Harold Plenderleith

INTRODUCTORY LECTURE

It is a sure sign of the advancement of civilisation in a country when she becomes conscious of a desire to preserve her cultural heritage. This heritage may take the form, largely, of documentary material, of paintings, fine pottery or bronze, but a major portion of the national patrimony will certainly consist of monuments set up out-of-doors, castles, temples, sculptures; set up to commemorate some event or, less consciously, remaining from a bygone age as a souvenir of what has gone before. Monuments exist to remind us of the glories of the past and they provide a mute commentary on the development of mankind in his struggle towards enlightenment: or they may be erected to commemorate great men who in their day, gave of their best for a just cause and whose memory lives on. It is of the nature of the monument that it should continue to exist as a reminder and ensample to future generations — in a word that it should be permanent — and to this end it is commonly executed in solid resistant building stone or is sculptured in fine-grained marble.

Unfortunately, time takes its toll and the last word is with time. The hardest rocks may be virtually unchangeable but those more susceptible have suffered transformations through the geological ages and have given rise to our sandstones and limestones and these in turn have become metamorphosed into such things as quartzite and marble. Slowly, inevitably (but sometimes less slowly depending upon conditions) these younger stones have continued to change, [1] becoming stained, cracking, chipping and exfoliating. In this emergency, aid is sought from the architect and the chemist because chemists and architects are specialists in the study of materials. Technical enquiries are initiated in the laboratory and the field; efforts are made to discover the cause, to define the problem; but what seemed at first to be a simple issue comes to be recognised to be, in fact, one of great complexity. There can be no panacea, no effective deterrent, no preservative for stonework exposed in the open that is of general application and can be relied upon to restore a healthy condition to the material or even, for that matter, arrest decay.

The decay of stone depends on many factors, — on its chemical and physical nature and condition, how it was quarried and how it was worked in constructing the monument. The stone may be of a desirable type and quality but of the worthy types of stone not all examples, even from the same quarry, are of equal solidarity or suitability though, as to colour and texture, on superficial examination, the difference between good and inferior material may not be easily appreciated. And just as the study of a layer of old paint involves much more than the study of pigment and of binding medium, so the study of an ancient structure involves much more than the study of the stone and the mortar of wich it is composed.

In considering the nature of old structures we may, on the simplest analysis, expect to find a system that is two-fold. There will be, first, the presence of good unchanged stone in the monument, and, second, the existence of changed (disfigured, weakened) bad stone. As for the first, architect and chemist alike devote themselves, by testing and careful selection to ensuring that today only material that is known to be satisfactory is used for the structure and that it is employed in a rational fashion. The more care expended in this, the smaller will be the ultimate problem of preservation. As for the weakened stone, the architect, the chemist and the manufacturer of trade products have done their best during three or four generations to cope with stone decay by the application of certain chemical substances, the so-called "stone preservatives"; they have tried all the obvious things; they have shown the greatest ingenuity in designing forms of treatment, but — we must accept the fact — with certain execeptions they have failed and not only failed but too often, have done more harm in the long run by their efforts than if they had left the stone to continue to decay in the ordinary way.

Why should this be? There are a host of reasons. We are dealing with a complex having many variables. Two only of these may be mentioned at present. Stone is normally porous and the pores contain air. This air expands and contracts with changing temperature and the stone is said to breathe. Now if the surface is hardened or sealed up effectively with a "preservative" the air will be locked in and the strains, in consequence, may then be of such magnitude that the whole of the outer skin is liable eventually to crack away. The surface, when it becomes weakened, is literally blown off! Again, if a solution is applied to porous stone, it first penetrates and later the solvent dries out, the dissolved material following it back to the surface where it is eventually deposited in solid form as an impervious skin with, consequently, the same ill-effects as before. Such treatment by solutions can only hope to be effective when the stone is very porous and when it is protected from exposure to extremes of temperature and humidity. The stone must be thoroughly permeated with the solution as is usually possible only in a specially equipped laboratory and it amounts to this, that the object so treated has to find a permanent home in a museum or antiquarium.

Great claims have been made for certain types of silica compounds that effectively waterproof stone surfaces without clogging the pores and it is understood that these so-called silicones are used in a big way for treating concrete highways and bridges, especially in America. Here the aim is not so much one of stone-preservation, as to save on the considerable sums of money that must be expended on cleaning; for the treated cement, being waterproof, is less liable to become stained with mud or dirty water and therefore may be the more easily hosed clean if silicone protection has been applied. The family of silicones and siliconates is so large, however, that one cannot rule out the possibility that some modern method of preservation may be evolved with their aid suitable, at least, for some type of stone-preservation problem; but, as yet, it appears doubtful as to whether anything of the kind is in sight. There is an element of danger here for much harm can be done to old stone structures by the indiscriminate application of silicones.

I repeat that in all of these remarks, I have in mind monuments that are exposed in the open. The problem indoors is an entirely different one and hardly concerns us in our consideration of the subject today.

The mention of porosity calls attention to the peculiarities of physical structure that may be seen, for example, by makin micro cross sections and much work has been devoted, to studying the shapes of pores and grains and their relative distribution. Many stones are seen to consist of solid particles held together by a cementing material and, clearly, an attack on either one or the other phase will cause disintegration.

At this stage it may be useful to refer to some of the many agencies that are liable to cause damage to ancient structures for they vary widely with latitude and with altitude. Stone preservation in say, Pittsburg, Leningrad, Rome and in Morocco, India and Korea presents entirely different problems and the interests of this Conference would not be served by trying to simplify the issue. Symptoms they may share in common but in each locality there is seen to be an individual emphasis on at least one main type of attack.

Snow and ice take their toll of soft stones in the north (phenomenon of gelivity); soot and acids with the accompanying formation of salty efflorescence is the legacy of industrial atmospheres (phenomenon of sulphatation). Wind-born and desert salts are also potent destroyers. And who can say why the marbles of Agrigento and of Trapani in the clear atmosphere of Southern Sicily should suddendly go powdery? In hot climates expansion-contraction effects and the forms of attrition that result from a constant exposure to wind-blown sand are in evidence and when there are periods of very heavy rain, as in monsoon countries, the damage is aggravated. Destruction resulting from such obviuos causes is manifest but who would have expected to find that bacteria are to be reckoned among the agents responsible for the deterioration of stone work? And yet much work has been done and published in this connexion by Pochon [3] and his associates. Bacteria, algae, moss, lichens and plant growths of various kinds are destructive and damage is also done in various parts of the world by wild bees and other insects, bats, pigeons and parrots and by the higher animals! What new scientific methods are available for the control of such a variety of threats to the existence of monuments? We may hope to hear something of this from later speakers.

The Rome Centre for the Study of the Conservation of Cultural Property which I represent is in touch with such problems in many countries from all over the world and also with scientific laboratories where specialized studies are being made for the testing and grading of stone and for studying its behaviour under controlled conditions of all kinds. It is for this reason perhaps that one tends to feel little critical of the title allocated to me for this discourse because, the wider ones experience, the more certain one becomes that in order to ensure the preservation of anything of value, new methods — however scientific they may claim to be — have to be applied with great circumspection, and this for the very simple reason that, in the last analysis, there is only one test that matters, namely, the test of time.

This does not mean that nothing can be done. Far from it. I am an incurable optimist in this regard. Technique is always capable of being refined and one has only to consider how dependent we are for basic knowledge upon the researches and valuable publications of the *Building Research Station* in England and the *Institut technique du Batiment et des Travaux Publics* in France (to mention only two of such organisations) in order to realize how hopeless would be our problem, if new methods were not constantly under review and the older mechanisms being subjected to more and more intimate elucidation.

Dr. R. Sneyers, Chef de Laboratoire of *l'Institut royal du patrimoine artistique* in Brussels is a *rapporteur* on the Subject of "stone" for the Museum Laboratories Committee of ICOM of which I have the honour to be chairman. Many of you here will have already helped him, no doubt, in answering his first Questionnaire dealing with this subject and the results have already borne fruit in a promising research programme. I would be grateful if you would continue to give him your cooperation in this matter, as I will always be glad to do myself, for it is an easy way for us to make a contribution to this subject of our common interest.

To return to the main issue, we must agree that one of our major problems in conservation is that of how best to get protective substances into porous material without forming a skin. This problem of penetration has been at least partly solved by the use of emulsions carrying consolidating plastic material. Such emulsions can be made to penetrate porous stone in the same manner as solutions but, on drying, the emulsion is broken down into its constituents leaving the solid consolidating matter behind, well within the fabric, whilst the solvent (in this case water) evaporates harmlessly away.

Emulsions were used with considerable effect in consolidating parts of the very porous sandstone monuments in Nubia, for example at Abu Simbel, where it was actually found possible, by gravity, to get emulsions of methyl methacrylate to penetrate into the sandstone to a depth of between one and two feet. On cutting an experimental block that had been so treated, the consolidated stone took the shape roughly, of half of a giant lemon that had been bisected equatorially. Although the synthetic consolidant, methyl methacrylate is somewhat volatile at high temperatures and liable to be decomposed by sunlight, it seems unlikely that this will affect the consolidated interior of the stone at least for a very long time to come. It has the disadvantage, however, of being at the present time somewhat expensive for use on a large scale. Incidentally, for repairs of a mechanical nature, stainless steel pins or dowels are preferred because the sandstones in question are always liable to contain a certain quantity of soluble salt which would be corrosive to other metals. Epoxy resins also played their part as adhesives.

In preparing the temple of Buhen in the Sudan for transfer to Khartoum the delicate surfaces of the great stone blocks required protection. Certain painted bas-reliefs were fixed as if they had been pastel or chalk drawings, with a spray of very thin shellac in alcohol and then, partly to avoid great expense and partly to prevent skin formation we chose to give the necessary surface protection by sticking cotton scrim-cloth to the exposed surfaces of the stones using as adhesive carboxymethylcellulose. This scheme worked well and the textile was easily removable afterwards, when it had served its purpose. Some months later I had the satisfaction of receiving a cable from Khartoum to say that the temple had now been delivered in its entirety and there was no evidence of damage of any kind. This was thanks very largly to Professor Emery and to the skill of Dr. Hinkel, an engineer, expert in methods, ancient and modern, of manipulating very heavy and delicate blocks of stone.

It is appropriate for our Conference that the New York Times (International Edition) in a recent issue published a lengthy article on the affects of air-pollution on what it called "the worlds stone art", that is, monuments. This article took the form of a world survey covering eight European countries as well as the United States where stone preservation has become a subject of serious study in the *Institute of Fine Arts Conservation Center and the Department of Chemistry of New York University*. However, on the whole, it is a sad story with but few bright features and one has the conviction, from its perusal, that to check the erosion that results from exposure to contaminated air there is only one certain procedure to be followed and that is to operate on the air rather than the monument. Much has already been done to enforce the application of anti-pollution laws not only in America but in the larger industrial areas of Europe and notably in England, with striking benefits. If in Rome, which is, so-far, a non-industrial city, the effects of an unusually severe winter can leave their mark on the Colosseum and the Arch of Titus, this is unfortunately a matter beyond control; but the control of industrial fumes is in our hands and it cannot be too strongly urged that, with the expansion of industry in the present generation, our ancient structures are menaced, nay indeed, doomed to loose for all time their strength and character unless a strict measure of environmental control is introduced so that the atmosphere that we breathe is clean and free from soot and sulphur compounds. The actual saving on the cost of essential restoration work on stone would then be enormous. Unfortunately, in the colder countries, as Schaffer [4] has pointed out the open domestic fire is regarded as a necessity and this can do much harm. The answer, of course, is to permit only the burning of smokeless fuel.

There remains the problem of what to do with the building already stained with soot and the victim of sulphatation. Camerman [5] in Belgium advocated washing. In 1957 Rawlins [6] published a very interesting and well-illustrated article in *Studies in Conservation* entitled "The Cleaning of Stonework" in the course of which he collected together from architects and surveyors throughout England experiences relating directly to the cleaning of ancient stone structures, — cathedrals, abbeys and secular buildings. The results of washing with water were altogether favourable (though it was emphasised that this was an exercise not to be conducted when there was any expectation of frost!). The cleaned buildings were improved in appearance and it might be expected that the deleterious action of acid and soot deposits was, at least, checked. The decision had to be taken in each case as to whether it was intended to remove stains *and* loose accretions or the latter only: there were the various possibilities of using water sprays of various types, steam jets or simply a long-continued trickle of clean water falling gently over the stone.

For the up-to-date sequel and development of these processes we have to go to Paris where a long-term project of washing public buildings is yielding results of the greatest interest and revealing, incidentally, the extent to which deterioration had proceeded; incrustations of carbon were found to have masked architectural features and even in places to have concealed the very nature of the stone itself. One of the most revealing examples of the beneficent results that have attended the washing of public buildings is to be seen in the Court du Louvre, that fine quadrangle situated within the building of the Palace, where coloured, jewel-like, ornamental panels of marble have appeared as if by magic, set in the façade of a building which, before, was of a uniform black tone; and the elevation as a whole has again sprung to life, the stone having regained its original pale honey colour and the ornamental details essential to the architectural conception are once again in evidence. The Madeleine is another of several great buildings that has benefited enormously from cleaning. So much for the aesthetic aspect; but I am convinced that the benefits in the interests of conservation are equally considerable.

Whether washing can be justly described as a new scientific method is open to doubt, but the science comes in the method of application, the choice of a suitable period of the year and the avoidance of the use of chemical cleaners, more especially of lye and soda which alkalies are the ruination of building stones.

In an entirely different setting, in far Pakistan, spray washing coupled with the installation of tube-wells is regarded as the only hope of recovering the ancient ruins of Mohenjodaro. These ruins within the last decade have suffered severely by a rise in the level of the watertable due to the proliferation of the Indus river canal system so essential for the growth of rice. The rising waters have brought with them a locally high concentration of sodium sulphate, which salt, absorbed in solution into the old bricks by capillarity, has crystallised everywhere giving the site the appearance of being covered with snow! Plans are being developed to ower the watertable and according to the recommended scheme, the old buildings will be washed by a gentle spray of fresh water supplied by portable equipment such as is used for the maintenance of the fine "greens" of a golf course. It is hoped by this means to get rid of the salt. The matter has become urgent and treatment nust be carried out soon otherwise the lower levels of this classical Aryan Site which have never as yet been completely excavated, will be lost to us for all time.

One should make more than passing reference to the deleterious action of vater and to the modern methods of control but I must content myself now vith the thought that this is covered very thoroughly in Dr. Massari's monograph 7] which I feel sure will be in the hands of most architects. In a recent comuniation [8] he describes how he traced a case of waterlogging in the old Pantheonike church of S. Maria della Rotonda in Albano to the presence of a large ondensing area of wall rather than to the usual cause (capillarity) and the steps hat were taken to overcome this embarrassing condition. It makes fascinating eading.

Researches on stone preservation and the protection of ancient structures re, I suppose, little more than 100 years old. The subject has been explored in reat detail to the extent that few methods can claim to be entirely recent.

One such, however, is probably the application of electroosmosis for stabilising the ground under a building by the removal of water from clay foundations nd such like. The principle is to force the water into drainage wells by passing low direct current through the earth, the wells having metal stand pipes that onstitute the negative poles and from which the water can eventually be pumped. classical example of a successful operation of this kind is provided by the church f St. Anna in Warsaw which stands on a steep slope and which showed signs f slipping. The foundations of the church were stabilised by Cebertowicz [9] by he application of the principle of electroosmosis. The problem of the leaning ower of Pisa is of a different nature and in this case a successful solution, according Terracina [10], must be based upon his discovery of an inequality of contact ressures on diametrically opposite sides of the structure and he has been able suggest steps that might be taken in order to realize an inversion of these rimitive differences.

It remains to make reference to another form of conservation that might be escribed more correctly as a salvage operation but is certainly within the category f a new method for preserving ancient structures. I refer, of course, to the removal of the monument, as a whole, from its original threatened site to a place of safety.

Recent history provides many examples of successful operations of this kind. The two cases that I have in mind at present are those of the removal of a church in Switzerland to a new position to make way for the extension of the highway and, secondly, the rather tricky operation involved in the salvage of Henry VIIIth's winecellar that was discovered below Whitehall Gardens in London in what in its day had been ground level.

The position of the cellar in regard to the plans for developing the site could not have been more awkard and it was decided, accordingly, in 1946 (I quote from the *Illustrated London News* [11]) "that the cellar which is 62 feet long, 32 feet wide and 20 feet high should be removed to a new position. The whole building weighing approximately 800 tons when prepared for the operation, was first moved 43 ft. 6 ins. laterally on a staging and was then lowered by screwjacks through a distance of 18 fet. 9 ins. and ultimately rolled back 33 ft. 10 ins. to its present position approximately beneath its original site "and all without any evidence of structural distortion!"

These and similar achievements will be familiar at least to the architects among us and it was in the light of the success of such undertakings that I urged the formation of an international panel of engineers to consider dispassionately the Gazzola scheme for saving the temples of Abu Simbel by elevating them to the safety of the gebel, above what, on the completion of the High Dam project, will eventually be the new water level. This seemed to me to be a very important alternative to the various other schemes then under consideration.

The sequel we know. The panel was formed, it accepted the scheme and actually gave it precedence over the others but the cost was high. I stated in public in Cairo at the time that if this operation were not carried through to a successful issue and Abu Simbel saved, future generations would look back to ours as to a dark age when, although money was available for any form of war equipment, a major monument, of world importance, had to be sacrificed for lack of the financial support necessary to save it. I am still of this opinion!

We should rejoice, however, at the large measure of success that has attended the UNESCO appeals for safeguarding the other Nubian monuments and in particular in the thought that Philae will reappear after years of submersion to take her rightful place once again as "the Pearl of the Nile". Mercifully, the Nubian sandstone of which Philae is composed, is much less powdery than that further up the Nile at Abu Simbel and seems to have been improved rather than otherwise from the thorough washing it has had in recent years.

My commission is completed. I was invited to introduce the topic of conservation in a general way and I have tried to do so. Now we shall look forward to hearing more specific reports from those fortunate people with laboratory facilities who are leading the attack on the many problems in our field for which answers have as yet to be found.

Harold Plenderleith
CONFÉRENCE INTRODUCTIVE
RÉSUMÉ.

Une introduction générale sur la conservation des Monuments doit tenir compte de la variété des structures et des nombreux types des matériaux de construction. On doit considérer les macro et les micro caractériques des pierres et les diverses formes de détérioration auxquelles elles sont soumises en étant exposées aux intempéries. Au cours de l'étude des effets du milieu et de la pollution atmosphérique, l'influence de la latitude, pour déterminer le type prédominant de détérioration, est à remarquer.

On a déployé beaucoup d'ingéniosité, bien que sans résultats et parfois même avec des résultats désastreux, pour tenter de découvrir des substances chimiques sûres permettant de conserver la pierre. Des caractéristiques importantes sont la porosité et les difficultés rencontrées concernant l'imprégnation sans donner lieu à la formation de pellicule et les espérances actuelles sont basées sur l'utilisation possible d'émulsion contenant de matériaux silicieux qui puissent constituer une barrière contre l'action de l'eau et offrent donc immédiatement une résistance aux diverses formes de détérioration, tout en laissant filtrer l'air dans la structure des pierres.

D'un autre côté, des exemples sont donnés pour illustrer la pratique moderne de nettoyage des monuments avec de l'eau, l'élimination de l'humidité par l'électro-osmose et le renforcement là où se trouvent des pierres au moyen d'imprégnation en profondeur avec des matériaux plastiques et, finalement, le sauvetage par le transfert du monument menacé dans un autre endroit.

[1] Iniguez Herrero, J., Min. Educ. Nac., Madrid, 1961 *Alteración de Calizas y Aveniscas como materiales de Construcción.*
[2] Schoeller, H., « *Les Eaux Souterraines* ».
[3] Pochon J. et al., « *Role of bacteria on alterations of stone monuments* », Chimie et Industrie 65 (1951) and « *Bacterial participation in the degradation of Angkor Temple (Cambodia)* Compt. rendu 248 (1959).
[4] Schaffer, R. J., « *The Effects of Air Pollution on Buildings and Metalwork* », Reprint from « *Air Pollution* », Ed. M. W. Thring (Butterworth).
[5] Camerman, C., « *Les pierres de taille calcaires* » (Bruxelles, Service Géologique de Belgique, 1952).
[6] Rawlins, F. I. G., « *The Cleaning of Stonework* », Studies in Conservation, Vol. III, 1957.
[7] Massari, G., « *Risanamento igienico dei locali umidi* » 2nd. Edizione Ampliata, 1959.
[8] Massari, G. et al., « *Impiego della termometria a raggi infrarossi nello studio dell'umidità delle murature* », La Ricerca Scientifica, Anno 32, Serie 2, Parte II-A, vol. 2, n. 4, 1962.
[9] Zielinski, K., « *The Petrification of Soil by the method of R. Cebertowicz* », Polish Scientific Publications, Warsaw, 1956.
[10] Terracina, F., « *Foundations of the Tower of Pisa* », Geotechnique, 1962; « *La Torre di Pisa* », L'ingegnere (A.N.I.A.I.), 1961.
[11] *Illustrated London News*, October 11, 1952.