth. The carbonaceous accretions are removed either by air-abrasion or by laser treatment.

Characteristics of Consolidants on Stone Objects:

The choice of a good consolidant is very important. The consolidant must penetrate the stone thoroughly and not simply sit on the surface to obviate removal by abrasion. The protective layer or the consolidant should breathe, i.e. allow water vapour to escape. It should be reversible, so that anything applied to the stone can subsequently be removed and a different treatment used, if found to be more suitable. The consolidant should not alter the appearance of the object on which applied.

Acrylic resins like perspex, polyesters, epoxy resins like, polyvinyl acetate, polyvinyl chloride, Araldite are some consolidants which are in use. Recently Paraloid B72 is also in common use. Organosilanes are largely used in the consolidation of stone objects. Tri methoxy methyl silane and triethoxy methyl silane are very commonly used of which the later is preferred as the former is more volatile and leaves off methanol which is poisonous. Perfluoropolyethers are composed of carbon, oxygen and fluorine and are extremely stable to light, heat and chemical agents; are permeable to gases; are transparent and colourless; and are insoluble in water and common solvents, although able to be dissolved.

Restoration of Stone Objects:

Restoration is often necessary for reasons of safety of the object and is carried out using modern materials in a manner sympathetic to the existing structure, but not necessarily identical with it.

Doweling can be done in the case of broken objects by joining the pieces by means of stainless steel headless rods, called *dowel* and adhesives.

One of the main causes of moisture formation in stone buildings and objects which are directly in touch with the ground is the rise of water from the ground to the body of the object through the capillary pores present in the stone. Hence stone objects should never to displayed by embedding parts of them in the ground or in brick or cement pedestals. Stone sculptures can be placed on brick or cement pedestals only when a moisture barrier, like a plastic sheet, is inserted in the pedestal, just above the ground.

General Care:

Stone materials should never be white-washed, painted. Salt should never be sprinkled. The soot deposits due to burning of lamps etc., should be cleaned by solvents like benzene, spirit, acetone. Oil accretions by touching should also be removed as above.

CERAMICS

Early man started using the naturally available materials for his daily use. Clay was certainly among man's earliest discoveries of natural materials adaptable to his needs. Ceramics is the general term for an object made out of clay like pottery, porcelain and earthen ware. Ceramic materials were in vogue in the sites of ancient culture throughout the world. The red and black wares, polished wares, megalithic potteries and the modern glazed wares are familiar to India.

Constitution, Types of Ceramics:

Ceramics has its principal raw material clay whose ingredients are alumina and silica, with varying quantities of other minerals. The composition varies from clay to clay. When clay is fired dehydration, oxidation and vitrification take place. Ceramic objects differ according to the kind of clay used and the heat applied in firing. The various types of ceramics are earthenware, terracotta, stoneware, porcelain. Clay forms may be decorated in a wide variety of ways glazed or unglazed.

Deterioration of Ceramics:

Most of the ceramic objects are excavated and are saturated with the salts of the soil, if they are unglazed or broken.

Unbaked clay objects are very fragile and are easily affected by water. Even high humidity will make it to disintegrate.

Unbaked clay objects are vulnerable to shock and disintegration occurs when severe vibration or shock is inherited by the object. Baked clay objects are also vulnerable to shock and severe vibration.

Rough unfired clay objects as well as weathered baked clay objects are easily accumulated with dust and is difficult to remove the dust.

Since clay objects are fragile, they are vulnerable to abrasion and scratches.

Conservation of Ceramics:

Since unbaked clay objects are prone to the damages due to water, moisture, shock, vibration etc., care should be taken to conserve them. Such objects should be impregnated with a consolidative resin like polyvinyl acetate. Larger objects may be impregnated by means of brushing and small objects may be vacuum impregnated. Unbaked clay objects may be hardened by baking it. Clay objects if once baked then they may be washed to remove the salts present in them.

The excavated baked objects may be soaked in running water and the salts present are leached out by this process. Any stain found on them may be removed by using solvents like acetone, benzene etc., after they are dried. In order to remove the dirt 1% teepol in water may be used and brushed well with a soft brush.

Encrustations on the ceramics may be softened by moistened pads. Fine scalpels may be used to take off the softened encrustations.

Mending of Ceramics:

Most of the excavated ceramics are found broken and portions are not found. The broken pieces have to be mended. It requires great patience. It is always better to number them and put them together. The broken edges should be cleaned with a soft brush and then with rectified spirit. The adhesive, normally the acrylic resin, should be applied at the broken edges and joined. The joints should be filled with a filler like acrylic resin and matched with acrylic colours.

GLASS AND GLAZES

The use of glass dates back to 3000 B.C. Mesopotamians, probably, were the first user of glass. Ancient glasses were found to have either magnesium or aluminium. Those glasses which contained aluminium are much durable than the other. Pottery and mud bricks were also glazed to make them impermeable to water. The glazes used were similar in composition to glass artefacts although often made opaque to cover defects on the surface of the substrate. For similar reasons metals were sometimes coated with coloured enamels, which were also glossy in nature.

Liquid glass is cooled below the melting point too rapidly to crystallise. Glass is a supercooled liquid. Glass is made by heating silica (silicon dioxide), soda (sodium carbonate) and lime (calcium oxide). In a typical sodalime glass (75% sand, 15% soda and 10% lime). Soda lowers the melting point of silicon dioxide from 1710° C to 700-500°C and the lime stabilises the glass by making it insoluble in water. Potash glass and lead glass are stronger varieties of glass.

Coloured Glasses:

Small amounts, usually less than 0.5% by mass of metallic oxides impart colour to glass. eg. Ferrous oxide – blue, ferric oxide-yellow, both iron oxides-green, copper-red, cadmium - orange, chromium - orange, titanium - yellow, nickel - yellow, blue, cobalt - blue, violet, iron – blue, yellow, green, amber, manganese - violet, pink, black.

Defects in Glass:

Glass is preserved well in a dry climate. Devitrification may take place due to the growth of seed crystals into larger in course of time. The glass may lose its transparency and become cloudy or crizzled which is commonly called as *glass disease*. When moisture is in prolonged contact with glass the cations such as sodium, potassium and calcium are leached out and replaced by hydrogen and a layer of alkali metal hydroxides such as sodium, potassium and calcium hydroxides are formed at the surface of the glass. They are very hygroscopic and absorb more water. If left untreated at a pH above seven the silicate network breaks down and the glass may become so badly crizzled that small flakes break off when the glass is handled. Acid rain containing dissolved oxides of sulphur and nitrogen contributes deterioration resulting in sulphates and nitrates.

Conservation of Glass:

The deterioration of glass can be stopped by avoiding contact of water with glass. The soluble alkali salts are washed with water, dried with rectified spirit, acetone or ether and stored in low humidity cases keeping silica gel. Broken glass vessels are repaired by using cellulose nitrate adhesives like *Durafix* which does not shrink or undergo discolouration.

In the restoration of glass i.e infilling the missing parts thermoplastic, methacrylate resins such as perspex are often used. The most successful results are with certain acrylic and polyester resins, as they are transparent, do not yellow, appear similar to glass and can be tinted simulating the stained glasses.

Stained Glass

Glass is a silicate. The overall stability of the glass depends on what elements are added and the precise quantities used. It is at the initial melting stage that colour is introduced. This usually take the form of various metal oxides which are either dissolved into the glass or applied on top of a clear sheet of glass. When we talk of the stained glass, we have to see the glass, surface decoration, lead and the cement used to fix them with the lead cames.

Deterioration in Stained Glass:

There are both physical and chemical deteriorations in stained glass.

Physical Deterioration:

The physical damages include such factor as strong winds, hardened cement, bad fixing, faulty design of the structure, loss of paint due to bad fixing, vandalism, etc.

Chemical Deterioration

The chemical deterioration is due to the condensation of water on glass. If water is allowed to remain on the surface of glass for a prolonged period, it attacks the glass by releasing the alkali metal ions forming the hydroxides. By this, the glass will become weaker in its structure and more likely to crack and deteriorate.

Conservation Treatment

Surface dirt is removed by a detergent in deionised water. No water is left behind on the surface. In order to remove the cement used in the stained glass, the cement portion is soaked in a detergent solution. The accretions are removed by air abrasion by sodium bicarbonate. The mended portions are cleaned with acetone. The corroded lead cames are replaced with new ones.

Part IV
Organic Objects

ETHNOGRAPHIC OBJECTS

Ethnology is the science of the races of mankind. Ethnography is the scientific description of the races of mankind. The materials used by the races of mankind are called ethnographic materials. Ritual objects of all kinds, secular objects, tools, machines, equipments connected with trades, domestic utensils, ornaments and jewelleries, clothes, musical instruments, weapons, are some of the types of objects of mankind. Museums normally collect and preserve those objects belonging to the tribes. Metals, especially iron and copper alloys, but also gold, silver, lead and aluminium, glass and stone beads, wood, fibres, grass, skin, animal fibres, bone, teeth, clay, ceramics, textiles, feather, latex are some of the types of materials of the ethnographic collections.

Damages Caused

Climatic variations affect materials of organic nature and paintings. Insects are the main enemies. They are wood-borers, white ants, cockroaches, etc. Cockroach is a great destroyer of subtle patinas, paintwork, feather decoration, textiles and dessicated skin like preserved bodies, mummies etc. Rats cause damage to ethnographic materials. Lizards, gechos damage the materials by their droppings. There is a great number of fungi both wet and dry of the flowering and the filament type which cause extensive and fundamental damage. There are many surface moulds which constantly recur, especially during the wet seasons. These destroy protein elements in patina and will grow well on any film of moisture or finger marks left on metals, and there is even a distinct mould which attacks glass. The acids produced by mould metabolism permanently etch the surfaces.

Conservation Measures

In this book the conservation measures are dealt with by the material used to make the museum objects rather than the type of object. But, a general method of conserving the ethnographic materials is dealt with in this heading.

Mechanical Cleaning

Airbrasive method of cleaning is one of the physical methods of cleaning. The airbrasive process employs a system of grit spraying which is so refined and controlled that it may be used to clean ethnographic materials which are disfigured by corrosion products, mud, dusts and other types of loose, non-greasy dirt which might have been accumulated during use, improper storage or during exhibition where the objects were not protected by cases.

Good conditioned basketry specimens may be cleaned with dolomite airbrasive cleaning. Greasy basketry specimens may be cleaned with a solvent such as acetone, alcohol etc., and dried.

A great deal of bead work occur in conjunction with other materials such as leather and cloth. Sometimes it occurs with metal or basketry. Dolomite or glass-bead powder abrasive cleaning may be done.

Copper and brass objects may be cleaned with dolomite abrasive cleaning. If the corrosion is merely a thin layer of tarnish or silver, glass bead airbrasive will do. Iron objects can be best cleaned with dolomite airbrasive cleaning.

Metallic embroidery - a silver, gold or silver with a gold wash may be cleaned with glass-bead airbrasive cleaning, which remove the tarnish quickly and leave a satin finish.

Chemical Treatment

Ethnographic objects are mostly organic and are prone to all types of deterioration. Due to usage they are adherent with oily or greasy coat. All such materials when added to the museum collection they should be fumigated. Wooden objects may be fumigated with methyl bromide, textiles with paradichlorobenzene or naphthalene.

The creasy or oily ethnographic material may be cleaned with solvents such as acetone, benzene, toluene, rectified spirit etc., and dried.

Since ethnographic objects are complex materials the type of material in the object may be treated according to the type. It is always better to give protective coating to metals attached to the objects. The weakened wooden portions may be consolidated by injecting with 10% Paraloid B 72 in xylene.

The ethnographic specimens may be sprayed with ortho-phenyl-phenol in spirit to prevent mould growth.

Mummies

Mummy is derived from a Persian word 'mummia', meaning 'bitumen'. As the dead bodies in Egypt, in later periods, were treated with bitumen like molten resin the preserved bodies were called mummies.

Mummification of human bodies was the practice adopted in ancient Egypt for the disposal of dead bodies. Human body consists of a large amount of water to the extent of 75 percent. If this water can be dried out artificially or otherwise, the body can be made to preserve almost indefinitely. This is the basic principle of mummification. Desiccating the body with the help of dehydrating chemicals like calcium hydroxide, common salt or natron found in Egypt in abundance was commonly practised. The body was dried with natron and wrapped in linen bandages and a plaster case to give it a human form. Sometimes, it was painted also. This bandaged body was placed in a wooden coffin or sarcophagus, which was quite often elaborately decorated and painted.

Causes of Deterioration

Higher humidity affects the surface by mould growth. Very dry conditions between 40 to 50 percent relative humidity and 18 to 20°C temperature make the mummies to brittle.

The linen wrappings in some parts of the mummy are lost and portions of the body get exposed.

Conservation Measures:

Water or water based solutions should never be used for the cleaning of dirt on mummies. Only organic solvents like acetone, spirit, tetrachloroethylene, xylene are used. 0.5% solution of ortho phenyl phenol in spirit is sprayed to avoid insect attack. The lost linen portions may be repaired with fresh linen strips and molten resin.

WOODEN OBJECTS

Wood is a part of a tree. Wood can be obtained from monocot plants (palm trees) and from dicot plants (branched trees). There are two parts in all these timbers. They are heart wood and sap wood. The heart wood (strong) contains some organic liquids like *lignin* which makes the wood insect proof. The sap wood (soft) is easily prone to insects.

Wooden Objects in Museums:

The use of wood by man is from the earliest times. Wood was used for making agricultural implements, transports, household articles, hunting weapons, houses etc. Museums possess objects like wood carvings, handi-crafted objects, household articles, parts of houses, folk and tribal objects.

Deterioration in Wooden Objects:

Wood, even though hard and durable, being an organic material is very vulnerable to various causes of deterioration both of natural and manmade.

Wood is fibrous and cellular. A seasoned wood is said to have its water content in equilibrium with the atmosphere. When the wood is kept in a very dry atmosphere because of its quick drying, cracks are developed. Because of the change in relative humidity wooden objects warp.

In moist condition, wooden objects are easily affected by insects such as beetles. The powder-post beetles make their entries into wood and give out fine powders. This damages the whole wood without anybody's knowledge. Among the insects the most damaging one is termite or white ant.

If wooden objects are kept in damp condition for a long time, they may develop fungal growth which weakens the surface. A really dangerous type of fungal attack on wood is called *dry rot.*

Excavated wooden objects should be kept wrapped with wet gunny bags, otherwise they may disintegrate.

Wood carvings from temple car appear to have hardened oily accre-tions disfiguring the details of the sculptures. This is due to the application of protective coating of oil to preserve the sculptures at the time of festivals. Repeated coatings of oils and leaving the temple cars along the streets allowing dust to accumulate made the woodcarvings to appear disfigured with caked up oil. Similar case may also occur when repeatedly painting is done to protect the surface.

Mishandling and vandalism also affect wooden objects. Faulty handling, display and storage create a havoc in the protection of wooden objects.

Conservation Measures:

Wooden objects should be segregated from the soil and walls in order to avoid the contact of termites. The showcases and the area of the display as well as storage areas should be treated for insects and pests with Aldrin, chloropyriphos, Dursban TC etc.

Wide variations of climate cause disastrous effect on wooden objects. Therefore maintaining microclimate of humidity range between 45 to 60% and temperature between 20 to 23°C avoids damages on objects. Microclimate inside the cases may be maintained by air-conditioning the galleries. Specific areas may have different R.H. because of want of air circulation. It may be better to provide fans to circulate air. If air-conditioning is not possible, those cases which need absorption of moisture, silica gel may be provided to remove the excess of moisture. This controls insect and fungal growth besides distortion of wooden objects.

Insect attacked wooden objects may be fumigated with a mixture of carbon disulphide and carbon tetra chloride (1:4) in a closed chamber. This kills the powder-post beetles. Then the holes are filled with wooden putty mixed with an insecticide like D.D.T. The growth of fungus is eradicated by the application of 1% orthophenyl phenol in rectified spirit.

In the fumigation of wooden artefacts methyl bromide is preferred for the following reasons:

(a) It kills eggs, larvae, pupae and adults of insects.
(b) It is non-inflammable and non-explosive.
(c) It is easy to apply and does not stain.
(d) It is economical in use and leaves non-toxic residues.
(e) It has a high degree of penetration and no residual odour.
(f) It is chemically stable and can be stored in steel cylinders for an indefinite period.
(g) Its low boiling point permits rapid vapourisation.

Water logged wooden objects may be brought to the laboratory by keeping them in water or wrapped with wet gunny bags. They may be conserved by *freeze drying* in which the water in the wood in frozen and is removed by vacuum sublimation by the *polyethylene glycol method.* Wood is placed in a solution of polyethylene glycol which slowly replaces the water inside the wood.

Warping of wood may be set right by application of water and oil at the concave side and keeping light weight on the other side with proper padding. After required flat surface in regained the sides are coated with resins like poly vinyl acetate to avoid water absorption.

The accretions on the wooden objects may be removed by the use of solvents and softening agents. If accumulated dirt only is found on unpainted wooden objects they may be removed by using teepol in rectified spirit. The excess teepol used is removed by rectified spirit. If dirt is accumulated on painted wooden objects care should be taken to remove the dirt. Benzene, rectified spirit may be used by means of cotton swabs and the dirt may be removed area by area.

In the case of oily caked up accretions, the conservation treatment is difficult. In such cases the accretions may be softened, by the use of organic solvents like acetone, rectified spirit, benzene. Care should be taken to avoid fire. In such cases, a hot solution of 5% sodium carbonate is conveniently used to soften the hard material. Brushing with tooth brush and removing the material using blunt scalpels will clean the wooden objects. Thorough washing is done to remove the sodium carbonate used, if necessary. The wooden object should be dried under shade. When dried, the insect holes and cracks are filled with putty made out of wood and insecticide like D.D.T. A 2% solution of As Cu in water may be applied as an insecticide as well as fungicide.

The galleries should be vacuum cleaned. Dust in the wooden objects should be brushed off using soft brushes regularly. Since wooden objects are delicate in nature great care should be taken in handling and storing them. The wooden objects may be wrapped in polythene bags in the storage to avoid dust. They may be stacked in wooden racks. The storage area where the wooden objects are stored insecticides like B.H.C, D.D.T. may be sprinkled. Fogging with D.D.V.P. may be done to drive off insects.

Protective Coating:

When the surface is cleaned for the accumulated dust and dirt the surface is cleaned and it should be protected from further accretions. Varnish may be applied to give a glossy look when there is no painted surface. If painted surface is available a 2% solution of polyvinyl acetate in toluene may be applied as a protective coating.

PAPER BASED OBJECTS

Among the materials used for writing, the oldest records are stone and baked clay (6000 B.C.). Papyrus was widely used in Egypt from 3000 B.C. to about 900 A.D. Leather, parchment, vellum, silk, ivory, bone, wood, paper, palmleaf, metal, stone etc., are some other writing materials. Papyrus and paper, even though prone to decay, were widely used as writing materials.

Papyrus:

Papyrus - a type of sedge - was used to manufacture papyrus. (Greek, Papyros = the paper reed). Rolls of paper have survived for thousands of years in the dry atmosphere of Egypt.

Deterioration of Papyrus and its Remedy:

Brittleness is the major defect due to loss of water. The normalcy will be regained by moistening.

Biological damages can be stopped by treating them with fungicides and insecticides.

Paper:

The word paper is derived from papyrus. The method of manufacture of paper is entirely different from that of papyrus. The plant fibres were used for the manufacture of paper in the earlier days. Until 20th Century linen and cotton rags were used. But nowadays, wood pulp is mostly used for this purpose. The credit of inventing paper goes to the Chinese. Even though the use of paper was known for so many centuries, at about second Century A.D. only it was used for writing purposes. Cellulose is the chemical compound present in paper. Cellulose in paper is a condensation polymer.

Deterioration in Paper:

The two factors responsible for the deterioration of paper are,

1) Intrinsic factors and 2) Environmental factors.

Intrinsic Factors:

Acidity is the major deteriorating factor in paper. The essential cause of acidity is the existence of hydrogen ions. If the pH range is less than 7 it is acidic and it is alkaline if the pH is above 7.

The acidity in paper is due to the formation of acid within the molecules. The '*alum*' used in paper is hydrolysed and this increases the acidity. The lignin present in the paper increases the acidity. The residue of the chemicals used during the manufacture of paper increases the acidity. The cellulose decomposes and increases the acidity.

Environmental Factors:

The various environmental factors responsible are moisture, dust, oxides of nitrogen, sulphur and carbon, biological agents etc., besides mishandling, faulty storage and vandalism.

Moisture:

Either the increase of acidity, volume increase or sticking of art papers are due to the excess of moisture. The moisture content is measured by means of relative humidity (R.H.). When the relative humidity is more than 60% it adds water to paper which encourages various deteriorations to follow. The ideal condition is to maintain the R.H. at 55 to 60%.

Suspended Particulate Matter:

Suspended particulate matter in the atmosphere settles on paper and helps to disintegrate at moist condition . The suspended particulate matter is very high in industrial area and in Madras it goes above 1300 micrograms per cubic meter at certain areas .

Oxides of Sulphur and Nitrogen:

In the Madras city the oxides of sulphur, carbon and nitrogen are very high due to industries and automobiles. These oxides dissolve in moist air and increase the acidity of the atmosphere which increases in turn the acidity of paper.

Biodeterioration:

The moisture in paper encourages mould and fungal growth and insect attack. Common insects are silver fish, book moth, beetles, bookworm etc. *Foxing* is the formation of small brown spots which are due to biological activity as well as due to iron impurity in the paper.

Deacidification of Paper:

Deacidification is the removal of acidity from paper. This can be effected by dry methods as well as wet methods.

Dry Deacidification:

The paper materials are deacidified by keeping them in an ammoniacal atmosphere in a closed cabinet. The acid is neutralised by ammonia which is basic in nature. Mass deacidification is done by fumigating with diethyl zinc.

Wet Deacidification:

If the paper has permanent inks wet deacidification can be effected. Otherwise the writings will be lost . Anyhow, the wet deacidification may be done with the help of methanol, ethanol, diethylether etc.

By Hydroxide:

A saturated lime water deacidifies the paper material and then reacts with carbon dioxide, forming calcium carbonate which acts as a reserve to neutralise any subsequent acidity. If the use of water is to be avoided, sometimes a saturated solution of barium hydroxide is also used as it dissolves in methanol.

By Bicarbonate:

Magnesium bicarbonate is also used to neutralise the acid and the magnesium carbonate thus formed is used as the reserve against acidity.

Cleaning and Bleaching of Paper:

The stains formed on paper may be removed by the use of non-abrasive erasers, soaking in water to remove or reduce staining and by the use of organic solvents like toluene, hexane, methanol, ethanol, pyridine, chloroform, trichloroethane, acetone etc. The pigment should be tested before the use of the above solvents.

The chlorine dioxide evolved by the action of formaldehyde on sodium chlorite is a mild bleaching agent in water medium. Chloramin-T in alcohol is also used. Chlorates and hypochlorites are powerful bleaches. Therefore they should be used in a very low concentration. Hydrogen peroxide is also used. In case, water is to be avoided, hydrogen peroxide in diethyl ether must be used.

Inks and Adhesives:

In the earlier times soot mixed with vegetable gum was used as ink. Later iron gall inks were used. Nowadays chemical inks are used. Therefore it is always safer to test the ink for the fastness before any conservation work is started.

In order to remove the old pastes used in binding etc., enzymes are used to separate the sheets, if rebinding is required. In the present day, carboxy-methyl-cellulose, wheat flour paste, maida flour paste etc., are used along with little (0.1%) fungicide like paranitrophenol and insecticide like mercuric chloride and copper sulphate.

Repair of Paper Materials:

If the paper is very fragile it can be strengthened by lamination. This can be effected by a laminator with the help of cellulose acetate foil and tissue paper under heat or by hand lamination with cellulose acetate foil and tissue paper using acetone to convert an acetate foil as a paste in cold condition.

Chiffon lamination is also effected by the use of chiffon and maida or wheat flour paste. All these repairs are reversible. If any method is ineffective, the lamination can be reversed at a later date.

Care of Paper Materials:

A suitable storage condition of constant temperature of about 20°C and a relative humidity of 55-60% in a pollution free atmosphere.

A proper storage of paper manuscripts should he made. The manuscripts, books etc., should be kept perpendicular to the shelves and cleaned periodically by vacuum cleaner.

It should be ensured that proper ventilation and air circulation is made, if air conditioning is not done.

While handling, if the books or manuscripts are very fragile, a proper book rest should be provided.

Paper materials should he periodically fumigated with the help of thymol or paradichlorobenzene to eradicate the fungal and mould growth.

Papier-mache

Well pounded water soaked paper is in the form of pulp and is called papier-mache. It is being used traditionally to make boxes, baskets, decorative objects. Quite often they are prepared hollow. These objects are mostly found decorated in colours or paints and are varnished or lacquered.

Damages to Papier-mache

Since the main constituent of papier-mache is paper, it is affected by high relative humidity and highly prone to fungal growth. Insects also damage these type of objects.

Conservation Measures

Since papier-mache is similar to paper the treatment is also similar to paper based materials.

These objects are very weak and fragile. Therefore, they should be handled carefully.

PALMLEAF MANUSCRIPTS

In the tropical countries palm trees are in vogue and the palm leaves were used as writing materials. Styluses were used to inscribe on palm leaves. Museum, temples, libraries etc., are in possession of palmleaf manuscripts which consist of sthalapuranas, accounts, Ramayana, Mahabharatha, local history, medicine etc., which should be preserved.

Preparation of Palmleaf Manuscripts:

The tender leaves of 4 to 5 weeks old are cut into required size and dried under shade or buried under marshy water. On the contrary, they are boiled in stream or in turmeric solution. Such seasoned palmleaves are inscribed by stylus. Since the inscribed letters are having the colour of the leaf the inscribed portions were either applied with the essence of *Kadukkai* (Terminalia chebula) or green leaves of *kovakkai plant* (Coccinea grandis). The letters after sometime appear black, making it legible to read. The palmleaf manuscripts ranges from 4 cm to 85 cm in length and upto a bundle thickness of 50 cms. Sometimes the palm-leaves are painted. The edges of bundles are gold gilded.

Deterioration of Palmleaf Manuscripts:

Palmleaf manuscripts are organic in nature and therefore they are affected by high humidity, microorganisms, insects, dust, heat, mishandling, vandalism and ill-maintenance. When certain insects attack them they bore holes from one edge to the other making a tunnel and hence the leaves are stuck together. The edges are accumulated with dust and they attract fungal attack. Normally the palmleaf manuscripts were preserved in the lofts of the kitchen. They are accumulated with soot and smoke. Silver fish etc., eat away the surface and letters are lost.

Traditional Preservation:

The palmleaf manuscript bundles were dusted, cleaned with turmeric powder and bundled by cloth keeping neem (Azadirachta Indica) dry leaves or cus-cus, called vettiver (Vetriveria zizanoides). Sometimes powdered pepper (Piper nigrum), pattai (Cinnamomum zeylanicum), cloves (Caryophyllus aromaticus) etc., are mixed and kept in between the bundles in a cloth sachet. These are used to drive away the insects and micro organisms.

Conservation of Palmleaves:

The stuck palmleaves of the bundles are baked in a steam vessel. The steam percolates and moistens the clayey materials and the leaves are easily separated. The leaves are cleaned with brush followed by rectified spirit. Then a 5% solution of citronella oil or lemon grass oil or olive oil in rectified spirit or the extract prepared out of fresh palmleaves in rectified spirit is applied and allowed to dry in shade. The oil used restores flexibility to the palmleaf as the cells in the leaves absorb oil. If the palmleaf is distorted 1:1 rectified spirit-water mixture is applied and pressed between oil paper and kept under weight. When dried it is found flat. Then 5% oil in spirit is applied and dried. This act not only gives flexibility but also provides insecticidal and fungicidal property to the palmleaf manuscripts.

Restoration of Palm Leaves:

The broken palmleaf manuscripts should be restored. The restoration can be done in many ways. Because of the cleaning process or natural means the letters become illegible. Therefore, the inscribed portions should be rubbed with *kadukkai* essence, *kovai plant leaves* or lamp black in oil. Then the mending is done. The torn portions are cut to the required size keeping similar uninscribed leaf underneath with a knife. The affected portions are now pasted at the edges with the cut leaves. At times lamination by chiffon using maida flour paste is done. Lamination by cellulose acetate foil and acetone is also is done but the edges are trimmed so that the leaves may breathe. Joining of the torn portions or breakage may be repaired by using polyvinyl acetate in toluene or Paraloid B72.

General Care:

Since the palmleaves are easily stained, they may be displayed by keeping them under polythene bag or cover. By this way dust is also avoided. The displayed as well as storage areas should be kept clean as well as treated with insecticides and fungicides. Fogging with D.D.V.P. will be effective as it penetrates through the leaves and drive away the insects and fungi.

The palmleaves are tied keeping two planks of teak wood on both sides which is slightly wider than the leaves so as to give a protection from distortion and physical damage. The bundles are stacked in such a way that they stand on the support of the planks. This avoids dust to be accumulated at the edges of the leaves. Since high humidity bulges the bundle and attracts insects and micro-organisms the galleries and storage areas may be air-conditioned. Otherwise they may be kept inside showcases and silica gel may be kept inside them to absorb excess of moisture.

TEXTILES

There are references for the use of leaves and leather as dress materials. Barks of certain trees were also used to make clothes. When man learnt to spin and weave, the fibres and textiles came into existence. The invention of dyes made man to make coloured fabrics. Designing of the textiles took importance when man wanted to have aesthetic beauty.

Types of Textiles:

Textiles are made out of natural and man made fibres. Fibres from plants, animals and insects, like cotton, flax, hemp, jute, wool, silk are natural fibres. Nylon, polyesters, terylene etc., are made out of synthetic materials and are man-made. Museums possess all types of textiles viz. barks, leaves and costumes ranging from a simple cotton saree to ornately decorated costumes of silk or wool. Care of textiles of natural fibres is of importance and of concern to the museum curators and private collectors.

Biological Agents:

Micro-organisms like fungi, moulds grow on textiles made of cotton, flax, hemp, jute, wool etc. Fungi not only weaken the fibres but also leave stains which are difficult to remove.

Insects play a havoc in the case of textiles. Termites destroy all types of textiles when suitable damp condition prevails. Wool-moths attack woollen materials. Certain beetles like the dermested beetles damage wool and silk.

Mishandling and Vandalism:

Improper display and storages cause greater damages to the textiles. Neglect and ill-maintenance also matter much. Vandalism is yet another serious factor which damages our museum textiles.

Conservation Measures:

Acidity in textiles makes them to change the colour and weakens the fibres. Acidity of the textiles is found out by pH papers. From the colour change, we can find out the pH and say whether the textile is acidic (pH: upto 7) or alkaline (pH : over 7). If the textile is plain without any colour, it may be deacidified by fumigation with ammonia in a closed chamber. In case of fast coloured fabrics, the acidity may be removed by keeping the textile in between chiffon cloths on a glass support and washing with 1% teepol in distilled water. It should be thoroughly washed in water to remove acidity as well as the soap completely.

The stain may be removed by *ringing* method. The stained side is padded with cotton and from the other side a solvent like acetone is applied which loosens the stain and is absorbed by the cotton pad. In European countries wet methods of treatment are abandoned.

There are several methods of strengthening textiles. This can be done either by mounting, lamination or by impregnation. Mounting of weakened textiles is done on strong backing cloth by means of needle and thread or by *velcro*. Lamination by chiffon is also done by stitching. Impregnation can be done by methylmethacrylate. Freeze-drying may be done once a year to avoid all biological activities at –20°C. The movement of insects in the galleries or storage areas are identified by the use of various *insect traps,* which are card board devices with sticky material, to catch insects.

Mending of Textiles:

If the textiles are found torn, they need mending. The darning may be done by fixing the textile in a frame. While darning is done, the thread of the same size as that of the original textile is used. In European countries the fibres for darning are dyed by the conservator with the use of the similar type of dye used in the original textile.

General Care:

Since all kinds of textiles are extremely susceptible to light, care should be taken in the following lines: In the displayed area the intensity of illumination should be kept low, which may range from 50-100 lux. Ultra violet absorption filters may be used in the light sources. Natural light has ultraviolet radiation and so natural light should never be allowed in the galleries as well as storage areas but only artificial source of light, that too indirect light, should be used.

High relative humidity favours always fungal growth as well as insect attack. Therefore, it is always good to control moisture by air-conditioning the galleries. In order to avoid fungal growth in textiles, they may be periodically fumigated with thymol. Naphthalein balls may be kept in the display cases. Fumigation with DDVP may be done periodically both in the galleries as well as storage areas .

Since insects damage the textiles, insecticides and termicides should be applied both in the galleries and storage areas. Termicides like Dursban TC, Aldrin and insecticides like D.D.T., B.H.C. may be used.

Since dust creates a lot of problems, dust filters may be fixed in the air-conditioners. Regular vacuum cleaning should be done both in the galleries and storage areas. The textiles are covered by polythene covers and stored.

Because of the various shapes and sizes of the costumes, it is difficult to have a proper storage. One method is to store them in cabinets and hang them on padded hangers, with polythene sheets or bags to cover them. Contrarily, they are stored flat with pads or sheets of tissue paper inserted in the folds. To store costumes in a flat position, wooden drawers in cup-boards are useful.

Regular inspection is to be made to find out the defects, if any. Periodical application of insecticides, fungicides and termicides and a good maintenance of the area keep all the textiles in good condition. Pre monsoon application of biocides in the galleries and storage areas considerably avoids fungal and mould growth.

LEATHER BASED OBJECTS

Early man learnt to make leather out of animal skin and used them for his day-to-day life. Various processed skin and its products like clothes, parchments, scrolls, households, vessels, shields, puppets, footware etc., are preserved in the museums. Science museums, natural history and multipurpose museums even preserve stuffed animals, birds, insects, pests, pelts etc.

Leather Processing:

Skin is a net work of protein fibres chiefly *collagen*. Leather is nothing but cured skin which is dehaired, defatted, made nonputrient and impervious to water. Unless cured, the raw skin would be destroyed by moulds and bacteria. Tanning is a method of finishing skins to produce leather. Tanning can be done either by barks of certain trees or by minerals like salts of chromium which renders leather impervious to water while preserving its flexibility. Semi-tanned leather is produced by stretching the skin from which flesh etc., has been removed and then rubbing on it an oil or a fat emulsion. The skin becomes soft and flexible by this and then it is smoked. Semitanned leather is used to make costumes, pouches, headgears etc.

The skin of goat, buffalo or cow is processed by defleshing and defatting and rubbing with cowdung ash to make the leather for musical instruments. In case of stuffing of animals, alum and arsenical paste is used. In case of stuffing of birds, alum and borax are used. In case of insects formalin, olive oil etc., are used. Glycerin and xylene are also used in order to retain the colour of feathers.

Deterioration of Skin and its Products:

There are various deteriorating factors of skin and its products as they are organic in nature. High humidity affects old leather objects as the moisture increases the water content of the leather and facilitates the growth of microorganisms, insects and pests.

Brittleness or *hardening* is another defect in these type of materials. When leather looses its water content i.e. when leather is dehydrated it gets hardened and distorts in shape. Slight mechanical stress will make it to break.

Dust accumulation creates a lot of problems by becoming dirt which not only obscures the details on it but also makes it to deteriorate. Pollutants like oxides of sulphur, carbon and nitrogen dissolve in the moisture present in the atmosphere and increase the acidity in leather.

Conservation Measures:

As leather and associated materials are organic in nature it is always better to maintain the relative humidity and temperature at optimum levels. Air conditioners fitted with filters reduce dust.

Animal skin and its products should be periodically fumigated with thymol in order to protect them from fungal attack. The galleries and storage areas may be fogged with D.D.V.P. in order to protect them from insects and pest. Nifol, 0.3% paranitrophenol in alcohol, 0.25% pentachlorophenol in alcohol are good fungicides.

Hardened leather objects may be treated and flexibility may be restored to a certain extent by applying and rubbing some leather dressing materials. 2% solution of castor oil in rectified spirit is applied on leather portion and rubbed with a soft cloth. The superficial, excess castor oil is removed with the help of rectified spirit. When there is any distortion, the concave portion is treated with 5% water in rectified spirit and the area is flattened and then treated for flexibility by 2% castor oil in rectified spirit.

Shadow puppets are prepared from leather and they are dyed both sides. Their treatment is not easy. Such objects are accumulated with dirt and are illegible. The dirt is removed by soft brush. Rectified spirit is applied by a soft brush. The edges of the puppets all around are treated with 2% castor oil in rectified spirit. If the dye is fast, castor oil in rectified spirit may be applied throughout and flexibility is restored.

Fungal affected leather objects are fumigated, dried under shade and the dried fungal growth is removed by vacuum cleaning. Fungal affected objects are segregated from other objects immediately. New additions should be kept separately and they may be either kept on display or in the reserve only after fumigation and cleaning.

General Care:

Vacuum cleaning is done in the galleries and storage areas periodically to get rid off dust.

High light intensity should be avoided otherwise the natural colours on feather, leather, pelt etc., will be faded.

All objects should be covered with polythene bags and stored on racks.

Leather puppets should be stored in shallow drawers interleaved with acid-free tissue papers.

Storage should be maintained dark and neat.

FEATHER OBJECTS

Feathers form art objects on their own rarely. They become part of an object such as head-dress, crown etc. They are almost always secured to some kind of substrates, such as netting, basketry or hide and the method of attachment of the feathers may be sticking, tying, etc.

Composition:

Protein – *'keratin'* – is the main constituent in feather. It is similar to that of hair but with a rather different molecular structure. Feathers are not flexible as hair but will break if folded or stretched.

Causes of Deterioration:

Feathers are inherently quite stable, but gradually they become brittle over a period of years. They become brittle below 40% R.H. and mould develops over 65% R.H. The bright yellow and red colours in the feathers fade at higher levels of light. Feathers are susceptible to dust which settles and become trapped. The dirt soils the appearance also provides an additional food source for insects and moulds. Insects attack feathers at larval stage.

Treatment of Feather Work

The dirt may be removed by brushing with soft brush using rectified spirit. The eggs of the insects may be removed by brushing. The feather work is fumigated with D.D.V.P. (Vapona). New acquisitions should be fumigated with paradichlorobenzene before they are added to the collection.

Control Measures:

It is better to maintain the R.H. between 45 and 60% and temperature between 20°C to 22°C. In the case of coloured feathers they should not be exposed above 100 lux. Dust should be avoided either by filtration or keeping the objects in showcases.

Infested objects should be isolated and fumigated. Careful handling is important as feathers can be easily bent or broken, or the vanes disrupted. In handling such objects both the hands should be used. Folding should be avoided.

Feather work should be stored in dark and cool areas with protection against dust. Open storage should be avoided. Handling objects while inspection should be avoided. Objects should be displayed within cases having lesser light upto 100 lux.

BONE AND IVORY OBJECTS

Bone and ivory were early raw materials for carving out artifacts. Bone was used to make fish-hooks, arrow heads, tools, implements etc. Ivory was used to carve, etch, stain, paint, gild, inlay with metals and with precious and semiprecious stones. It is also used to inlay on wood and for veneering.

Composition of Bone and Ivory:

Objects made of bone and ivory are indistinguishable by mere sight. The main inorganic constituents are calcium phosphate associated with carbonate and fluoride and the organic constituent is *ossein*. Both have cellular structure. Ivory has a hard and dense tissue known as *dentine* which results in striations which may be seen radiating from the centre of the tusk.

Deteriorations in Bone and Ivory:

Bone and ivory are *anisotropic* having directional properties and for this reason they are easily warped upon exposure to heat and damp.

They are decomposed by the prolonged action of water due to hydrolysis of the ossein. They are disintegrated by acids.

Being porous and of light coloured they are easily stained. They tend to become brittle with age and they lose their natural colour when exposed to sunlight. When buried in the ground for prolonged periods of time they are disintegrated either by salt encrustation or by water. With the onset of fossilization the organic content gradually disappears and the remaining calcareous matter becomes associated with silica in the form of quartz and with mineral salts derived from the ground. Old bone and ivory often have an yellow colour and this is accepted as a form of *natural patination* which may help to enhance the appearance.

Conservation of Bone and Ivory Objects:

There are various methods of conservation of bone and ivory objects. Depending upon the type of defects the treatment varies.

Removing Surface Dirt:

Accumulated dirt, soot and grease obscure the beauty of the objects of bone and ivory. If the condition of bone or ivory object is fairly good a 1% solution of teepol in water is brushed on the surface and the dirt is removed with cotton swabs. Prolonged contact with water should be avoided. When fragility is observed the procedure is adopted with teepol in rectified spirit.

Removing Soluble Salts:

Excavated bone and ivory objects are found to contain absorbed salts which tend to crystallise out effecting disintegration, if they were buried in salty ground. The removal of salts from bone and ivory objects is extremely difficult. The soluble salts should be dissolved out by water. But, prolonged immersion or washing will damage the structure and it may warp. The soluble salt encrusted objects are immersed in distilled water for 5 seconds and is repeated a number of times with fresh distilled water. Then, two washings in 95% alcohol is made. Finally the object is immersed for one minute, and dried in air.

Removing Insoluble Salts:

Removal of incrustations of calcium carbonate or calcium sulphate from bone and ivory objects are a professional conservator's job. A small area of about 1 square centimeter is taken and brushed with a 1% solution of hydrochloric acid for a few seconds and the reacted material is removed immediately by a blotting paper. This is repeated. The incrustation is removed by means of pin or scalpel without making any scratch or abrasion. In order to remove the traces of acid the object is washed in several changes of distilled water for a few seconds at a time and then dried by alcohol and finally with ether. If only calcium sulphate is present it should be removed by mechanical means even by vibrotool very carefully provided the object is strong enough. Otherwise it may be left as such.

Strengthening:

When bone or ivory object is weak, it may be strengthened by impregnating it with a 5% solution of polyvinyl acetate in toluene. This may be done 3 or 4 times to do a justification. Fragile objects may be vacuum impregnated. During excavation, a water emulsion of poly vinyl acetate (P.V.A.) or polymethacrylate may be used to strengthen wet and soft bone or ivory objects before removal of the object. Bone and ivory objects may be given a protective coating of 2% P.V.A. in toluene.

Restoration of Bone and Ivory Objects:

In the restoration of bone and ivory objects suitable adhesives which will not be affected by humidity are used. Nitro cellulose based adhesive is good for restoration. Water soluble adhesives should never be used.

General Care:

Since bone and ivory objects are porous and are easily scratched, stained etc., they should be wrapped in a clean soft acid-free tissue paper and kept on padded shelves or in padded boxes.

Very badly affected objects should be kept in showcases which are provided with silica gel to control relative humidity by absorbing moisture.

LACQUERWARE

Lacquering was a very popular technique for finishing an object. Wood, cane, leather, papier-mache, metal etc., are the base of lacquered objects. On all lacquered objects decoration of various types is applied. Gold leaf designs are also common on lacquered work. The lacs are of two different varieties. One is made by using the processed and coloured sap of a tree, the Rhus verniofera. The resin from the tree Ficus religiosa is also a lac. The resin after processing results in the lac of commerce ie. shellac.

Damages to lacquerware

Moisture affects the lacquerware. The objects on contact with water become chalky or white or opaque. Very low humidity make the lacquer objects brittle and the lacquered portions may be chipped of. They are easily abraded.

Conservation Measures:

Lacquer objects and lac coated objects should not be cleaned with water or an aqueous solution as they become opaque or white with water. As they are fragile, shocks and abrasion should be avoided. Soft brushes should be used for cleaning. They should be wrapped in soft tissue paper and kept in padded boxes or shelves.

RUBBER OBJECTS

Museums nowadays collect objects of all types. In European countries, present day objects are collected and displayed. Ethnographic museums or multipurpose museums like Madras Museum collect objects of rubber. The rubber is present in the form of natural rubber bands, coloured balloons, rubber tubing, tyres, inner tubes.

Constituents of Rubber

Natural rubber is prepared out of the latex from rubber tree. Rubber is largely composed of unsaturated polymers like poly isoprene, polyputadiene, poly styrene co-butadiene.

Causes of Deterioration

Since rubber is an unsaturated chemical compound, it is susceptible to oxidation. When rubber is oxidised the product may be softened or hardened. Attack by ozone causes embrittlement and subsequent cracking of the rubber objects. Prolonged, uncontrolled oxidation and attack by ozone results in disintegration of rubber and serious damage to objects.

Conservation Measures

There are several measures which can be tried to protect rubber from its degradation. There are both physical and chemical methods.

Physical methods involve introducing a barrier between rubber and atmosphere ie. giving a coating on the rubber or sealing the object in a bag which is oxygen proof. Coating of chemicals or resins will alter the appearance of the rubber object.

Chemical method include keeping an oxygen free environment to rubber by keeping the rubber in a nitrogen atmosphere and the oxygen present may be absorbed by keeping Ageless which is nothing but finely divided active iron, which forms iron oxides and hydroxides on absorption of oxygen. The materials which are considered to have suitable properties are polyvinylidene chloride film, Cryovac BDF 200 film. The physical condition of the rubber objects may be monitored periodically by photography in order to see the change.

PAINTINGS ON CANVAS

India is well known for the traditional paintings such as larger paintings on wall paper, leather, canvas etc. There are paintings executed by artists of Persian and Indian schools and developed over the centuries. The canvas paintings were introduced by the Europeans in India. Especially British artists excelled in this form of art and we have thousands of British paintings on canvas in India.

Composition of Paintings on Canvas:

Paintings have a complex multilayered structure whatever may be their forms. They are support, ground, paint and varnish. In the case of paintings on canvas, the canvas support for a paintings is a strong cloth made from unbleached hemp, flax or other coarse yarn. The canvas was coated, or primed, with an inert white powder like chalk, gesso, zinc oxide, titanium oxide in a glue medium, to form a uniform layer or ground. Modern canvases are brought ready-primed with lead white and linseed oil. The paint layer overlay the ground and consisted of an aggregate of finely ground pigment particles suspended in a binding medium i.e. either oil colour or water colour. The usual finish was to apply a coat of varnish, to give an enhanced gloss and to protect the painting from light, dust and other environmental factors.

Pigments and Dyes:

From antiquity right upto the late nineteenth Century, artists' pigments were almost exclusively inorganic materials - either natural minerals (or synthetic substances resembling them) or else residue from the careful calcination of organic matter such as bone and ivory. The pigments are invariably insoluble in a binding medium and therefore they are used as suspensions.

Dyes used from ancient times to the late nineteenth Century were obtained from plants and animals. Modern dyes and pigments are essentially organic compounds rather than in-organic. Dyes are generally soluble in water and bound to the textile. The natural dyes have not been widely used in painting, because of their tendency to fade and lack of intensity of colour. The madder and indigo are of plant origin and they are fast colours.

Some of the ancient pigments are (white) chalk, gypsum, kaolin, lead white, bone white; (black) lampblack, pyrolusite; (yellow) ochres, siennas, orpiment; (red) hematite, vermilion, red lead, realgar; (green) malachite, chrysocolla, verdigris; (blue) azurite, ultramarine.

Deterioration of Paintings:

The deterioration of paintings may be a result of deterioration of any one or more of the constituent layers viz. support, ground, pigment and varnish.

Deterioration of the Canvas:

Deterioration of the canvas is due to the oxidation of the cellulose fibres. There is always a danger of the growth of micro-organisms like fungi, moulds etc., in humid conditions. Silver-fish, cockroaches, beetles, and termites are some of the insects that damage paintings. Climatic variations have a profound effect on the condition of the paintings.

Deterioration of Paint:

Paint slowly deteriorates, and may eventually be destroyed by the combined action of atmospheric oxygen and photo oxidation.

Cleavage of paint layer from the ground due to climatic variations causes flaking of paint because the paint is unable to adapt to the change. Atmospheric pollution like sulphurdioxide, hydrogen sulphide, dust particles are very harmful for paintings. For example, white lead becomes black, lead sulphide, by the action of hydrogen sulphide. In situation of high stress cracks develop in the paint layer.

The Varnish Layer:

There are two kinds of varnishes. One is '*spirit varnish*' - after loss of solvent by evaporation. It gives varnish film which is brittle, not very durable and changes its colour due to ageing. The other varnish is '*oil varnish*'. The drying of the varnish film is due to polymerisation of the terpenoid constituents. This may be accompanied by oxidation from atmospheric oxygen. Minute cracks are called *craquelures*.

Conservation of Paintings:

Weak canvas may be strengthened by relining. The old canvas is backed with a new canvas of similar weave count, the two being cleaned and joined together by an adhesive which is reversible in nature. In Indian condition wax-resin adhesives are used which not only strengthen the canvas but also give flexibility to the old canvas. During relining, front facing is done with tissue paper and reversible paste like maida-flour paste for protecting the damaged paint layer and is removed by moistening and scraping it with nail. Spirit varnishes when become dark are easily removed by dissolving by solvents like alcohol, benzene. If needed, restrainers like turpentine

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Paintings

may be used. Oil varnishes require special methods, depending on the composition of the varnish and its age. Mixture solvents are used to remove the varnish layer. Black leadwhite portions may be cleaned with hydrogen peroxide. After the cleaning of the surface, the loss of pigment are restored by inpainting using acrylic paints. In order to protect the surface, picture varnish or polyvinyl acetate in polycyclo hexanone is sprayed.

Care of Paintings on Canvas:

When the paintings are affected by biological agents, they may be fumigated with a vapour type insecticide or fungicide, most commonly by thymol or paradichlorobenzene. Since prolonged fumigation softens the oil, fumigation should be limited for a shorter duration.

Since light is very damaging to paintings, day light should be avoided. Fluorescent tubes with filters can be used. Indirect lights will be better. Since incandescent bulbs give off heat powerful direct focus lights should be avoided. It should be seen that the light level is less than 100 lux where paintings are exhibited.

Since climatic variations affect the paintings air-conditioning of the paintings gallery is ideal. Otherwise the paintings may be displayed in a gallery where humidity is controlled.

Atmospheric pollution like dust, sulphur-dioxide, hydrogen sulphide is harmful to paintings. In the absence of air-conditioning and air filtration, the only practical method to protect paintings from atmospheric pollution is to exhibit them in glassed frames. While providing glass there should be little space between the glass and the painted surface to avoid the condensed water which may affect the painted surface.

Oil paintings on canvas should be kept stretched and framed and the canvas should be tightened with wedges and keys. The paintings should be held in their frames by mural plates screwed to the frame with brass screws.

Oil paintings on canvas if needed to be rolled, the painted surface should be kept outside while rolling.

In storage, the painted surfaces should never be allowed to come in contact with one another or with anything hard. Storage bins with spacers that allow the paintings to be kept in a vertical position without touching one another are advisable. Paintings may be suspended with hooks on the parallel vertical grill frames. The frames are fairly near each other and are fitted with sliding frames that slide along the rails in the ceiling and the floor, so that each frame can be slid out for inspection of the picture suspended on the grill.

If the paintings are unglassed they should be covered when kept in the storage. If the paintings are not glazed in the galleries, railings should be provided to avoid vandalism. The paintings should be suspended slightly inclined in order to avoid dust.

A padded, rolling trolley should be used for the transport of very large or heavy paintings to avoid mishandling. When transported even to a short distance the painting should not face the sun. Too much flash light should be avoided. Focus lamps for photographing, film shooting or videographing should be avoided.

In the galleries where paintings are displayed or in storages sweeping should never be done. Vacuum cleaning should be done. If dust is found on the surface of paintings, fine hair brush should be used to dust them off.

DRAWINGS, PRINTS AND PAINTINGS ON PAPER

After the invention of paper, paper was used as a support for paintings, drawings and prints. Paper boards were also used for these purposes.

Deterioration to Paper Paintings:

Moisture, heat, light, dust, insects are the various deteriorating agencies other than mishandling, faulty display and storage and neglect.

Conservation of Paper Art Work:

The paper or paper-board is changed to brown because of acidity. Because of age, the surface gets accumulated dust which obscures the look of the print or painting. The stains are removed by fine eraser. The acidity is removed by applying barium hydroxide (saturated solution) at the back of the print, very carefully. Vapour phase bleaching may be done in case moisture removes the pigments. When mending is required, the inconspicuous corners of the paper print are taken and filled in the missing areas. Fragile paper works are chiffon laminated with maida flour paste added with insecticide and fungicide (0.1% ortho nitrophenol) at the back side. The excess paste is very carefully squeezed out by a squeezer. When slightly dried under shade it is kept between blotting papers at the back and oil paper in the front and weight is placed over it. After one day, it is taken out.

Care of Paper Art Works:

Painting or prints on paper or paper-boards may be damaged when they are bent or folded. Physical handling quite often makes them to deteriorate. Therefore, the painting on paper is mounted between hinged mats of good acid-free mount-board with a window cut top mat for allowing the painting to be seen while holding it securely in place. The window cut mount is pasted with a tissue paper to avoid dust from falling on the painting, print or drawing.

To protect the painted surface from abrasion and scratches, the paintings should be kept between soft tissue papers and lifted by the corners so that hands do not come in contact with the painted surface.

For storage of mounted paper paintings, prints etc., solander boxes are used. Prints, paintings and drawings are protected by providing glass fronts. The glass should never touch the painted surface. Therefore acid free board or all mat strip may be placed all around in between the paintings and frame. For the safety of the back of the painting, a stiff acid- free hard-board or hand made board may be used.

When displayed, a low intensity of light to the maximum of 50 lux is used. If the gallery or storage is air-conditioned throughout the day, the longevity is improved.

THANJAVUR PAINTINGS

The Thanjavur paintings are in the gilded and gemset techniques and are sacred icons of the Hindu deities. The *iconic* style is therefore not an isolated phenomenon but is spread throughout the southern India and was practiced for about 200 years, approximately 1700-1900 A.D.

Painting Technique:

A sheet of card board is coated with tamarind seed paste (white of the seed with gum) to a jack tree wooden base which is single or joined one. One or two cloths are pasted to the card board. A lime paste is coated, which is called *sudhai* and smoothened. Details are drawn and the positions where gem stones are to be set are marked. *Sukkan* (unboiled limestone ground with glue) is applied and the surrounding is raised with sukkan. Over the relief areas gold paper is cut into strips and pasted with tamarind seed paste. The gold work on Thanjavur painting is of two distinct varieties. Gold gilding is either with pure gold leaf or with gold paper.

Damages in Thanjavur Painting:

Since the Thanjavur paintings are composite in nature, the problems are also multiple. Since the wooden planks are joined, they give way due to age and cracking is noticed on the paint as well as the textile and card board support. The gold paper is lost due to insect attack. The space between the textile and plank are affected by insects and the card board is badly damaged. Loss of gemstones and cut glasses which are used for ornamentation are noticed. At times it is noticed that the paint applied on white gem stones are also lost due to abrasion. Loss of pigment is noticed. Wrinkling of the surface due to cleavage of support layers, water stain and fading of paints are noticed.

Conservation Treatment:

Main Support:

The main support of the painting is fine cloth when there is some loose adhesion, tamarind seed paste is used to fix the textile with the accessory support.

Accessory Support:

The fine cloth is normally pasted on a card-board which is in turn pasted to jack tree plank, which may be a sheer single plank or two planks joined together and reinforced by two or three reapers. The planks are set right and the cracks, if any, are filled with wooden putty.

Loss of Stones, Pigments, Gold Gilding etc.:

The missing stones from the paintings are replaced by new stones and fixed in place using tamarind paste. The gold paper strips are cut and pasted wherever there are loss of gold leaf. If there is any loss of pigment with the places are infilled with lime paste and matched with water colours. The blue background is redone with blue powder ground with gum. If the gilded areas are found to be dark, the areas are cleaned with cotton swabs dipped in rectified spirit, acetone, toluene etc.

Frame:

The Thanjavur paintings have a broad and light wooden frame. The bottom frame is sometimes broader than the other three sides. The plaster ornaments are repaired if lost. The frames are cleaned, with fine *emery* and sprayed with a gild prepared out of gold gild powder and resin in thinner. It gives a good look.

Glass Front:

Thanjavur paintings are generally provided with glass fronts or with frames with provision for glass front. If there is no glass front a 3mm glass front is provided with a spacer in between the painted surface and glass.

Backing:

Most of the paintings do not have any backing. The wooden plank is exposed to humidity and dust. The planks are applied with insecticide, the holes, if any, are filled with the insecticide like D.D.T. and wax and coated with varnish to avoid water absorption at the back. The gap between the plank and frame is pasted with a cloth to avoid the entry of dust and insects. If necessary, plywood backing may be given.

General Care of Thanjavur Paintings:

Thanjavur paintings should be periodically examined for their condition. Application of spray of insecticides may be given at the backing. It is better to fumigate the paintings in paradichlorobenzene to drive off any insect trapped inside the frame work

GLASS PAINTINGS

The technique of making glass paintings was in vogue in Europe before the 18th Century. The glass manufacturing central European countries produced cheaper variety of glass which was used as the support of the folk art painting. The greater part of these paintings were religious. Glass painting technique seems to have spread all over Europe. Painting on glass, therefore, originated as a derivative art in a new medium. The Thanjavur glass painting is quite southern. The subject matter of Thanjavur glass paintings are both religious and secular.

Technique of Painting on Glass:

In this type of painting, plain glass forms the support. The picture is drawn first with the brush outlines and then the details in tempera which will when finished, appear uppermost. Then the larger areas of opaque colour are brushed in. The paintings are generally flat except for the drapery and the face and body of the figures where a summery fullness is achieved by shading. When gold or silver effects are required, gold and silver gilded papers are used. The shading is really a kind of modelling which tries to show the roundness of forms and is not related to cast shadow. Thus the usual painting method is reversed. The picture is then mounted with its unpainted side foremost so that it is seen through the glass.

Damages to Glass Paintings:

Glass painting is a fragile material which when falls down is broken into pieces and so the art work is lost. The paint pigments are lost both by insects and abrasion. Water stains them. Fading of colours occurs. Gold paper, gild paper pasted are detached due to high humidity. Flaking of paint layer is also noticed. Due to alkaline nature glass disease is also noticed on the front side of the glass.

Conservation of Paintings on Glass:

Unlike other paintings, painting on glass has the support which acts as the surface protection. When the glass is broken the painting looses its support as well as painting. The loss of pigment is restored by tempera colours. Wherever the gold gilded paper is detached it is pasted again with polyvinyl acetate in toluene or Paraloid B72. The broken pieces are aligned together on a thin glass plate of equal size in the reverse order and the joints are made with 5% polyvinyl acetate in toluene. The missing portions are replaced with acrylic sheets of same thickness, then the details are drawn. When all the broken pieces are joined together and all restorations includ ing retouching are over, another thin glass of same size is kept at the back of the painting. Actually the broken glass painting should be sandwiched by two plain glass sheets. The glass painting is fixed together at the edges with gummed tape avoiding entry of dust and moisture.

Frame:

Generally all glass paintings have wooden decorated frames. The frames are sprayed with gold gild to have a better look when all the gold gilds are abraded or lost by wear and tear. Since the glass itself acts as the front of the painting, no further glass front is needed in the case of glass paintings.

Backing:

The back side of the painting should be protected well. Otherwise, they will be eaten by insects. A proper backing either with a chemically treated plywood, wooden plank or aluminium sheet gives good protection from dust, moisture and insects.

Care of Paintings on Glass:

Utmost care should be exercised in preserving the paintings on glass. Nothing should hit the glass as the glass itself is the ground and support for the painting. If no backing is found, backing should be provided immediately. The paintings should be suspended or displayed using strong white nylon threads and also giving proper support at the bottom at an inclined angle. The paintings may be sprayed with insecticides like D.D.T., B.H.C. to eradicate the insects. The back of the painting should never touch the wall. The backing may either be applied with varnish or pasted with cloth to avoid absorption of moisture.

WALL PAINTINGS

Paintings are associated with religious activities mostly. Some of the temples in Tamil Nadu are blessed with paintings on walls. Both organic and inorganic pigments were used. A knowledge about their technique of execution, decay and maintenance will help those concerned to preserve them for posterity.

Painting Technique:

The paintings which are executed on wall (i.e.. muir) are called *mural paintings*. The wall can be the surface of a cave or building by stone, mortar, mud, brick structure. Over the selected surface a thin layer of painting using vegetable dyes, lamp black or white kaolin might be created as in the early cave paintings. Such primitive paintings are executed by the application of an aqueous solution of the pigment/dye over the selected surface, preferably porous to permit the dye to percolate in. Later on, it was developed such that the solution was either added with animal glue or vegetable gum to give a solution of workable consistency. This glue or gum gave the dye a certain adhesive quality specially required when the wall or plaster was prepared in advance to accept the paint and a binding medium was required to bring about a true bonding. When the painter used the wet plaster to create a painting and used the nature of the lime wash to create a natural colour without an organic binder, the painter is said to have created a true fresco (buono), when he chooses to work on a dry plaster to express his creativity and requires a binding element in his paint to adhere to the plaster, he creates a fresco (secco). Belonging to this last group of painting with a binder on a dry plaster are the South Indian paintings and these have been termed the tempera.

Deteriorations and Their Causes:

Flaking of paint layer, lifting up of the paint layer in the form of cups, blistering, cohesion, scroll formation, fading of paint layers, abrasion, physical damage by mishandling and vandalism are the various deteriorations on the wall paintings.

There are various causes for the deteriorations of wall paintings. There are variations in the humidity and temperature, particulate matter such as dust, soot, smoke, tarry and greasy matter due to burning of lamps, camphor etc., atmospheric pollutants such as oxides of carbon, sulphur and nitrogen, biological growth and droppings of birds and bats, insect nests, seepage of water, salt action, cracks in the building etc.

Disintegration of the binding medium, pigments chemical changes in them, expansion and contraction etc., are the causes within the painted layers.

Cleaning of Wall Paintings:

The accumulated dust should be brushed off using a soft squirrel hair brush. The accretions, if any, may be removed by gentle abrasion. The salts formed on the painting may be removed by scrapping. The patches of white washings should be removed by mechanical means.

The biological growth should be removed mechanically and then gently brushed with brush.

Grease, smoke, soot etc., are removed by using a 10-20% aqueous ammonia or 10-20% butylamine in water. When blistering, cohesion, cupping, cracking are noticed experts should be consulted.

The ceiling should be properly repaired to avoid leakage and seepage.

Care of Wall Paintings:

Wall paintings should never be disturbed. Birds like pigeons, bats should be avoided. Squirrels, rats should be avoided by proper monitoring means. If possible the painted walls may be screened to avoid long exposure to light. During renovation the conservation experts may be consulted.

If the wall paintings are found detached from stone or brick walls they may be transferred by the experts and preserved for posterity.

Stancheons and ropes may be provided to avoid human touch.

PHOTOGRAPHS

The art of photography came into existence in the nineteenth Century. Museums preserve photographs, negatives, slides, cassettes etc. Therefore, the information regarding the preservation and care of photographic materials are much useful to the curators or collectors of such materials.

History of Photographic Materials:

In order to take measures to preserve photographs - positive, negative or slide - one must have a knowledge how a photograph will behave. Photographic processes are of three groups viz. silver based, iron based and chromium based. Out of these, the silver based photographs are the famous ones. Paper was used as support which could not give sharp images. Glass negative was used in 1847. Glass supports are nowadays replaced by celluloid, cellulose nitrate or cellulose acetate or even latest by polyester film.

Deterioration of Photographs:

Photograph is a very complex material, having several components like support, binding medium and photosensitive image forming chemical which may react in different ways to various factors of deterioration. The common deteriorations noticed in photographs are yellowing, stains, separation of emulsion, fungal attack, insect attack, scratches, finger prints, folds etc.

Conservation of Photographs:

In the case of glass negatives, due to age the emulsion becomes brittle, cracks and falls off at slightest shock or touch. Since gelatin is easily prone to damage by water, the negatives or photographs should never be touched on the face, but should be held at the edges.

Photographs or negatives should never be kept together as they stick to each other in a humid condition and it is very difficult to separate them without damage. If the humidity is very low, the gelatin portion starts cracking.

Micro-organisms like fungi affect the photographs at humid environment. Silver fish eats the gelatin as well as paper. It is a irreparable loss.

While framing photographs the glass should never touch the photograph but spacer should be provided between them.

In case of accidental water soaking, the photograph should be dried without any blotting paper. The surfaces should be cleaned with a soft brush. The photographs are kept inside oil covers and stacked in a cabinet which is kept in an air-conditioned room. Colour film, being very colour fugitive, it needs low temperature for preservation. The safest storage environment for all photographic materials, whether colour or black and white, is a temperature as low as possible, preferably below freezing, and an R.H. of around 30%.

Care of Floppy Disks

Magnetic Tape

A magnetic tape is a common input/output recording media used for storing large amount of data in a predetermined orderly sequence. Its widespread use is due to its high tranfer rate, storage density, mass storage capability, compact size and relatively low cost of operation.

The following are the physical precautions which will protect and extend the life of a floppy disc.

1. Avoid temperature extremes. All materials are subject to contraction or expansion in severe cold or heat. The suitable temperature for keeping the media may be from 10°C to 52°C. It should not be kept under direct sunlight.

2. Do not leave the media near any source of magnetic fields like magnets, telephone, X-ray equipment etc.

3. Do not bend or crease the media.

4. Do not get contaminants on the media. Contaminations like smoke particles, fingerprints, oils, hair etc., cause serious problems on the magnetic disc surface.

5. Never touch or put anything on the disc.

6. Keep the mini floppy disc inside the cover when it is not in use.

7. Protect floppy discs from dust and humidity.

8. Do not lube the floppy discs.

DOCUMENTATION IN CONSERVATION

Documentation is one of the important aspects of conservation. Classifying the books in a conservation laboratory and documenting them, documenting slides, photographic negatives, cassettes, floppy discs, condition reports, conservation reports, classifying the objects on their suitability for exhibition, loan etc., come under documentation in conservation.

Classification of Conservation Books:

Classification of books is the basic need of a library. There is no museum without a library. Books are very important for a museum curator or conservator for reference as he has to learn the latest techniques of conservation etc. If they are classified and documented properly it will be of much help to the users. Most of the large museums have a central library to cater the needs of the staff, trainees and researchers. Besides the central library, conservation departmental libraries are also available in order to have immediate access to the staff. It is better to classify the conservation books for their easy location. The conservation books may be broadly classified in various ways. The following is one of the methods : I. Bibliography II. Sources of literature, III. Museology, IV. History of conservation, V. Climatology etc., are the main divisions. Then, each main division may be sub divided and another number is given as follows :III Museology, III.A General Museology, III.B. Architecture of Museums III.C Museum Organisation, etc. Catalogue cards may be prepared and arranged in the index cabinets.

Documenting Non-book Materials:

Besides conventional documents there are micro-copies, film slides, movie films, photographic negatives, video cassettes, floppy discs etc., available which are documented properly enabling easy retrieval and educating the trainees or researchers.

i) Photographic Negatives:

Photography is also a very important aspect in conservation. It gives the real picture of the object before and after conservation treatment. Some museums resort into five types of photography viz. black and white, colour, slide, ultra-violet and infra-red. The negatives and slides are classified and documented for easy reference. The negatives are put in covers which contain particulars like name of the object, accession number, department from which the object was received, number of the negative before treatment and after treatment, reference to publication etc. They are kept in order in closed cabinets either subject-wise or material-wise. Similarly slides are also documented, accessioned and arranged in grooved cabinets.

ii) Video-Cassettes:

The various conservation treatments are recorded in video cassettes and they are also documented subject-wise which may be used by the trainees or scholars who study the subject of conservation.

Documentation of Conservation Work:

The conservation work is initiated by the collection departments, when the museum objects are catalogued, sent for temporary exhibition or when they are sent on loan. Besides these, the affected objects which are displayed or stored in the storage areas are also sent for conservation treatment. Certain museums arrange for quarterly inspection of the galleries and storage with the collection curators and conservators. When an object is affected, a request for conservation treatment is sent to the conservation department mentioning the name of the object, its location, the date on which the object is to be returned after conservation etc. The conservator checks the condition of the object and suggests the proposed conservation treatment and is got approved by the head of the collection department. Then the object is received for treatment. In some museums, the curators of the collection department sent the objects for conservation and the type of treatment required is discussed with the conservator. The object is examined very well even with the help of microscopes and are recorded in the conservation card. Name of the object, previous treatment, if any, reference about its publication, all types of photographic references, date of receipt, date of starting the conservation work, duration of treatment, chemicals used, method, name of the conservator, etc., are included.

The opinion of the conservator whether it is eligible for display, loan etc., is entered. The condition of the object after treatment is detailed. The date of completion of the work as well as return are mentioned. This information will be much useful when the object goes for exhibition, loan or comes for conservation treatment again.

Condition Report:

There are preliminary condition reports prepared by conservators to establish whether on object or work of art is fit for exhibition and if possible the kind of treatment required to make it safe to travel.

Part VI

General Conservation Guidelines

An essential feature of the preliminary condition report form is its conciseness. The ticking of the squares, or encircling of words, makes the inspection go quickly.

A second type of report form is that used for recording the condition either when an object leaves an institution for an exhibition, or on arrival at the museum where the exhibition takes place. The documentation also includes such vital information as the packing systems used and the mode of travel. The documentation information included should be useful to the head of the collections or registrar for insurance claim apart from obvious record purposes. The condition report is also seen by conservators of the borrowing institution and if any defect is noticed, it is mentioned in the report. This report goes along with the loaned objects. Besides these, registers are maintained in the conservation laboratory for documentation work.

Computer Documentation:

Most of the European museums now switched over from manual card documentation into computer documentation. It is an easy retrieval system which can be reformed both by the collections department staff and conservation staff if their computer is linked with the master one.

EXHIBITIONS AND CONSERVATION MEASURES

Museum exists to preserve the art objects in its collection through proper exhibitions to understand and enjoy it. In the exhibition galleries certain guidelines should be practiced in order to keep the objects in a better state for posterity. In order to take care of exhibited museum objects, one must know about the supporting materials used in display and the environmental factors.

Guidelines for Supporting Materials:

1. Two dimensional objects like paintings, prints etc., must be suspended or fixed to walls or display panels with proper supports like nylon threads or mural plates.

2. Three dimensional objects like bronze sculptures, stone sculptures etc., should be displayed on pedestals, properly secured or within showcases having proper suppo .. The supporting materials used to secure the objects should neither mask, soil nor chemically react upon contact.

3. Pins and supporting wires should be standard stainless steel and covered with nylon or polyethylene tubing. Nylon filament is also good, provided it does not cut into or stain the object and is strong enough.

4. While stapling, staples should never be used in contact with objects, but should be covered over with insulating materials.

5. When mounts are used, it is better to use perspex, plexiglass etc.

6. Textiles, costumes etc., should be supported with padded hangers.

7. Show case for museum objects should be constructed using non-reactive materials, adhesives and coatings, so as not to cause deterioration or discolouration during long-term exposure. Raw plywood surfaces are to be avoided because of possible formaldehyde emissions.

Environmental Guidelines in Exhibition:

1. The exhibition area must be environmentally controlled and free from all construction, decoration or related activity. Freshly painted areas should be allowed to dry for at least two days under active air circulation. There should be at least a minimum time gap of two months between plastering of walls and exhibition.

2. The exhibition must have limited and controlled access with provision for daytime security by trained persons and at other times be furnished with intrusion, smoke and fire detectors.

3. Works of art and other objects should not be exposed to sunlight, heating, too much cooling or placed close to lamps.

4. Floor cleaners and cleaning operations should not be hazardous through splashing, chemical exposures, or mechanical damage.

5. In case of renovation, repair or painting the exhibition galleries, the objects should be well covered with polythene sheets and reinforced with wooden structures all around.

6. Thermo hygrometers should be placed in sensitive locations above the floor level to record relative humidity and temperature throughout to take control measures of decay.

7. The light level for light-sensitive objects should be in between 50 and 100 lux, that too, for a limited exposure.

8. Photography, movie and video work should be controlled, as too much light affects works of art.

9. It is better to limit on the maximum number of persons permitted at any one time in the gallery depending on the exhibition space and the capacity of the air-conditioning system.

10. In order to restrict vandalism in the exhibited area,stancheons with ropes may be provided. The security staff may be instructed to act vigilantly.

11. Researchers and visitors who take notes may be asked to use only pencils which will avoid marking on objects either by forgetfully or accidentally.

There may be some more problems to be tackled by the curators or persons in-charge of collections depending upon the need.

STORAGE AND CONSERVATION GUIDELINES

There is a natural tendency to relax conservation vigilance when the museum objects are out of sight in storage or in vaults. The basic principle of storage is to keep the objects in a physically secured environment and yet to permit ready access for inspection before their removal to the galleries, storage or other locations.

Storage Devices:

There are various storage devices and they are expected to meet the physical and environmental criteria intended for preserving the museum objects against damages.

Stacking:

Paintings and flat framed works, prints, photographs etc., may be placed on pads and stacked vertically using cardboards as separators. In group stacking it is necessary to ensure that the pads are skid-proof, that the angle of stacking is average, and that the largest objects are kept first. Three dimensional objects like sculptures, large objects should be placed on pallets to permit easy handling and lifting.

Shelving:

Shelves may be constructed either by wood or preferably by metal for storage of two-dimensional or three-dimensional objects. Vertical slots may be designed for flat items and bays set up for objects. Boxes of different sizes may be made and objects kept wrapped with acid-free tissue paper inside. This method will utilise all the spaces available in the shelves, when there is only a limited space.

Drawers and Cabinets:

Drawers are used for flat works of art on paper, card-board and textiles, maps and similar items, and also, when appropriately designed, for small objects. Interleaves of acid-free tissue papers are used. The drawers for coins are with slots in them. Cabinets are also used for two dimensional and three dimensional objects.

Sliding Screens:

Sliding screens are very common for paintings and flat works and occasionally for decorative art, or arts which can be suspected by appropriate hooks. Such system is economical of floor space and are efficient for examination and retrieval purposes.

Compaction Devices:

Compaction device is fairly recent in the museum world and answers in the requirements for more storage and less space. Compaction equipment is intended for permanent storage primarily. The compaction units are either electrically or manually operated. The manual type of compaction equipment is probably more useful for museum storage, as it is less likely to go wrong. In this type normally textiles are preserved.

Vaults:

Vaults and security storage areas are used for extremely valuable objects, e.g. gold and silver coins, precious stones or other treasures like silver, gold and diamond jewelleries.

Conservation Guidelines:

1. Storage areas should be maintained clean and the waste and condemned furniture should not be stacked in the storage.

2. Regular vacuum cleaning should be done to get rid off dust.

3. If open storage is maintained, the objects should be covered by polyethylene sheets or bags.

4. In order to avoid wastage of space in the storage as well as to avoid dust, slotted angle shelves should be arranged with different sized boxes containing objects to fit in the space available.

5. The R.H. and temperature should be maintained at the optimum level and it should be monitored regularly.

6. Light sensitive objects should always be kept closed by screens.

7. When scholars are allowed to study the reserve collection pencil only should be allowed for writing. Otherwise there is a likelihood of objects being stained by ink.

8. Biocides should be used regularly to drive off insects and micro-organisms. Before the advent of monsoon organic objects should be fumigated with thymol in order to avoid the growth of fungi and fogged with D.D.V.P. to avoid insect attack.

9. Smoking should never be allowed inside the storage area as it involves fire risk.

10. Open fire should never be used even in the form of lamps.

11. When objects are removed from higher shelves ladders should be used with care.

12. Objects should never be kept near windows.

13. Proper pallets should be placed under heavy objects in order to facilitate lifting or handling them.

14. No object should be directly placed on the floor.

15. Lead coins should not be stored in wooden cabinets, but on plastic trays, as volatile acids emanated from wood affect lead coins.

16. It is better not to have the conservation laboratory attached to the storage as it involves fire risk.

LOANING AND INSURANCE

When some national or international great exhibitions are conducted, museum objects are received on loan basis. Loan agreement is made between the lending and borrowing institutions. The memorandum of agreement of loaning sets out the conditions, duration of loan and insurance coverage for the specified number of works of art or museum objects and for a definite period. In the loan agreement the lender and the borrower agree on the security, conservation and all other technical conditions for the entire period of the loan on 'nail to nail' or 'wall to wall' basis. When specifications are made on the conservation and security of the loaned objects in the agreement, these are implemented by the borrower and the institutions where the exhibition is held.

The loan agreement will have the following particulars:

1. Exhibition title, description of the borrowing and lending institutions and date of agreement.

2. Ownership and details of the owner of the objects.

3. Complete description of the objects including materials used, artist/craftsman, provenance, accession number etc.

4. Dimensions and weight of the object including its photograph or shape.

Condition Report:

Technical conditions of loaning of museum objects are laid by the lending institutions and the borrowing institution agrees to it. Condition reports are prepared by the lending institution or the reports are prepared jointly by both the institutions. Borrowing institution has to prepare condition report when there is any change in the appearance of the object and send it to the lending institution. Borrowing institution will have to maintain the environmental control. Conditions to photography is laid, as too much light will affect works of art. All care should be taken by the borrower in the exhibition and storage areas. Both the institutions agree that the assessed value is only for insurance purposes and the liability of the borrowing institution will be limited to the insured value only. The borrower should do the packing, transportation and insurance at their cost. The agreement is signed by both the institutions along with witnesses.

The loaned museum objects will be accompanied by couriers who are the *defacto* ambassadors of the lending authorities and as such are often empowered to make spot decisions, when emergency arises. The couriers are normally curators, registrars who have enough knowledge of shipping, transportation and conservation of museum objects. The condition reports, associated photographs, environmental records, charts etc., are filled in properly so that they can be readily accessed in the event of subsequent insurance claims etc., when such damage or loss occurs.

Insurance :

Insuring museum objects sent on loan is very important. Insurance is made on 'nail to nail' or 'wall to wall' basis. This means the overall protection of the loaned objects from the time they leave the lending institution till they reach the lending institution back safely, within the prescribed time limit. There are a lot of scopes for damage or loss to occur to the objects in transit, at airports, docks, storage areas, exhibition areas or upon arrival and despatch at each venue of the exhibition.

Expert and Evaluation Committee:

This committee is either constituted by the Government or the managing body of the lending institution to assess the insurance value in the event of loss or damage of the object to be sent for exhibition outside the museum. This committee will have six to seven members. viz. head of the lending institution, two or three experts, two or three conservators, a representative from the Government. Basing on the age, rarity, value etc., of the objects they may be categorised as

A : rare-cannot be loaned

B : can be loaned after the approval of the committee followed by the order of the Government or the management body.

List of objects to be sent along with photographs and catalogued data such as photograph, size, weight, description, materials etc., is given to the Expert and Evaluation Committee members. The committee will decide the insurance value of the objects and the total insurance value will be arrived at.

Insurance Coverage:

Insurance coverage rates are called for from various insurance companies. The lowest rate is accepted and the same is paid after the approval of the committee as well as the Government or management body of the lending institution.

Loss or Damage to the Loaned Objects:

In the event of damage or loss the borrowing institution intimates the case to the lending institution and insurance company. The extent of damage on receipt of the object will be assessed by the committee and the same should be intimated to the insurance company for settlement after seeking orders from the Government or management of the lending institution as the case may be. In case there is a loss of the loaned objects the full insured value will be received from the insurance company.

Thus conservation plays a very important role in loaning and insurance of objects. But insurance does not save the object but compensates monetarily.

PACKING OF MUSEUM OBJECTS

The primary aim of packing of museum objects is to protect them physically and environmentally at all stages through, to the place of exhibition in relation to the type of transportation. The packing system should not involve complicated procedures in packing or unpacking. The materials of packaging, packing systems and guidelines in packing are essential to take care of the museum objects for posterity.

Packaging Materials:

Natural materials such as wood are used in packing to avoid cost as well as environmental changes as wood is buffering the environmental changes. Packing containers are made out of wood, plywood, fibre board, block board, steel etc. Traditionally cushioning materials such as cloth, straw, gunny bags were used. All of them absorb moisture and transfer it to the objects resulting in decay. In recent years, a variety of foamed plastic materials in the form of balls, peanuts, spaghetti, derived from polyethylene foam, polystyrene foam and polyurethane foam are used in surround packing or float packing. Rubber, polythene air bubbles also are used. For wrapping the museum objects acid-free tissue paper, corrugated cardboard, polyethylene wrapper, polyethylene cellular film air in sealed bubbles, polyethylene cellular film, open cells in film etc., are used. For binding pressure tapes are used.

Packing Systems:

Depending upon the type of museum objects (two dimensional or three-dimensional) condition, size, type of transit, weight, distance, duration etc., the packing system has to be chosen. There are many systems and techniques of packing either expensive or moderate. Depending upon the museum's budget the packing also can be chosen. When the packing is done by contractors the specifications should be given and the whole operation should be supervised by a conservation personnel.

Single Packing:

Single packing is very simple and is meant for short distance travel and personalised transport of objects like paintings, prints, drawings, photographs etc., are wrapped with tissue paper or kraft paper, and surrounded with additional soft paper padding materials and kept in a slightly larger container made out of wood, plywood or hard board which is provided with a handle to carry.

Multiple Packing:

The packing system in which more similar flat works arranged in layers separated by rigid panels with the free space at the perimeter and edges which are stuffed with cushion shreds is called multiple packing. On the contrary instead of rigid panels interleaving the objects may be replaced by corner pads and the slack face all around are filled with cushioning materials.

Horizontal Tray Packing:

Accommodating flat museum objects in individual adjustable tray designed with shock absorbers at the corners which are inturn grooved to the inner walls of the packing case is the horizontal tray system of packing.

Vertical Tray Packing:

Panels fixed with flat objects are slid vertically which can slide out and in along the grooves made at two opposite inner walls of the packing cases is vertical tray packing. The vertical panels may have holes or slots for fixing the objects to it.

Track System of Packing:

In the place of vertical sliding panels , a system of tracks can be installed in side the packing cases in order to pack the framed works by sliding along the tracks. In this system also we can accommodate framed paintings, works on paper, photographs etc. Proper shock absorbing materials between the tracks and inner walls of the packing case will avoid the transfer of shocks to the packed museum objects.

Horizontal Slide-out Tray Packing:

In this type of packing the slide-out panels are like trays to which the objects are attached. The objects should be held by cushioned fixtures having winged nuts.

Float Packing:

The surround packing of three dimensional objects in a packing case with stuffing materials is called float packing. In this packing heavy objects like bronze sculptures, marble sculptures etc., should be wrapped with tissue paper and then stuffing materials like polyethylene, polyurethane balls etc., are filled in the empty space of the packing case. The packing materials should be clean, dry and free from any deleterious chemicals. The inner wall of the packing case may be lined with polystyrene slabs. It is better to cushion the bottom of the case where bronze is kept with a shock-absorbing layer of 1 cm thick rubber sheet.

Compartment Packing:

Compartment packing is similar to the float packing but a number of small objects are packed in different compartments within the same packing case. The case should be sturdy, designed for carrying the weight.

Template Packing:

It is a packing for complex shaped three dimensional objects by fitting the object in padded form or templates which conform to selected contours of the object. The object is wrapped with soft tissue paper and the contact edges of the template with the materials is also provided with soft materials to avoid abrasion and the object is fixed in position. Small sculptures or heavy objects can be packed in a compartmentalised box employing similar template holding devices for each items as required.

Rigid Foam Template Packing:

In this type of packing the object is packed within a packing case in a rigid foam plastic like expanded polystyrene, polyurethane or poly ethylene which is trimmed, shaped or scooped out or cut to fit around the contours of the object. In this case also the object is wrapped with tissue paper and polyethylene film.

Double Case Packing:

In this packing a packed case is placed inside another case and the interspace between two cases is filled with cushioning materials to avoid shocks and vibrations.

Conservation Measures:

1. Air-tight packing cases will avoid change of R.H. and therefore mould growth is avoided.

2. Before packing all the interior wood, filling materials should be fumigated with a fungicide, like thymol.

3. The organic objects and paintings should be treated for the eradication of insects and fungi with suitable insecticides.

4. The packing case should be marked with the directional marks at which it should be positioned.

5. In case of complicated packing system the procedure of unpacking should be instructed in the case.

6. Screw eyes, wires from the frames of the objects should be removed from all two dimensional objects while packing.

7. Lids of cases should be bolted or screwed down. Nailing should not be allowed.

TRANSPORTATION OF MUSEUM OBJECTS

There are many opportunities for damage to occur while the museum objects are transported internally within the museum premises or externally for longer distances including shipping or flight. Damages may result to museum objects from any of the following:

i. Carelessness and improper handling

ii. Inadequate holding devices and transporting equipments.

iii. Improper packing

iv. Over crowded storage

v. A narrow passage ways etc.

No longer can museum objects be hand-carried from one location to another but must be transported on trollies or carts properly padded. Preparation of the museum objects ready for the transportation and handling the objects are the two important conservation aspects in the transportation.

Paintings:

For safety in handling, paintings should be lifted or carried by both the lower and upper edges of the frame, with the painting side facing the person. as what can be seen is better protected. For larger paintings more persons may be required. When temporarily resting a framed painting on the floor, it should sit on soft pads to protect the lower frame and its corners. A large sized paintings should be transported on a special padded trolley.

Works on Paper:

The works on paper are of two types. One is fine art on paper, eg. water colours, pastels, drawings, engravings, etchings, lithographs, oil paintings on paper supports and the other is archival collection. eg. manuscripts, rare books, prints, posters, maps, documents, photographs, film , video and audio tapes, floppy discs etc.

In the care and proper handling of works on paper, emphasis is placed on very careful and clean manipulation, isolation from dust, humidity and temperature control and minimising their exposure to the harmful components of light. The art work should be hinged to a board having a front window cut mount covered with acid-free tissue paper. It is better not to bend while transporting. They may be kept in special boxes to avoid folds and bends.

Sculptures:

Tall objects with narrow base should never be transported on a trolley in a standing position. It must lie flat, otherwise it may fall down and serious damage will occur. When we keep it flat proper padding should be given, otherwise it may be abraded. Weak parts should not be held while lifting. While packing is done, the objects should be fixed in position with proper padding to avoid shock.

Ceramics, Glass:

Ceramics, glass and other fragile objects should invariably be protected by wrapping in soft tissue paper or cloth in several layers. Such objects while transporting from one place to the other should always be placed on a trolley, it should be padded to protect the objects from shocks during transportation. Cushioned padding should be given when packed for longer distances.

Ethnographic Collections:

Garments, textiles, feather works, puppets, masks etc., have to be well supported avoiding folding and compressing and distributing the weight as much as possible. Special boxes may accommodate more garments keeping tissue paper in between. Large textiles and carpets should be rolled (not folded). The rolling should be on large diameter tubes using acid-free tissue paper over the tube and also as interleaving. It is important that the edge of the textile is more than 3 cm interior from the edge of the roller tube. Small sections of textiles, e.g., ancient fragments, can be sandwiched between pieces of acrylic plastic with sealed edges.

SAMPLING AND ANALYSIS

The notoriety of the analytical chemists as destructive scientists have been the maxim through the past centuries. Substances given for analysis would never return back whole. But this notoriety is now a phenomenon of the past because, now there exists a large number of modern instrumental techniques at the behest of an Archaeological or Conservation Chemist with which he can analyse materials with an insufficient amount of the sample or sometimes with no damage to the material or object at all. The earliest demand for chemical analysis are made in the field of metals. Archimedes (287 - 212 BC) is perhaps the world's first non-destructive analyst as far as the historical records go. Only since the middle of the 19th Century non-destructive analysis has come to be practiced mainly by the impact of physics on chemistry through the incursion of instrumentation.

The sophistication of these instruments have evolved to such a degree that the analytical factors such as precision, sensitivity, selectivity and non-destructivity have taken a leap in the 19th Century, especially with the coming of the age of electronics.

When a series of objects is to be analysed there are certain questions which must be asked before one decides upon the method of analysis to be used. Before choosing a particular sampling technique it is imperative to consider whether the analysis is intended to involve only the surface, body, or the whole of the object, then resort to sampling accordingly.

From the angle of a curator, conservator or conservation scientist the term *sample* connotes in its broadest sense, the fragment under examination, whether it is detached or not, from the antiquity. The method of sampling should not disfigure the antiquity as it is likely to spoil the aesthetic beauty and hence its antique value. A very simple method of sampling of homogeneous materials especially metallic objects without causing visible damages consists in rubbing with a roughened quartz rod across the specimens to be analysed and dissolving the rubbed out sample in suitable solvents. Alternatively, apply a drop of concentrated nitric acid by means of a capillary tube on the spot area of the specimen to be analysed, leave it for a minute, suck the solution thus formed by a capillary tube and analyse drop of the solution by the technique adopted by H. Weisz. Electrographic sampling has been successfully adopted by a number of chemists without causing visible damage to the antiquities.

Non-destructive Sampling:

Non-destructive sampling is the best sampling as we want to preserve the past artefacts for posterity. In case of metals, electrographic sampling of metal antiquities was independently developed by Glazunov and Fritz. It consists in anodically dissolving a minute amount of the test specimen on to a piece of quantitative filter paper soaked in a suitable electrolyte. When a direct current is passed, an infinitesimal amount of the anode surface gets dissolved and the ions are imbibed on to the electrolyte soaked paper. The sample thus transferred is subjected to micro chemical analysis or by the Weisz ring-oven technique .

Destructive Sampling:

In general for chemical, instrumental or metallographic studies, samples are usually collected by filing, cutting, core cutting, drilling etc. Whatever may be the method of sampling, the sampling should not disfigure the object. The sampling should be done only at inconspicuous corners. If sample is drilled or core cut, the hole is filled with wax to avoid the moisture and air to be trapped inside. It is always better to keep sample falling down from objects and documented properly which can be analysed later.

Chemical Analysis:

Semi-micro techniques are used in the qualitative identification of elements. Microanalysis by Weisz ring-oven technique is adopted for the qualitative identification of elements present in the various parts of the metallic antiquities as well as inorganic dyes or pigments. When macro samples are available classical macro method of chemical analysis such as gravimetry is resorted to in determining the composition of the major elements in the antiquities. By specific gravity measurements the composition of small objects can be derived.

All Glass Ring-Oven:

The improvised two piece, all glass Weisz Ring-Oven consists of a round-bottomed cylinder, 45mm diameter and 70mm long. The upperface is ground and it has in the centre a well, 22mm diameter and 25mm deep. A tall, side-tube serves as an air condenser, while the short one opposite is for pouring the heating liquid in and out. The ground surface in the centre is covered with a cylindrical 70 x 25mm platinum foil or plate having in the centre a hole of 22mm diameter welded smoothly to another platinum foil or plate, is rolled and slipped into the well of the furnace, such that the upper ring made by the roll is flush with the flat circular platinum foil. The filter paper circle imbibed with the sample is placed over the platinum foil and is pressed down by a circular glass plate with a 22mm hole in the centre. The ring-oven is heated with acetone and the sample is eluted by 0.1 M hydrochloric acid and the sample is concentrated in the form of a ring. The qualitative detection of several metallic ions is carried out on a single ring cut into several sectors and identifying the individual ions in the mixture of several ions by applying specific, sensitive spot test reagents.

Chromatographic Methods:

Paints, pigments, dyes etc., may be separated and analysed by Weisz ring-oven technique.

Instrumental Methods of Analysis:

One of the most important factors to have an insight into the composition and behaviour of materials is the instrumental techniques. Most of these methods are based on interactions between some form of electromagnetic radiations – ultraviolet, infra-red and X-radiation, for example the atoms and molecules present in artefacts, together with any products of corrosion or incrustation X-ray diffraction method is the interaction with outer electrons, X-ray fluorescence method is the interaction with inner electrons and the neutron activation method is the interaction with the atomic nuclei.

Non-destructive Methods:

If the tests on a museum object is non-destructive, the complete integrity of the object is then preserved. If the object is small and is able to withstand very high vacuum, it may be subjected to the non-destructive methods like X-ray fluorescence analysis, electron probe micro analysis, neutron activation analysis. In these methods only the outer surface of the object can be investigated .

Destructive Methods:

If a small sample of the object is available, analytical methods like atomic absorption spectroscopy, metallography, mass spectroscopy, X-ray diffraction, scanning electron spectroscopy, auger electron spectroscopy, Mossbauer effect spectroscopy, photo acoustic spectroscopy, infra-red spectroscopy, electron spectroscopy for chemical analysis may be utilised depending upon the requirement.

Technique	Form of Energy	Application
1. Atomic Absorption Spectroscopy (AAS)	Light, visible, ultra-violet and infra-red	Elemental composition of materials.
2. Auger Electron Spectroscopy (AES)	Electrons	Surface analysis of solids
3. Electron Probe Micro Analysis (EPMA)	Electrons	Elemental composition on the surface
4. Infra-Red Spect-roscopy (IRS)	Light, visible, U.V. and I.R.	Identifying resins, varni-shes and pigments.
5. Mossbauer Effect Spectroscopy (MES)	Gamma radiation	Study of corrosion, pigments and ceramics.
6. Metallography	Light, visible, U.V. and I.R.	To study phases in alloys and corrosion of metals.
7. Mass Spectros-copy (MS)	Ions	Analysis of isotopes for provenance studies.
8. Neutron Activation Analysis (NAA)	Neutrons	Analysing inorganic surfaces
9. Optical Microscopy (OM)	Light, visible, U.V. and I.R.	Identifying fibres, pig-ments and studying corrosion
10. Photo Acoustic Spectroscopy (PAS)	Light, visible, U.V. and I.R.	Pigment identification on ceramics.
11. Scanning Electron Microscopy (SEM)	Electrons	Structure and surface
12. X-Radiation	X-rays	Internal structure of wood, stone etc.
13. X-Ray Diffraction (XRD)	X-rays	Identificatrion of metals, pigments, ceramics etc.
14. X-Ray Fluorescence (XRF)	X-rays	Elemental composition of solids.

Guidelines for analysis:

1. Loose samples may always be preserved for analysis.

2. Non-destructive sampling or non-destructive analysis should be preferred.

3. While taking samples on destructive basis, we should restrict to minimum that too from inconspicuous spots.

4. When samples are taken by mechanical means the strength of the object should be kept in mind.

eg. when drilling for samples the hole should be blocked by wax as soon as sampling is over.

5. In the case of lead, while taking sample heat should not be produced as the heat changes the phase of lead.

6 . Vibro methods should be avoided in the case of fragile objects.

7. When chemicals are used to take samples care should be taken to remove all the chemicals used for the purpose.

8. The documentation must have a reference about the locality on the object from which the sample is taken.

9. When two or three pieces are joined together analysis should be made with the three pieces. eg. In case of the bronze icons the main image and the pedestal may have different compositions.

10. Sample collected should be kept in air tight containers to avoid the contamination.

CONSERVATION IN EXCAVATION

Archaeological excavation is a slow, systematic and planned digging to study the nature and contents of the occupied layers in the reverse order in which they were laid down during the natural burial.

"The things the excavator finds are not his own property, to treat as he pleases, or neglect as he chooses. They are a direct legacy from the past to the present age, he but the privileged intermediary through whose hands they come; and if, by carelessness, slackness or ignorance, he lessens the sum of knowledge that might have been obtained from them, he knows himself to be guilty of an archaeological crime of the first magnitude. Destruction of evidence is so painfully easy, and yet so hopelessly irreparable" (H.Carter and A.C. Mace). Even though excavation and related techniques have developed well, the standards of conservation related to excavation have not developed to the same extent. The reason is that the excavations at times are carried out in the absence of a conservator or chemist in the site. Excavation and conservation should be considered together for getting maximum information from the objects and for their preservation for posterity.

The archaeological conservation starts from the planning of excavation, the actual removal of objects from the site – till the objects reach the museum after excavation. In the case of excavation, the conservation techniques have to be applied at the site itself to excavated objects during and immediately after their exposure to the atmosphere. This is called the *field archaeological conservation* which is distinct from laboratory archaeological conservation. When an excavation is to be planned both excavation aims and conservation needs are to be satisfied.

The conservation aspects of an excavation involve three stages. They are 1) Conservation before excavation 2) Conservation during excavation and 3) Conservation after excavation.

Conservation before Excavation:

Preventive conservation of the site may be studied in advance. The data on local environmental variables such as temperature and relative humidity of the excavation site, extent of shade, the predominant wind direction and its frequency, soil characteristics, water table etc., will be useful to choose the time for excavation besides giving an ecological interpretation of the site.

2) Conservation During Excavation:

The buried objects over the years attain an equilibrium with their surroundings. When they are exposed by excavation, they are subjected to sudden change in their environment such as temperature and relative humidity and in their access to light and atmospheric factors. The aim of the excavator must be to minimise the environmental shock to the excavated objects during their exposure packing and transport to the site store. A temporary roof over the trenches is good to control the ambient environment.

3) Conservation After Excavation:

For a successful conservation of excavated objects at the site good communication among excavators, site custodians and conservators or archaeological chemists is important. The various aspects of conservation are investigative cleaning, stabilisation, consolidation, protection. safe storage and guarding of the excavated objects. The conservation measures will be either preventive or remedial or interventive.

First Aid to Objects:

As the equilibrium of the buried objects is abruptly disturbed because of their exposure to the atmosphere, the decay or corrosion or disintegration process starts. Organic materials deteriorate faster than the inorganic objects. Even though the objects are retrieved from the same place their treatment may differ from object to object.

Metals:

The metallic objects after lifting from the excavated site have to be conserved. Silver and gold objects can not be identified when they have impurities like copper. They may appear greenish in colour due to corrosion of copper. Silver objects either may appear black or red. They should be packed in well-padded boxes. Gold objects may be cleaned by dilute nitric acid. Gold gilded objects will loose the gild if they are cleaned. Thick layers of corrosion should not be removed. Excavated iron objects should be dried under shade and they should not be kept in wet condition. Silica gel will be of use when packed in plastic bags. Excavated lead objects will be covered with greyish – white corrosion products. Acid free time paper should be used to pack them.

Organic Objects:

Excavated Organic Objects very easily disintegrate. Bone and ivory objects should be dried slowly and thoroughly. After removing loose silicious materials from bone objects, they should be immersed in 15% acetic acid for about 10-15 minutes. Then it is coated with 10% polystyrene in toluene or Paraloid B72 and continued the treatment in acetic acid and washed in water till it is cleaned. Ivory is sensitive to water and so it should be wrapped as in found condition in damp acid-free tissue and polythene sheets. Shells are found in good condition and so they are washed in water. Normally leather does not survive. It is more common for leather to be found in a waterlogged condition. Such leather should be packed wet in polythene covers. Freeze-drying can be done. Dry leather should never be moistened or flattened but should be wrapped in acid-free tissue. It should be flattened only by the application of leather dressing chemicals. Wood is found either in dry or waterlogged conditions. Extremely dry wooden objects may be consolidated by Paraloid B72 or poly vinyl acetate in toluene or acetone. Water logged wood would be packed in polythene covers and sealed with fungicides like Panacid. Wood which needs to be dated should never be contaminated with fungicide or consolidant. Dry textiles should be packed carefully in acid-free tissue. Water logged textile should be sealed in polythene bag with water mixed with fungicides like 0.01% Panacid.

Inorganic Objects:

Mostly excavated stone objects are found in good condition. They are washed with water using soft brush. The salts are removed by poulticing with paper pulp. Dry glass should not be moistened. The hand lumps may be softened by alcohol or water. Avoiding water is good. It should be packed and padded with acid-free tissue paper and should not be allowed to shake or move. Wet glasses should be kept wet and packed in polyether foam containing a fungicide like 0.01% Panacid. Baked clay objects may be washed but care should be taken to remove the dirt by wooden knife. Insoluble salts, adherent to the potteries, may be removed by the use of weak acids formed by thorough washing in water. The washings should be continued till the pH of the washings is seven. If the pottery is found to contain soluble salts, it should not be allowed to dry but should be packed using polyether foam moistened with fungicide like ortho phenyl phenol, Panacid and packed in polythene covers. Since the poulticing will take a long time, it may be done in the laboratory. Unpacked dry clay objects should never be washed in water. The hard encrustations may be removed by adding drops of alcohol and brushing with the help of a soft brush. Glazed potteries should be cleaned with brush. If needed to be consolidated, Paraloid B72 or polyvinyl acetate in toluene or acetone may be used. Damp objects should be backed wet adding fungicides like ortho phenyl phenol, Panacid.

Anyhow, the conservation at the excavation site is a first aid. The laboratory treatment is necessary for the upkeep of the objects, in the museums as mentioned in the earlier chapters.

DATING OF ANTIQUITIES

Most of the antiquities are dated through the inscriptions available on them or through the associated finds in an excavation. Whatever may be the method of dating, date of antiquities is very essential to get the fullest information through them.

There are various methods of dating of antiquities. Here, a few methods of dating of antiquities are outlined.

Dendrochronological Dating

Dendrochronology may be defined as the study of the chronological sequence of annual growth rings in trees. Basic to a tree-ring chronology is the fact that each consecutive annual growth ring is assigned to the calender year in which it was formed. The outermost ring corresponds to the year of cutting the tree. When the quality of cross dating has been established and modern chronology developed for a given area, it is possible to date tree-ring material either wood or charcoal, from earliest periods.

Effectiveness of dendrochronology as a dating method depends on having 1, suitable sample of non-complacent wood. Normally 100 + rings are needed unless there is a particularly distinctive pattern. 2, a master chronology for that species in that region.

A dendro date will give an extremely accurate result for individual rings, giving a date accurate to a particular season of a particular year.

Radiocarbon dating

^{14}C is formed continuously in the upper atmosphere by the action of cosmic rays on ^{14}N. This ^{14}C is rapidly oxidised to $^{14}CO_2$ and mixed into the carbon dioxide, including ^{14}C, is absorbed into plants via photosynthesis. From plants it is passed through the food chain to the entire biosphere. It is also absorbed into the oceans, but more slowly, and with less rapid mixing.

Three forms (isotopes) of carbon occur in nature, ^{12}C, ^{13}C and ^{14}C. Of these ^{12}C and ^{13}C are stable, but ^{14}C is radioactive. This means that it decays spontaneously at a measurable date, defined by the half-life, the time taken for half of any amount to decay away. This is a constant specific to each radioactive isotope.

Since ^{14}C is continually being formed and decaying only a certain amount will be in the atmosphere at any one time. While a plant or animal is alive it will constantly replenish its content of ^{14}C via the food chain and remain in equilibrium within the atmospheric amount.

Once it dies, ^{14}C lost by decay will no longer be replaced and the amount trapped in its tissues will decline.

Since it is possible to measure the amount of ^{14}C remaining in a sample and rate of decay is known, if the original ^{14}C content is also known calculating the elapsed time since death is mathematically simple.

By this method bone, ivory, antler, wood, charcoal, textile, grain, plant materials can be dated. The actual weight needed depends on the age of the sample, the exact carbon content and the precision required. It ranges from 10 gms to 500 gms.

Carbon containing contamination affects the date. Objects which are consolidated with organic consolidants are not suitable. All radio carbon results are quoted with error terms, usually in the range ±50 to 100 years.

Thermoluminescence

Thermoluminescence (TL) is a property of crystalline materials which have been exposed to ionising radiation. When such materials are heated they emit both the incandescence normally associated with heat and a small amount of additional light is related to the amount of radiation to which the material has been exposed since it was last heated and hence to the elapsed time.

This method of dating was first developed for use with pottery, but has now been extended to other substances. In pottery, TL builds up in the quartz and feldspar crystals which occur naturally in clay. These receive ionising radiation, most from the alpha, beta and gamma emissions from the decay of uranium, thorium and potassium found throughout the soil and in the pottery itself. As this radiation travels through the crystals it releases free electrons. Some of these become trapped in defects in the crystal lattice. Depending on the nature of the defects these electrons can remain trapped over geological time, thus 'zeroing' the time clock. Subsequent exposure to radiation will result in a slow build up of TL with the amount depending on the elapsed time, the radiation dose from the surroundings and the sensitivity of the material. If both dose rate and sensitivity can be measured or estimated and the amount of TL present determined it should be possible to calculate the time since the last firing. In art historical terms TL is most often used as an authentication technique on pottery.

To produce precise TL dates requires an accurate assessment of the natural radiation dose to which the sample has been exposed. In an archaeological context this is determined by in situ measurements with a gamma spectrometer or by burying a small, radiation sensitive, capsule for a known length of time. For authenticity work on pottery, where the burial environment is not known, these levels have to be estimated and the result is correspondingly less precise.

Thermoluminescence dating can be applied to pottery, burnt flint, volcanic materials, baked clay, kilns, hearths, core materials in metal work, etc.

Sample size varies very much with material and circumstances, but between 50 and 100 mg are needed for an authenticity test.

The ultimate precision will depend on the characteristics of the materials and the precision with which the environmental dose rate can be determined, but results are normally quoted to ±5% to 10% or around ±25% for authenticities.

Part VII
Glossary & References

GLOSSARY

Ageless

It is a combination of iron filings and potassium chloride. Ageless eye looks violet in colour and it changes its colour to pink when oxygen is removed to the level of 0.5% of oxygen.

Airbrasive

The airbrasive unit consists of a metal cabinet containing a vibrator chamber which holds about 450 gms of an abrasive powder and a rubber hose which carries air to the chamber from either a carbon dioxide cylinder or an air compressor. Another hose delivers the mixture of air and the abrasive to a small nozzle at the end of a hand piece. The air pressure used is between 2.8 and 5.6 kg/cm^2 depending on the nature of the object. Abrasive powders which may be used are silicon carbide, aluminium oxide, calcium magnesium carbonate (dolomite), sodium carbonate, glass beads of size 50 microns etc. The abrasive dust and detached corrosion or adherent particles are taken up by vacuum into a dust collector box. The abrasive used is therefore not reusable.

Bleaching

Bleaching is a chemical process in which the dark colours developed due to age or staining may be removed by the use of bleaching chemicals like hydrogen peroxide, chlorine dioxide, chloramine-T etc.

Blistering

When there is an isolated cohesion between the adjacent strata of a painting, the paint layer becomes loose on the surface and it is called blistering.

Bloom

Bloom is the dull bluish-white appearance that develops in a transparent film of a painting and leads to a cloudiness. It forms on the varnish layer.

Cleavage

Cleavage is the cohesion between the adjacent strata of a painting.

Chloride (Test)

Sample is dissolved in nitric acid. A white precipitate with silver nitrate shows the presence of chloride.

Condensation

When air containing some water vapour is cooled, a stage is reached when the water vapour is changed to liquid. This phenomenon of change from vapour to liquid is known as condensation.

Dowelling

Dowelling is a technique of joining broken pieces of wood, metal, stone, etc., together by the use of a headless metallic pin or peg and an adhesive.

Ethoxide

Ethoxide is a mixture of 10% ethyleneoxide and 90% carbon dioxide.

Flaking

Loss of paint from the surface of a painting in the form of small particles or flakes.

Fumigation

Fumigation is a process by which an object is exposed to the gaseous chemicals in order to eradicate biological growth on it. The chemical can be a solid, liquid or gas. The effectiveness of the fumigation increases when done under vacuum. This process is called vacuum fumigation.

Hygroscopic Material

Hygroscopic material is one which has a tendency to absorb moisture.

Impregnation

Impregnation is a process by which a brittle or fragile object is filled with a consolidant like wax, poly vinyl acetate etc., in order to strengthen it. The impregnation will be effective, if it is done under vacuum.

Litmus paper

Litmus paper is a strip of paper dipped in a litmus solution and dried. The blue litmus paper when moistened and kept in any acidic material, it turns to pink. The red one changes to blue when comes into contact with an alkaline material.

Lux

Lux is a measure of intensity of illumination from the source or from the surface of objects.

Parchment

Parchment is made from the tough, white corium or inner layer of animal skin, by a process that relaxes and flattens the capillaries so that they are unable to reabsorb moisture. It is not subject to chemical deterioration and has proved to be extraordinarily durable as a material for fine writing.

pH paper

pH is in a way the scale of measurement of acidity. When the pH is seven, the substance is neutral. It is acidic, if it is less than seven and alkaline when it is above seven. The strip of paper changes its colour and the change in colour is compared with a colour chart and the pH is found out.

Relining

Relining is a method which can be used for saving a painting that is threatened by the failure of its support.

Restrainer

Restrainer is a chemical which is used to control the dissolution activity of a solvent in the case of cleaning of the varnish layer of paintings.

Saturated air

The air is said to be saturated when the air can no longer absorb any more of water vapour.

Seasoning of wood

Seasoning of wood is nothing but the controlled drying of wood to avoid warping etc.

Silica gel

Silica gel is a form of silica capable of absorbing a large quantity of water, as much as 40% of its weight from humid air being chemically inert.

REFERENCES

1. Agrawal, O.P.(Ed), Conservation in the Tropics, International Centre for Conservation, Rome, 1972.

2. Agrawal, O.P., Preservation of Art Objects and Library Materials. National Book Trust, India, 1993.

3. Andrew Oddy, (Ed), The Art of the Conservator, Published by the Trustees of the British Museum, 1992.

4. Arun Ghose, Conservation and Restoration of Cultural Heritage, Agam Kala Prakashan, Delhi, 1989.

5. Aiyappan and Satyamurti, S.T., (Ed), Handbook of Museum Technique, Government of Madras, 1960.

6. Cesareo, R., Sciuti, S., and Marabelli, M., Non-destructive Analysis of Ancient Bronzes, Studies in Conservation, 18, 1973.

7. David Burgess, Chemical Science and Conservation, Macmillan, 1990.

8. Garry Thomson, The Museum Environment, Butterworth – Heinemann, 1994.

9. Graham Martin, Preventive Conservation Guidelines for Development, Victoria and Albert Museum, London, July, 1993.

10. Gail Dextar Lord and Barry Lord, (Ed), The Manual of Museum Planning, London, 1991.

11. Gairola, T.R., Handbook of Chemical Conservation of Museum Objects, Department of Museology, University of Baroda, 1960.

12. Harinarayana, N., Bronze Casting, Madras, 1985.

13. Herbert Weisz, Micro-analysis by Ring-oven Technique, Pergamom Press, 1970.

14. Jaya Appasamy, Tanjavur Paintings of the Maratha Period, Published by Abhinav Publications, New Delhi.

15. Jeyaraj, V. and Agnes Paul, Electrographic Sampling, Indian Institute of Technology, Madras, 1984.

16. Jeyaraj, V., Correlation Between Composition, Metallographic Structure and Corrosion Products of Metallic Antiquities, Ph.D. Thesis, University of Madras, 1990.

17. Jeyaraj, V., Current Museum Policies and Practices in the U.K., Report prepared under the auspices of Nehru Trust, New Delhi, 1994.

18. Joseph Riederer, Achäeologie und Chemie, SMPK, Berlin, 1988.

19. Nathan Stolov, Cosnservation and Exhibitions, Butterworth, 1987.

20. Organ, R.M., Design for Scientific Conservation of Antiquities, Smithsonian, 1968.

21. Paramasivan, S., Chemical Investigations on Some Ancient Materials and Industries, University of Madras, 1930.

22. Plenderleith, H.J., Werner, A.E.A., Conservation of Antiquities and Works of Art, Oxford University Press, London, 1976.

23. Satya Prakash and Rawat, N.S., Chemical Study of Some Indian Archaeological Antiquities, Asia Publishing House, Bombay, 1965.

25. Stanley Price, N.P., (Ed), Conservation of Archaeological Excavation, ICCROM, Rome, 1984.

26. Susan Bradley, (Ed), A Guide to the Storage, Exhibition and Handling of Antiquities, Ethnographia and Pictorial Art, Department of Conservation, British Museum, London, 1993.

27. Thomson, G., (Ed), Recent Advances in Conservation, Butterworths, 1963.

28. Vincent Daniels, (Ed), Early Advances in Conservation, Department of Conservation, British Museum, London, 1988.

29. ZviGoffer, Archaeological Chemistry, John Wiley and Sons, 1980.

30. Conservation of Ethnographical Materials, Conference at Madrid: October 2-8, 1972, The International Council of Museums Committee for Conservation.