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CONSERVATION AND MAINTENANCE OF FLOOR MOSAICS IN ARCHAEOLOGICAL AREAS

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SUMMARY

In recent years, in the field of conservation and protection of excavation areas, there has been a growing conviction that preventive conservation – especially maintenance – is one of the most suitable tools for effective and extensive conservation, as it is the most practicable in cost-benefit terms. This discipline, which has only recently appeared on the conservation horizon, has its origins in antiquity. It offers a valid reply to the disproportion between the exigencies of conserving an ever-increasing amount of heritage and the growing demand for access by new generations of visitors.

In this article, techniques for the conservation and maintenance of mosaics in situ in archaeological areas will be discussed. This will be done by revisiting the sources and describing the modern techniques, proposing a methodological approach and supplying evaluations of the techniques, costs and results obtained. Archaeological mosaics displayed in museums, albeit numerous and not without maintenance problems themselves, will not be discussed, as they call for different conservation considerations and treatment techniques.

INTRODUCTION

Can it perhaps be said that a mosaic is eternal painting? Eternal, but not indestructible: eternal in the way that the works of man are not limitless and must be assured certain conditions in order to last truly. (Brandi, 1956: 93-100).

In recent years, in the field of conservation and protection of excavation areas, there has been a growing conviction that preventive conservation – especially maintenance – is one of the most suitable tools for effective and extensive conservation, as it is the most practicable in cost-benefit terms. This discipline, which has only recently appeared on the conservation horizon, has its origins in antiquity. It offers a valid reply to the disproportion between the exigencies of conserving an ever-increasing amount of heritage and the growing demand for access by new generations of visitors.

How can one reconcile the need for culture with the duty of preserving monuments for posterity? We will take a logical approach to this issue with facts and figures, comparing data taken from financial balance sheets and from some test cases in the field.

Prevention of damage, which calls for numerous technical activities and notably for strategic planning, is among the principal tools that can be used to preserve (as long as possible) *in situ* the material testimony of a past that is at the root of the historical memory of entire civilizations. This must occur in the context of a society with a vastly accelerated need for cultural consumption. The risk factors and the rate of deterioration have multiplied, for society has forgotten, in a rather suicidal collective amnesia, the ancient traditions of care, of continuity, and a sense of the duration of the creations of humankind.

The challenge is certainly titanic, and anyone involved in conservation realizes every day how feeble their weapons are, especially when they rely on radical restoration treatments and the use of so-called "miracle products" which are supposed to confer life eternal on materials. Objects are reduced to a state that could be defined as knowledgeable old age, in an unstable equilibrium between the primordial state of semi-aggregated material and the condition of worked form which reflects a former existence.

The high cost of this type of treatment and the short duration of its effects on the conservation of materials have led conservators to turn their attention to developing and mastering treatment techniques that – at the same cost – can lead to longer-term benefits for a greater number of monuments on display. Attention has primarily been paid to recovering the tradition of maintenance and care that has permitted the monuments of antiquity to survive to our day.

In this article, techniques for the conservation and maintenance of mosaics *in situ* in archaeological areas will be discussed. This will be done by revisiting the sources and describing the modern techniques, proposing a methodological approach and supplying evaluations of the techniques, costs and results obtained. Archaeological mosaics displayed in museums, albeit numerous and not without maintenance problems themselves, will not be

discussed, as they call for different conservation considerations and treatment techniques.

Preventive conservation and maintenance in ancient sources

"(...) And this you cannot deny, that no matter how large a building or how massive its walls, if it is not maintained it will deteriorate in a short time" (Averlino, 1972: Book I).

The need for prevention and maintenance for the survival of works – from the walls of buildings to their facings, as well as sculptural decoration – is well attested in the writings of Vitruvius, Pliny, Alberti's architectural treatises, Filarete and Renaissance recipe books.

The best-known quote about maintenance in modern times is still that of J. Ruskin, who stated in 1849: "The principle of modern times (...) is to neglect buildings first, and restore them afterwards. Take proper care of your monuments, and you will not need to restore them. A few sheets of lead put in time upon a roof, a few dead leaves and sticks swept in time out of a water-course, will save both roof and walls from ruin. Watch an old building with an anxious care; guard it as best you may, and at any cost, from every influence of dilapidation. (....) do this tenderly, and reverently, and continually, and many a generation will still be born and pass away beneath its shadow. Its evil day must come at last; but let it come declaredly and openly, and let no dishonouring and false substitute deprive it of the funeral offices of memory" (Ruskin, 1925: 356-357).

In ancient sources, indications of techniques for the maintenance of pavements are rare, whereas precautions to take to make durable works are described at length, together with the materials to be used and the main threats to their survival.

Pliny (Pliny the Elder, 1962) writes to this effect: "Open-air flooring was an invention of the Greeks, who roof their houses in this way, an easy method to use in regions with a warm climate, but unreliable wherever there is heavy rainfall and frost. It is essential that two sets of joists should be laid across each other, and that their ends should be nailed down to avoid warping. To fresh rubble should be added a third of its weight in pounded potsherds; and then the rubble, mixed with two-fifths of its weight in lime, should be rammed down to a thickness of one foot. After this, a final coat 4 1/2 inches thick must be applied to the rubble and large square stones not less than 1 1/2 inches thick laid on it. A fall of 1 1/2 inches in 10 feet should be maintained and the surface carefully polished with grindstones. It is considered impracticable to lay the wood floor with oak planks, because they warp; and furthermore, it is thought

advisable to spread a layer of fern or straw below the rubble so that the worst effects of the quicklime may not reach the planks. It is essential also to lay a foundation of round pebbles under the rubble. Tiled floors with a herring-bone pattern are constructed in a similar fashion".

Vitruvius (Vitruvius 1960: 203-204), in the section on outdoor paving, suggests insulating the mortar with oil in order to avoid frost damage: "In the open air, specially adapted kinds of floors must be made, because their framework, swelling with dampness, or shrinking from dryness, or sagging and settling, injures the floors by these changes; besides, the frost and rime will not let them go unhurt. Hence, if necessity drives, we must proceed as follows in order to make them as free from defects as possible. After finishing the plank flooring, lay a second plank flooring over it at right angles, and nail it down so as to give double protection to the framework. Then, mix with new broken stone one third of the quantity of pounded tile, and let lime be added to the mixture in the mortar trough in the proportion of two parts to five.

Having made the bedding, lay on this mixture of broken stone, and let it be not less than a foot thick when the beating is finished. Then, after laying the nucleus, as above described, construct the floor of large cubes cut about two digits each way, and let it have an inclination of two digits for every ten feet. If it is well put together and properly rubbed down, it will be free from all flaws. In order that the mortar in the joints may not suffer from frosts, drench it with oil-dregs every year before winter begins. Thus treated, it will not let the hoarfrost enter it.

If, however, it seems needful to use still greater care, lay two-foot tiles, jointed together in a bed of mortar, over the broken stone, with little channels of one finger's breadth cut in the faces of all the joints. Connect these channels and fill them with a mixture of lime and oil; then, rub the joints hard and make them compact. Thus, the lime sticking in the channels will harden and solidify into a mass, and so prevent water or anything else from penetrating through the joints. After this layer is finished, spread the nucleus upon it, and work it down by beating it with rods. Upon this lay the floor, at the inclination above described, either of large cubes or burnt brick in herring-bone pattern, and floors thus constructed will not soon be spoiled".

The passage given above is particularly interesting because, while supplying indications on the materials to use and how to put them into place, it also introduces the concept of a few maintenance activities to be carried out before the onset of winter (impregnation with oil once a year). It is perhaps the only such quote in the sources that is so precise about periodical maintenance. Moreover, certain procedures last up to the Quattrocento, as can be seen in

Alberti (Alberti, 1966: book III). In Chapter XVI on paving, he takes up the technique described by Vitruvius point by point and adds: "The work will be even more secure if between the packed rubble and the cement mixture one inserts tiles joined with lime mixed with oil".

Alberti, again, observes that "the lime mixed with oil protects the pavements from damage due to the elements" and "if a small crack forms in an outdoor pavement, fill it with sifted ashes mixed with oil, preferably linseed, and it will close up. Another excellent material for this purpose is clay thoroughly mixed with quicklime, baked in the kiln and immediately mixed with oil, so long as the crack has previously been perfectly dusted. The dust can be removed with brushes and blown out with a bellows".

In 1521, Cesare Cesariano, (Cesariano, 1981) in his edition of *De Architectura*, cites Vitruvius' notation about annual maintenance, and resolves the problem of frost protection by recommending soaking the pavement with a mixture of wax, turpentine and pine resin:

"Tamen Vitruvio pare voglia siano coperte tute le coniuncture nel tuto il pavimento quale sta sub divo: acio sia defendato da li gelicidii e coeleste pruine: per li hyemaly tempi: e questo sia fiendo per ciascuni anni: Ma io per cavarmi di tanta annuale feruitute: quando fusse bene exicato e como adusto dal Sole Ardentissimo: con la cera e terbentina e raxina di pino bene ferventissima iliniria saturissimamente epso pavimento in fino a tanto che la superficie restasse lucida e como vitrea: per che queste cose ho usato fare sopra le magne tessere di opera testacea: sopra la quale havea perfigurato li gnomonici horoligii e collocati in plano al modo havemo dimostrato li marmorei amussii. Et pertanto questa materia imbibita reice le coeleste passione ne mai se imbibe ne altra cosa sopra si applica: Et Questo in lo oppido di Villanterio agro papiense collocai in uno horto (....)".

A few years later, in Mons. Daniele Barbaro's 1556 edition of *De Architectura*, we find the following written about outdoor pavements: "(...) Similarly, it will be good to cover them with *amurca* (organic material resulting from the production of olive oil), or throw water over them in which lime has been slaked: and if you want to repair a broken terrace, take one part of crushed tiles and two of *bolo armeno* and mix fast on the fire, and having heated the terrace, throw this material over it and then spread it gently with a hot iron. Also, you can mix fresh white lime with marble dust in boiling water and let it dry. After doing this three or four times, mix it with milk and whatever colour you would like to have. And if you want to create a mosaic effect, put the material into forms, giving them whatever colour you like, but then add hot oil or a mix of the marble dust with *cacio* glue (caseinate), so long

as the glue is thinned with well-beaten egg white, then add the lime and mix well".

Both the materials and the techniques and tricks to prolong the life of pavements continue, with minor variations, throughout the sixteenth and seventeenth centuries.

Apart from the technical information, which is certainly most useful and illuminating for anyone working in the field of archaeological mosaics conservation, what emerges from these texts is the existence of an established approach to damage prevention and a stance in favour of continuous, planned maintenance. The purpose of the maintenance was to keep the artifacts working properly.

MAINTENANCE IN PRACTICE TODAY

Planning

Yet, in modern practice, what is maintenance exactly? In the etymological dictionary of the Italian language (Pianigiani, 1988), under "maintenance" one finds: "lat. Manutentiònem, composed of Mànus – hand – and Tentiònem, formed from Tèntus, past participle of Tèneo – I hold, possess, a Conservation latinism, Security for the maintenance of the thing". In effect, the term "maintenance" is a synonym for conservation, as if to say that no conservation is possible without maintenance. Today, maintenance of mosaics is carried out to preserve the historical message of the material and always goes hand in hand with preventive conservation measures. It involves, as an irrevocable premise, the drafting of a detailed plan in which the information about the object, the context to which it belongs and the objective one wishes to obtain have been analyzed in order to define in detail the means, techniques, materials, resources, times and costs of carrying out the work.

In this analysis, however, we cannot stop at broad statements, but must go into the specialized details and have an in-depth knowledge of the condition of the materials, the mechanisms of decay and deterioration, and the active and passive agents of aggression present in the conservation environment.

Even before defining any objectives, the first step in building a maintenance program is thus to collect and process the data about the mosaic or mosaics one intends to preserve.

Every factor that can affect present and future conservation must be examined, as well as how such factors might interact. Below, we schematically list the data required to obtain a relatively complete picture of conservation conditions:

- number of mosaics and their location in the archaeological area: this

could be a single mosaic or a number of them, either close together or scattered throughout different sectors

- the area can be exposed, covered, open or closed to the public, with vegetation, arid, etc.
- typology and constituent materials: dimensions, materials in the bedding layers and nucleus, nature of the covering (marble, glass paste, potsherds, etc.)
- current condition of the mosaics: time elapsed since excavation and thus relative exposure to new environmental conditions; whether there are mosaics that have never been restored, or detached and put back *in situ*, if so, defining the time elapsed and materials used for restoration (if any); or mosaics left *in situ* without lifting, with materials similar to the composition of the originals
- condition of the original materials, and of any others used in conservation and restoration treatments, presence (if any) of ancient restorations. To gather this information, it will be indispensable to carry out a thorough documentation of the state of affairs, using both graphic and photographic techniques. The base maps obtained will later be used as a system to evaluate the effectiveness of maintenance operations and as a basic point of reference
- typology and characteristics of the conservation environment. Analysis and identification of environmental risk factors is essential for defining what needs to be done. Factors to examine are: exposure to environmental damage (rain, frost, insulation, roots, groundwater flooding, soluble salts, pollution, etc.); and to anthropogenic damage (foot traffic, theft, vandalism, improper behaviour), as well as studying the times of exposure and the periods of increased risk.

A sustainable maintenance program is not only based on data collected in the field. Logistical information must also be added to the technical data, including the available resources, both economic and human.

The principal characteristic of a maintenance plan is continuity – the repetition at regular intervals of specific practices using low-cost treatments. The operations deemed necessary must be planned with a calendar at hand, managed and checked. Timid and, we might add, praiseworthy efforts in this direction have been made by a few administrations, and are beginning to show visible results in the conservation of the works. Such results, however, do not make news like the major, flashy restorations that attract all the limelight. The latter are responsible for burying, with class (and also at enormous expense) the other efforts towards a radical change in a culture dedicated to

consumerism and not to the duration and growth of culture.

To recall the words of G. Urbani: "restoration is always a *post factum* intervention, i.e., merely able to repair damage but certainly not to slow it down or even less to keep it from happening. For prevention to be possible, what is needed is a technical movement to change traditional restoration into what has so far been only posited in theoretical terms as preventive conservation. Such an approach, which we shall call "planned conservation", is addressed of necessity to individual heritage items and the environment in which they exist and which is responsible for all the possible causes of their deterioration. Its objective is thus the control of such causes and slowing down – as much as possible – the rate of deterioration processes, intervening at the same time and if necessary with maintenance treatment appropriate for the various types of materials (Urbani, 2000a; 104).

Maintenance techniques

The casuistry of mosaics is vast, and every mosaic must be studied case by case in relation to its context, so here we will limit ourselves to discussing the broad outlines of the operations possible in a maintenance project.

To maintain the artifacts, one must have at least the minimum material conservation conditions. In other words, one must first work directly on the mosaics to re-establish the physical and chemical equilibrium of the constituent materials. Minimal interventions for structural consolidation of detachments (using materials similar to the original ones), cleaning organic deposits from the surfaces, extracting soluble salts, weeding, removing roots (if any), stuccoing lacunae with lime mortar and reinforcing the mosaic edges – all these operations permit the artifact to interact with the environment, so long as the latter is controlled and safe. The environment must thus also be set up for conservation, including rainwater drainage, temporary or permanent coverings – directly on the mosaic if possible or above it if it must be visible – walkways to control foot traffic, non-invasive barriers against handling, and surveillance to avoid vandalism and theft.

Maintenance follows these interventions as a subsequent and necessary phase, and not as an autonomous intervention in itself. Thus, we will define the elements that make up a conservation treatment, departing from the premise that maintenance ultimately means conservation, even from a strictly linguistic perspective.

A project for mosaics conservation comprises:

- analysis of the current situation (see preceding paragraph) and documentation

- analysis of available resources and their allocation
- hands-on treatments limited to re-establishing the minimum conditions necessary to preserve the original materials, using materials that are both compatible with the original and reversible
- direct and indirect intervention on the mosaic's environment in order to contain or eliminate the appearance of damage or deterioration factors
- planned operations to maintain (maintenance) the effectiveness of environmental control systems and the results obtained, performed consistently at periodical intervals
- programs of public information, because "the work of art belongs to the spirit, to the universal conscience, and everyone must thus be allowed access to it" and "the ownership of a work of art (...) must be understood as custodianship, the most attentive custodianship, and one answers to the entire world" (Brandi, 1996: 282).

Maintenance interventions can be subdivided into "ordinary" maintenance, at intervals established according to a calendar, and "extraordinary" maintenance, dictated by the occurrence of infrequent or exceptional phenomena (earthquakes, floods, fires, hurricanes, etc.), which will certainly damage the works and the protection systems set up for them.

Ordinary maintenance is established to respond to known phenomena, and generally calls for all or a combination of the following operations:

- cleaning the surface of loose deposits with small brushes and vacuuming, and cleaning of more stubborn deposits with scalpels and vacuuming, especially in the spaces between the tesserae (fig. 1)
- damp cleaning with water and a surfactant having a bland biocide action (NeoDesogen at 2%), to be done with dampened synthetic sponges and stiff brushes
- manual weeding, including pulling out small roots
- chemical weed-killing
- application of a biocide for algae, moss and lichens
- checking the adherence of tesserae to the underlying layers and the mortar between them, with substitution of missing or damaged ones where necessary
- checking the compactness of the foundation mortars (both original and restored); infiltration of lime mortar into any detachments present and removal/substitution of unstable restoration materials
- checking mortar fills and substitution of any broken ones
- general survey of the surfaces, with particular attention to the

appearance of soluble salt efflorescence, alteration of the marble or glass-paste elements, lesions such as breaks, micro-fractures, scaling, which should be documented and linked to recent climatic events or other phenomena that had not been noticed previously temporary reburial with geo-textile bags filled with Leka grains or powder (Albini, Costanzi Cobau, Zizola, 1995: 491-500; Altieri, Laurenti, 1999: 727-733) (or else washed, large-grain pozzolana) when snow or frost are likely

- checking and cleaning of coverings and rainwater drainage, with removal of debris and leaves, replacement of unsuitable or inefficient or damaged elements
- checking the walkways and paths, with modifications if they do not function well
- updating information panels and replacement of damaged or illegible ones (table 1).

The frequency at which to perform these operations should be programmed on the basis of an analysis of the risk and environmental factors in any given context. Nevertheless, table 1 gives an indication of suggested intervals for these treatments (drawn from field experience), and the qualifications the staff should have for technical execution.

We pause here to consider the last part of the maintenance program, as someone might object that monuments are not preserved by maintaining visitor paths and facilities. And yet, even the most distracted individual might notice that where visitors are greeted with efficiency and interest, and guided toward comprehension and satisfaction of their expectations and intellectual and aesthetic curiosity, there is far less improper behaviour. Indeed, visitors reward such concern with greater care and attention, a humble desire to know more, which is expressed in the intention, confessed in an interior dialogue, to return to the place where they have understood and revisited a piece of history. Every monument of the past lives in the present by virtue of the capacity to extrapolate its meaning, as it is no longer in use, lived in or experienced. Therefore, to keep a monument alive and thereby preserve it, also means making an effort to help people enjoy its significance. Rough and neglected pathways, illegible or repetitive signage, faded by time and boring in content, are as damaging as a sudden frost. If frost can shatter mortar and injure tesserae, poorly managed information and visitor handling lead to loss of interest and ultimate oblivion, with consequences visible to all.

All the other operations, if performed regularly and consistently, slow the aging of the materials, prevent and reduce the risk of damage and avoid the danger of seeing the effect of conservation treatments come to naught.

Then there are the exceptional events that call for extraordinary maintenance – those not included in the regular program but dictated by emergencies. Such treatments must be carried out as soon as the need arises. One can speak of extraordinary maintenance when surfaces must be cleaned after high winds, or gutters must be repaired after collapsing under snow, and so forth. With even more dramatic events, more drastic prevention measures are called for, but these are emergency and first-aid treatments rather than maintenance.

To flesh out the outline given above, we will analyze the results of five current or proposed maintenance plans in archaeological sites that have different environmental conditions and characteristics. Comparison of the data obtained in the course of such experience will permit us to formulate a basic hypothesis about the time required for maintenance. Such a result must obviously not be taken as a specific operational prescription but as a reference point upon which to model, case by case, any drafting of a maintenance plan (Tables 2 and 3).

Those cases are referred to Masada, the Western Palace, Zippori, the building of the Nile (Costanzi Cobau, Nardi, 2003), Mamshit, the Byzantine church (Zizola, 2003), in Israel and two cases in Italy, in The thermae of the Cisiarii (Nardi, Zizola 1998: 17-21) and the Piazzale delle Corporazioni (Nardi, 2003).

In conclusion, we are convinced that "programmed conservation" is the only viable approach today to the preservation and conservation of the mosaic heritage, as it permits a distribution of resources to benefit the conservation and enhancement of a greater number of artifacts. Simple operations, performed with easily obtained, low-cost materials, help to extend the material's chances of survival, while at the same time assuring the fruition of the historical and aesthetic meaning it contains. Responding with drastic restorations once the damage has occurred implies high treatment costs and more interference with the original materials. Afterwards, needless to say, treatment will still be needed ever more frequently unless the mosaics are "protected" and regularly maintained.

As G. Urbani wrote in 1980 with regard to historic centres (and equally applicable to archaeological sites): "the advantages of a policy of programmed maintenance are such, and so many, that they impose a new rule of ethical conduct on specialists of traditional restoration, whereas none of the restoration charters formulated to date have touched on this aspect. Whenever one plans the restoration of a monument or isolated building, it must be obligatory that the decision to start work be taken only after calculating

whether, at the same cost, it would be more advantageous for that given historic centre to have one well-restored monument in a context of ruined buildings, or to make progress, however minimum, in the state of maintenance of the context itself – naturally also including the monument under consideration (Urbani 2000b: 35).

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Table 1

Operation	Min. annual frequency	Personnel
cleaning of loose surface deposits	4	Trained generic laborer
damp cleaning with water	2	Trained generic laborer
manual weeding	2	Trained generic laborer
chemical weed killing	1	Specialized laborer
biocide application	1	Specialized laborer
checking mortars in foundation and interstices	1	Specialized laborer
checking compactness of foundation mortarsand eventual infiltration with hydraulic lime mortar	1	Specialized laborer
checking mortar fills and replacement of broken ones	1	Specialized laborer
general survey of surfaces	4	Specialized laborer
temporary reburial with geo-textile bags filled with Leka grains and powder	According to a calendar	Trained generic laborer
checking and cleaning of covering systems and rainwater drainage	2	Trained generic laborer
checking of walkways and paths	2	Trained generic laborer
updating of information panels and replacement of damaged or illegible ones	1	Trained generic laborer

Table 1. Suggested intervals for maintenance treatments (drawn from field experience) and the qualifications the staff should have for technical execution.

Table 2

Monument	Mosaics	Environmental conditions	Conservation conditions	Operations performed	working hours a year	working hours per m^2 per year
Masada. Western Palace	polychrome geometric and black-and-white; total 20 m^2 *in situ*; last restoration 1994	- desert climate (abundant dust; high winds; driving rain) - vegetation absent	- semi-enclosed environment, with roof and walkways (vulnerable to dust and driving rain) - mosaic cannot be walked on	*dry dusting*: once every 2 weeks, 1 person, 1 hour; *cleaning with damp sponge*: once every 4 weeks, 1 person, 1.5 hours	40 hours	2 hours
Zippori. The building of the Nile	polychrome geometric and figurative; total 250 m^2 *in situ*; last restoration 1995.	- temperate climate - green area not bounded by trees	- semi-enclosed environment, with roof and protected visitor routes (vulnerable to driving rain) - mosaic cannot be walked on	*dry dusting*: once a week, 1 person, 8 hours; *cleaning with damp sponge*: once every 2 weeks, 1 person, 8 hours; *checking of mortars*: once a month, 1 person, 8 hours; *general survey*: once every 3 months, 1 person, 16 hours; *time available for extraordinary events:* 1 person, 40 hours.	824 hours	3 hours
Mamshit. The Byzantine church	figurative polychrome; total 80 m^2 *in situ*; last restoration 1999	desert climate (abundant dust; high winds; winter rain) no vegetation	- outdoors - direct seasonal reburial (four winter months); - mosaic cannot be walked on	*cleaning with damp sponge*: once every 2 months (for 8 months of the year), 1 person, 24 hours; *periodical* seasonal reburial	168 hours	2 hours

Table 2

				1 person, 24 hours, at beginning of winter; *uncovering and periodical seasonal cleaning*: 1 person, 48 hours, at beginning of summer		
Ostia. Baths of the Cisiarii	black-and-white figurative and geometric; total 260 m^2 *in situ*; last restoration 1995.	temperate climate, near the sea green area, bounded by trees	-outdoors, - partially protected by direct seasonal reburial (four winter months); - mosaic cannot be walked on	*dry dusting* *cleaning with damp sponge* *manual and chemical weed control* *periodical seasonal reburial and uncovering* *periodical general survey (including water drainage systems)* 1 person, twice a year, 180 working hours each time	360 hours	1.5 hours
Ostia. Piazzale delle Corporazioni	black-and-white figurative and geometric; total 1000 m^2; *in situ* on cement; last restoration: 1970s.	temperate climate, near the sea green area, bounded by trees	outdoors; mosaic cannot be walked on	*dry dusting* *cleaning with damp sponge* *checking of mortar solidity and consolidation between tesserae* *manual weeding* *renewal of broken cement stuccoing* *periodical general survey (including water drainage systems)*	1500 working hours	1.5 working hours

Comparison of the data obtained in the course of field experience permits us to formulate a basic hypothesis about the time required for maintenance.

Table 3

Monument	Environmental conditions	Time required per m^2 per year	Cost per m^2 per year, calculated on an average cost of 15 € per hour
Masada. Western Palace (20 m^2)	Desert, roofing, walkways	1.5 hours	22.5 €
Zippori. The building of the Nile (250 m^2)	Green area, roof, walkways	3 hours	45 €
Mamshit. Byzantine church (80 m^2)	Desert, outdoors/ temporary reburial, walkway	2 hours	30 €
Ostia. Baths of the Cisiarii	Temperate climate. Outdoors, temporary reburial	1.5 hours	22.5 €
Ostia. Piazzale delle Corporazioni	Temperate climate. Outdoors	1.5 hours	22.5 €

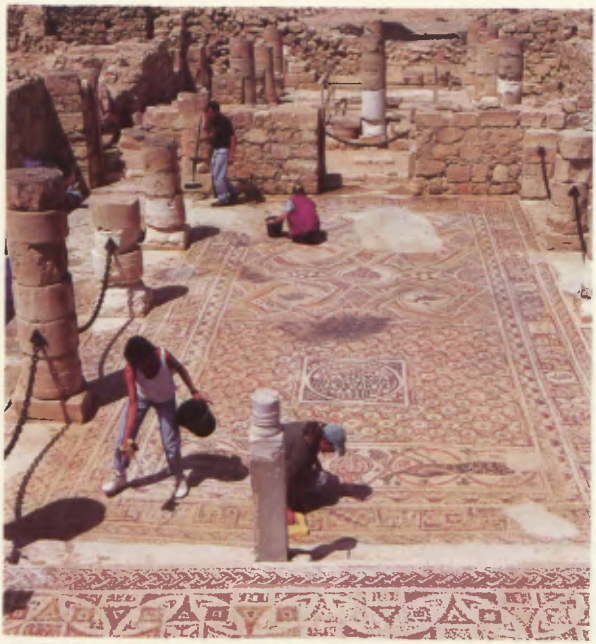
Table 3. Comparative costs for maintenance according to five different cases.

1. Soprintendenza Archeologica di Ostia Antica; National Parks Authority of Israel.
2. The CCA has performed maintenance treatments on open-air mosaics at Ostia Antica – Baths of the Cisiarii and Piazzale delle Corporazioni; Israel – Masada, Bath House and Western Palace; Zippori – Nile Building (fig. 2-5).

FIGURES

1. Cleaning of loose surface deposits and damp cleaning with water.

2. Masada, the Western Palace.



3 Mamshit, the Byzantine church.

4. Ostia Antica, the Baths of the Cisiarii

5. Ostia Antica, Piazzale delle Corporazioni.