THE SECOND INTERNATIONAL SYMPOSIUM ON THE DETERIORATION OF BUILDING STONES, ATHENS 1976

By A. Swaine

As science progresses at an ever increasing speed the destructive powers of the wastes and spent materials and fuels which we tip into the sea, into rivers, into old gravel pits or other convenient places, and the unwanted fumes discharged into the air mount to dangerous levels.

The effects of air pollution are not confined to the damage it undoubtedly does to living things; there is also the detrimental effect it has upon the materials of the buildings in which we live and work. So serious has this become that in some cases all out efforts are being made to save selected buildings and works of art, but unfortunately resources are painfully small and the remedies known are virtually experimental, whilst the world at large, and the populations of countries having a great architectural past are largely unaware of the threat.

The first Symposium, that set out to draw attention to the effects of pollution on building stones, took place at La Rochelle, France in 1972. The second Symposium took place between 27 September and 1 October 1976. Centred upon Athens, it was organised by the chair of Physical Chemistry of the N.T.U. of Athens. The hope was expressed by delegates that there would be further symposia, with a continuation of the excellent work begun.

It was evident from the numerous and excellent papers read that the subject is vast, and that delegates bringing with them accounts of their own problems were helping to provide an essential stock of information that could form the foundation for research and provide hope for the future. Athens was chosen because of the rapid and increasing deterioration of the buildings crowning the Acropolis. The choice of any other site might have been as good for reporting the problems encountered in various areas, but the impact of the choice of such a centre as

Athens, with its formidable problem of the Acropolis, could not have been bettered.

Delegates came from all parts of the world, and although they included a considerable number of Greeks, including the Inspector General of Ancient and Historic Monuments of the Ministry of Culture and Sciences of Greece, members were also drawn from ICOMOS, the Victoria and Albert Museum, the British Museum and from most of the European countries as well as America, Canada and India. The greater part of the proceedings were scientifically orientated, with emphasis upon chemistry, and the proceedings took place in the National Technical University of Athens. Although the sessions included visits to the Acropolis itself, with particular reference to the buildings there, the proceedings, which commenced at 9 am. and continued until 7.15 pm., were spread over the whole realm of the deterioration of stones in buildings as found in all parts of the world.

It became even more evident as delegate after delegate read his, or her, paper, illustrated with slides, that conditions varied according to the climate of the region, the types of stone used,

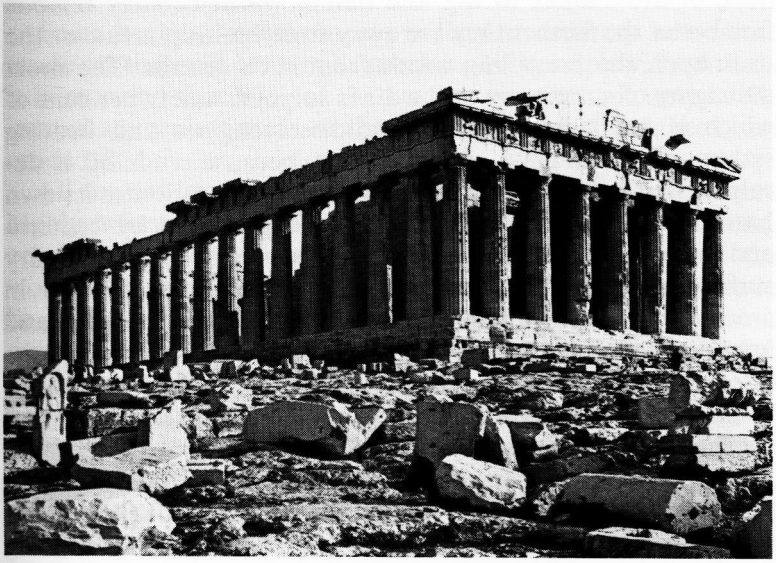

Fig. 1. The Parthenon.

whether or not buildings were subjected to the influence of sea air, humidity, rising damp, or pollution of the air from the burning of crude oil or more than one, or all of these things, to which could be added the effects of temperature change, wind, rain, frost and the sun. It also became clear beyond doubt that it would be wrong to suppose that there may soon be some panacea. Whilst the effects of pollution can be gauged fairly accurately, and the effects of rain can be judged, each building constitutes a problem to be considered in the light of the circumstances. As each problem is faced, it should be possible to build up a fund of information of great value to those who are called upon to care for monuments requiring skilled attention. Whilst great and most rewarding steps have been taken in the cleaning and stabilising of sculptures, and even façades, there is still a very long way to go before it will be safe to say that an economic or worthwhile practice for the protection of building stones can become part of normal building procedure, or form part of remedial exercises to save the buildings of the past.

Air pollution tends to be concentrated in the more densely populated areas, especially where they lie in hollows between hills, or are subject to fog and damp, whilst country regions fare better the further they are away from built-up areas, or the drift upon the prevailing winds from such centres. The most damaging of substances in the air is sulphur, ninety per cent of which is produced by factories, diesel engines and heating systems. The car plays a smaller part, because crude oil is desulphurised before use as petrol, although it contributes its own harmful ingredients. The other 10% is produced by bacteria and microflora. Effects would not be marked upon a dry surface and therefore the worst results are to be expected in areas where the stones used are subject to excessive rainfall and humid conditions. Humidity plus air pollution turns the deposits into diluted sulphurous acid, which neutralises the alkali content of the stones containing lime, such as marbles and some of the finer sandstones. Apart from destroying the surfaces of sculptures, the diluted acid fluid enters hair-cracks as well as the pores of stone, often to a considerable depth, passing down fissures that may not be evident to the naked eye, and causing the breakdown of the material within the thickness of the

blocks of stone themselves. Most centres throughout Europe have set up stations where rainfall can be measured, where the humidity can be gauged and where the sulphur content can be registered. By these means it is possible to keep a record of the increase in the destructive powers of pollution, or judge the improvements where action has been taken to cut down pollution by introducing either smokeless zones, or areas where heating aparatus or burners have been fitted with devices to minimise this. It has been found, for example, that SO_2 is neutralised where there are trees, and whereas trees are known to have died where pollution has been excessive, it seems to suggest that it would be sensible to plant more trees in towns where it is possible to place them, as well as work upon methods to reduce the effects of burnt crude oil.

Following the Venice Charter an appeal was made for the factories in the Magherra to do what they could to reduce pollution, and it was hoped that the ordinary domestic Venetian heating system might likewise become improved. It has been reported that there has been a remarkable reduction in the air pollution of Venice, but there remains the salt aspect of the Venetian atmosphere, as one might expect in an area in close contact with the sea.

Some heating systems in use in flats or ordinary houses use crude oil that will contain as much as 3·5% sulphur. In Athens it is reported that 60% of the heating systems, not only in the immediate central areas of the City but in greater Athens, use crude oil.

All the conference papers were not only interesting but were highly informative, and all stressed the seriousness of existing conditions. Such analyses from areas from all parts of the world where the finest architectural achievements of man are to be found, are absolutely essential. Without this information it would be little more than the entertainment of pious hopes that such and such a treatment might be effective. It is only by knowing the cause of the malady, the composition of the materials being affected and the conditions that exist that one can consider the use of chemicals to retard or neutralise these effects. Outstanding in their respective fields, and having something practical to offer were Kenneth Hempel and Anne Moncrieff of Great Britain, both of the Victoria and Albert

Museum. Miss Moncrieff spoke with considerable eloquence and deliberation and drew attention to the fact that one should not consider coating any kind of surface since this can only cause more damage in the long run. If used at all a treatment must be deep. Mr. Hempel illustrated his paper with slides of the work he has carried out on sculptures in Venice. His success on the Loggetta beneath St. Mark's Campanile is well known and he is now engaged upon the Porta della Carta of the Doge's Palace. By using a method of air extraction he has been able to get a penetration of 15 cm. thus bearing out the contention of Miss Moncrieff that if treatment is to be given to stone it must be deep if it is to be of any use at all. Marble is a very different material from the limestones and sandstones of which the greater buildings in Britain, such as the cathedrals, are built. A penetration of 15 cm into a material such as the fine marbles of Venice is an extraordinary achievement. By the use of silicone resin, which is virtually indestructible, it has not only the effect of keeping away the destruction of the surface by pollution, but the falling surface of the material is anchored once again to the stone of which it forms a part.

Another speaker who was extremely good was Barbara Penkala of Poland. Her slides of silica crystals magnified 1,000 times, showing the composition of stones in their natural state, and as attacked, was revealing in the extreme. Maria Serra of Italy spoke of Milan as being typical of central and northern Italy where there was considerable humidity present in walls, which showed itself mostly in the winter and the spring. M. Monte-Sila also of Italy spoke of the serious problem of microflora and the effects that these have upon stone, and the growth of sulphur bacteria once light is introduced. She illustrated this by calling attention to the recent opening of an ancient tomb where electric light had not been installed, and inspections were only done at short intervals using torches.

German delegates spoke also of the problems facing buildings in their country and the architect for Cologne Cathedral showed a number of slides of the different kinds of stone of which this cathedral is built. They number 50 in all, and his slides showed different degrees of corrosion and activity between them. Francois Pellerin of France spoke of a railway tunnel lined with stone, and illustrated his talk with slides emphasising that

magnesium also has a detrimental effect upon masonry work. Jean-Pierre Pauly, also of France, spoke of the Cathedral of Strasbourg and had noted that there were considerable changes in the quantities of chloride on each side of the building. For instance, it was found that three times as much had been discovered at the south-west end of the building as against the north-east end. He said that this was contained in the air and was deposited upon the walls during rain, and that a storm can deposit as much as one year's ordinary effects. He went on to say that chloride was very noticeable in a high wind in areas close to the sea, for instance, at La Rochelle it would seem that it is as much as 15 times higher than in Paris, where it had been impossible to detect it to any great extent.

Professor Zador of Hungary stressed the difficulty of trying to deal with whole stone façades of large buildings, and of the rapid decay of some Hungarian stone buildings where there was considerable rising damp. He also drew attention to the difference between those stones which have existed for centuries without conservation and those which have suffered from effects of time. He drew attention also to the harm that can come from cleaning by sand blasting and he was of the opinion that surface treatment was only the last stage in order to conserve. These views fell into line with all delegates who felt that one must think of the full thickness of the stone or wall in question, and all that takes place in and about it. To paint something upon the outside is no answer.

Franco Piacenti of Florence put the proceedings into perspective. He said that the chemist will analyse the changes in the stone and the scientist would explain what is happening. This being so, it leaves the restorer, upon whom all eyes will be directed, to perform some kind of miraculous rescue, armed with this information only, whereas with certain exceptions, it is known that to date he can only do very little.

The latter part of the week's discussions were given over to the Athenian problem. Proposal for dealing with this are considerable and amount to a partial rebuilding of the Parthenon itself and the removal of the remaining statues, as far as possible, for conservation indoors. The caryatid porch of the Erechtheion was already in the process of having casts made of the caryatids and of being dismantled, in order to place it

inside, in the same manner as the sculptures of the Parthenon. A number of visits were made to the Acropolis as well as other buildings in the immediate vicinity of ancient Athens, and to the laboratories and drawing offices constructed to deal with the works of conservation. V. Andronopoulos, the Director of the Geological Institute of Greece, spoke of the rock formation of the Acropolis. He said that the rock, which is composed of limestone in three ridges running roughly from east to west, was in no immediate danger of movement, and that although earthquakes occur in and around the whole area, the faults do not move any more, although slight tremors in the past have left their mark upon the buildings. The formation is of several folded layers of limestone, and these are showing evidence of corrosion from water falling upon the top. In the days of Pericles the area was almost completely paved and water was conducted away by a system of drains beneath the slabs of stone. These have long disappeared and the rock is laid bare.

The work that has been done to date is mostly of a research nature. A smokeless zone of considerable size around the Arcopolis has been suggested with no form of heating by crude oil within it. It is realised that the other areas surrounding this zone would send pollution into such an area, but the prevailing wind, as well as the fact that the rock stands above the plain, should keep the Acropolis area fairly clear. Pollution is ten times higher in winter than in summer, and the winter, contrary to popular belief, is disagreeable enough, lasting roughly from mid-November until March. This particular suggestion to create a zone where oil-burning heating systems would be banned drew considerable criticism inasmuch as it was felt that it would be exceedingly difficult to impose. It was thought however by some that the State could perhaps fix by law the type of fuel that should be used, and electricity was suggested as the right answer. Since 1975 agreement has been reached with the International Airways, and runs to and from Athens Airport have been so arranged as to remove a great deal of the vibration and fumes which aircraft create, thus avoiding damage from this particular source. Measured drawings of all the buildings upon the Acropolis site have been prepared to a variety of scales, and upon these drawings all cracks in the marble have been drawn. Many of them are not visible to the naked eye and have been

discovered by electronic means, which has enabled those preparing the drawings to measure the depth of the cracks and so relate them to the stones of which each building is built.

The history of ancient Greece culminating in the buildings upon the Acropolis we know as the Parthenon, the Erechtheion, Nike Apteros and the Propylaea, is well known. Excavations have revealed something of the earlier buildings which stood before the present ones, and the work proposed upon the site will take account of these as far as possible.

Apart from having been converted to a church, the Parthenon had stood virtually intact until the year 1687, when an attack was launched upon the Acropolis by the Venetian Francesco Morosini, and the building was blown up by a shell falling upon gunpowder stored inside and 28 columns fell to the ground. Following this frightful explosion, it suffered a further attack when Morosini, who had become the Doge (1688–94), tried to remove the central section of the west pediment, depicting the dispute between Athena and Poseidon, with the object of taking it back to Venice, but he only succeeded in strewing the ground with the broken remains. The few sections of sculpture which remain in this pediment were being removed during the period of the Symposium and it was expected that the sculptures at the east end would also be removed and exhibited indoors, after treatment.

In 1816 Lord Elgin, armed with permission from the Sultan to remove "Some stone blocks with inscriptions and figures" made off with 12 statues, 56 panels from the frieze and 15 metopes, a caryatid from the caryatid porch and a column from the north-east side of the Erechtheion, as well as parts of the temple of Athena Nike (Nike Apteros). Whereas it has been felt down the years, not without good reason, to have been an act not at all kindly disposed towards the buildings in question, there is little doubt that he may have saved them from a fate that might have been worse, the pollution from which they would have suffered had they stayed in place. There are also a piece of the frieze, and two metopes, in Paris.

Finally, in common with its neighbours, the Parthenon suffered still further, for during the War of Independence the Acropolis was the scene of siege and fighting. By 1833, with the liberation from the Turks, the whole area was left in ruins.

However within years the site was cleared of the Turkish village that had grown up upon it, the temple of Nike Apteros was reconstituted and in 1842 part of the Parthenon was restored, but it was not until the end of the century that there was a systematic restoration of the Acropolis as a whole. Balanos was the architect who put much of the Parthenon together as we know it. Most of the columns and lintels are, however, unrelated to one another. They can move, and so are dangerous. He was also the architect who in 1871 cut out a deep channel in the entablature of the caryatid porch and put in an iron frame supported on small iron columns, so that the weight was taken off the caryatids themselves. This has had the most disastrous effect over the years and the stonework is now in such a state that probably it would not stand much longer in the open. It is easy to criticise the early restorers, and one should not loose sight of the fact that they did what they thought was best with the materials and knowledge available. The present position is that a shelter has been built over and around it for the duration of the winter, and a proposal is that it should be taken down completely, and that reproductions, not only of the caryatids, but of the whole of this porch, should take its place, and that the original should be re-erected indoors.

A further proposal is that when the works of restoration to the Parthenon have been completed replicas of the sculptures probably of the fibre-glass type, should take the place of the original ones which the Greek Government have taken down, and plus copies of those now in the British Museum. The effect in due course, will be a splendour that can only be imagined.

UNESCO have sent experts to work with the Greek teams and the Greek Government have already given 50 million drachmas, about £800,000. This is a start, and it is hoped that money will become available from other sources as the work proceeds. The sections of the Parthenon to be rebuilt are the missing sections of the entablature upon the north side and the whole of the section upon the south side, re-using as many of the old stones as possible which now lie scattered upon the ground. Fortunately the building which is of white Pentellic marble, is almost within sight of the ancient quarries, and it should be possible to obtain sufficient new stone, where necessary, to supplement the missing members, or the existing

bruised sections, where they cannot be replaced, or where they must be repaired. A start has already been made to replace the flat coffered ceiling at the west end between the frieze of the Naos and the outer colonnade, which will protect some of the best sections of the sculpture of the Panathenaic frieze from the weather. No recommendations were made of a definite nature about treating the stone of the columns or entablature where they have been split or fractured, or where they are discoloured by corrosion or where algae is evident upon those areas away from the prevailing wind and rain. Doubtless this has been carefully considered and may be the subject of future decisions. Not unnaturally some delegates raised the question whether it would not destroy the extraordinary beauty of this most perfect of all buildings, split open in the manner in which we all know it, if it is rebuilt. It was pointed out, with considerable reason, that for aesthetic reasons alone it would be the correct thing to complete it, in spite of the point made, and for reasons of stability it is highly desirable that those columns which are now unrelated to one another, and unrelated to the sections of loose entablature placed there almost 100 years ago should be anchored. In order to do this it has been decided to use titanium alloy.

Other works envisaged will be the stablising of parts of the Acropolis walls to ensure as far as possible that water which can sink between the rocks and these walls should not be the cause of any of this masonry slipping out of position.

In conclusion it was suggested from various sides of the assembly that something akin to the Venice Charter should be prepared that would give strength to the efforts now being made to conserve the most perfect of all man's artistic achievements.