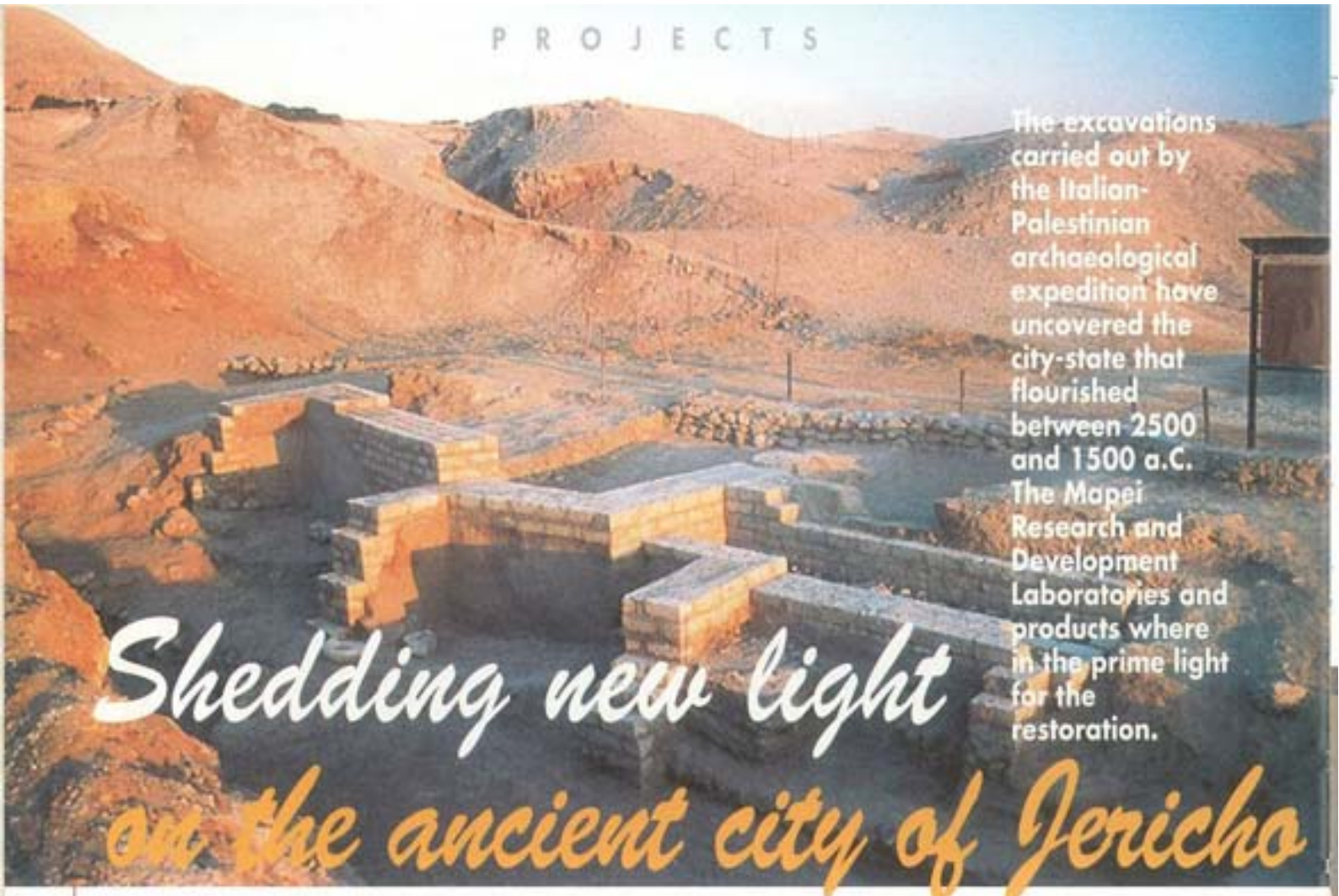
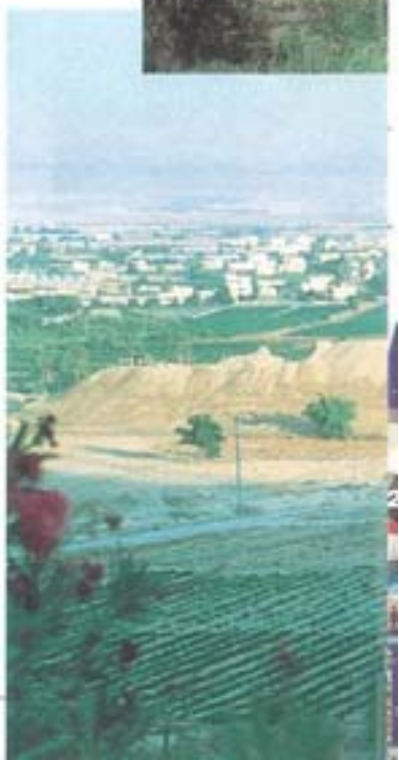


Shedding new light on the ancient city of Jericho

The excavations carried out by the Italian-Palestinian archaeological expedition have uncovered the city-state that flourished between 2500 and 1500 a.C. The Mapei Research and Development Laboratories and products where in the prime light for the restoration.

*by Nicolò Marchetti, Lorenzo Nigro, Hamdan Taha, Francesco Nigro, Tiziano Cerulli **

The archaeological expedition involving Rome's La Sapenzia University and Palestine's Department of Antiquities which was restarted in Tell es-Sutlan in the spring of 1997, has led to the discovery of the ruins of fortifications and buildings from the ancient city of Jericho, dating it to the 2nd and 3rd centuries BC. All of the areas covered by the dig have yielded very important data. Right from the start, the project has concentrated on the study of the urban structure of this extraordinary city, renowned as the world's oldest thanks to its astonishing 10,000 year history. 40 years on from the end of the last dig, the ancient city of Jericho (Tell es-Sultan or "Hill of the



**Nicolo Marchetti and Lorenzo Nigro are the leaders of Rome's La Sapienza University's archaeological expedition in Palestine, Hamdan Taha is director of the Palestinian Department of Antiquities, Francesco Nigo is architect to the Jericho expedition, and Tiziano Cerulli is head of the Testing Laboratory at the Mapei Research and Development Centre in Milan.*


HOTO 1


PHOTO 2

Photo 1, area B after restoration. Note the information board.
Photo 2, the Italian-Palestinian expedition at the end of the 1999 dig.
Photo 3, the dwellings in area F, 2500 BC.
Photo 4, Mount of the Temptations, which dominates the Jericho Oasis.
Photo 5, Tell es-Sultan (Jericho) from the south-west.

PHOTO 3

Sultan" in Arabic), now under the control of Palestine's Department of the Antiquities, is being excavated once again thanks to the joint Italian-Palestinian effort.

Situated on the raised western rim of the Jordan Valley, just eight kilometres from the northern shores of the Dead Sea, the Jericho Oasis (Oasi di Gerico) was one of the ecosystems that most encouraged the development of early agrarian society in the Near East. This was thanks to the underground river which is fed by the stratified rock in the mountains of the Desert of Judah and resurfaces at the foot of the limestone cliff dominated by the Mount of Temptation.

The archaeological expedition, which is financed in part by the Italian Ministry for Foreign Affairs and led by Hamdan Taha, Nicolò Marchetti and Lorenzo Nigro, students of Paolo Matthiae, began the third stint of digging and restoration in October-November 1999, concentrating on Bronze Age Jericho. They worked most specifically on two areas of the settlement, the first dating back to between 2,900 and 2,300 BC, a time when the city was first founded in Palestine, and the second to 2,000 and 1,550 BC when Jericho was one of the main city states of the region.

Birth of the first city

An area of beautifully preserved private dwellings was discovered in the very earliest version of the city of Jericho, dating back to the third millennium BC. Each house had an angle devoted to food preparation with grinding equipment, preservation pots, and a hearth. The largest of the houses consists of an entrance area with a large earthenware jar for corn built into the flooring, and a main room. Large preservation jars, a surface used for cutting and butchering meat (beef), and a large range of utensils and stone knives for the latter were found in the main room. In another part of the site, to the south, where a building had been found immediately inside the monumental six-metre high, four-metre thick air-dried brick walls in 1997, the archaeologists unearthed kitchens in which there were two huge mortars


PHOTO 4

PHOTO 5

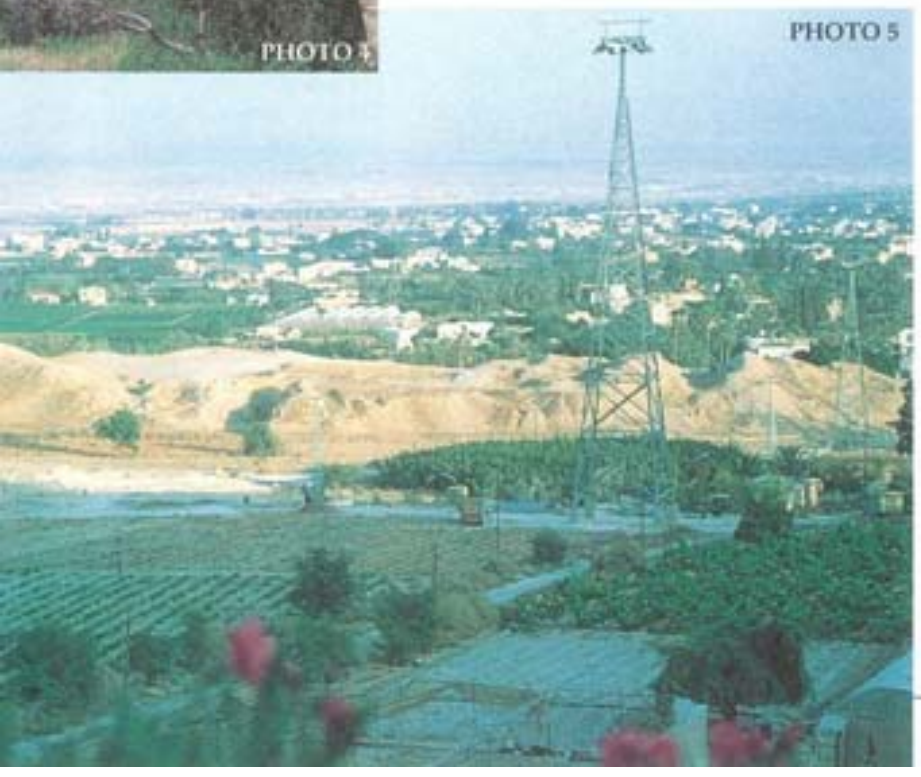



PHOTO 6

Photo 6, 1800 BC tomb, area G, 1999 dig. Note bronze earrings in situ.

which had been used for grinding grain (barley) and legumes (lentils). Pestles, weights, ceramic pots and other utensils bear witness to the every-day life in the building, too. In 1999, a new area was opened up on the slope facing Elisha's Spring where there are the remains of huge stone structures. The first surprise came with the discovery of a very rich 1800 BC tomb just a few centimetres below the surface, in which a girl of around 13 years old had been buried with her jewellery and amulets. A small sacrificial gazelle had also been placed beside her. A magnificent brick building dating from 2300 BC which had been destroyed by a terrible fire was also found at a depth of 2 metres.
An area of storehouses was also discovered, containing a host of earthenware jars which had been crushed and sealed by the carbonised roof beams. These probably contained the food for the staff who worked in this public building. It and its contents are being thoroughly investigated during the 2000 dig.


PHOTO 8


PHOTO 9

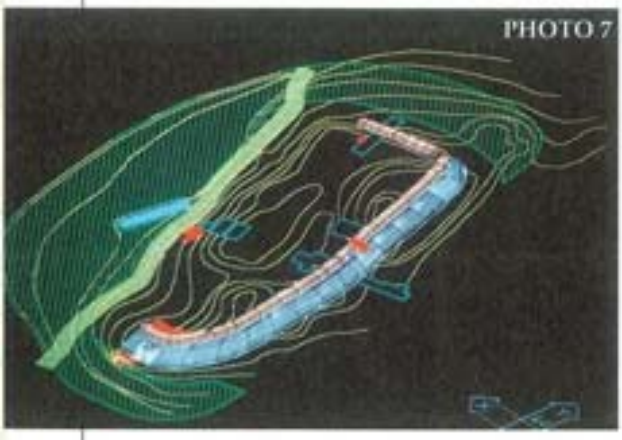


PHOTO 7

The city of the second millennium BC

Imposing 18-metre ramparts enclosed the sides of the settlement for four centuries between 2000 and 1500 BC. The oldest rampart consisted of a steep slope covered in limestone and surmounted by a fortifying five-metre thick brick wall. The second rampart, erected in around 1650 BC, had a very impressive six-metre high megalithic wall at its base. The latter would have helped contain the thrust of the rampart embankment.
The discovery in 1997 of the corner of a large stone structure inside the oldest rampart indicated that it might have been connected to the city gate which has never been found in 130 years of excavations. Thus a new area was opened up and a seven-metre wide stone tower joined to the curved stone wall was discovered beneath a five-metre mound of waste earth dumped during the 1930s digs. The most plausible theory is that this particular tower was connected to a

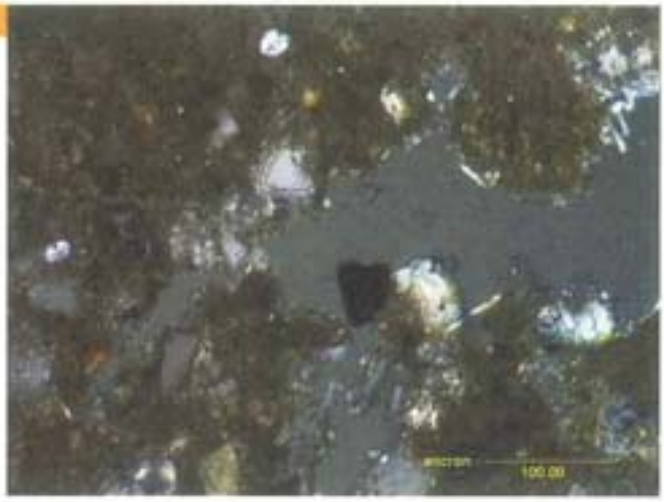

PHOTO 10

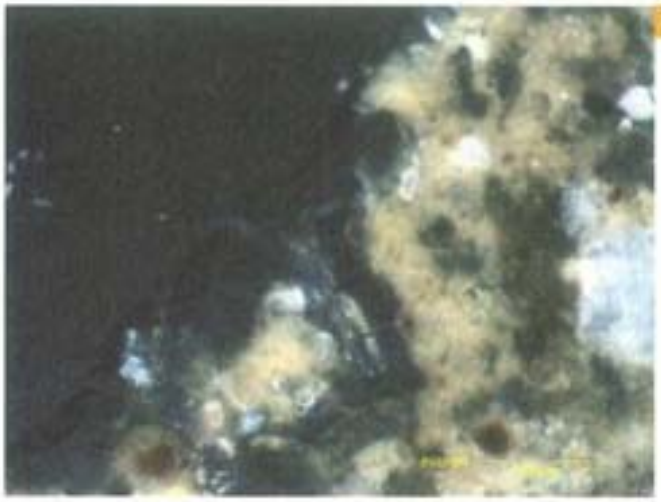
Photo 7, reconstruction of Jericho approximately 1900 BC. The first rampart is seen in white with the (still unconfirmed) area E gate, while the lower city around the spring is green.
Photo 8, the megalithic wall dating from 1600 BC at the base of the second defensive rampart in area A.
Photo 9,work in progress, area A, excavation of the layer with the large collapsed 1700 BC building.
Photo 10, restoration and reinforcement of the great brick tower belonging to the fort in area A, 1800 BC.
Figure A, original untreated brick.
Figure B, original treated brick. Note the silica "bridges".
Optical microscope imaging courtesy of Mapei R&D laboratory.

gigantic 1800 BC building which had been excavated nearby and which seems to have consisted of a fort defended by brick walls and towers. The two fortifications may thus have been part of an imposing access system to the city which faced towards Jerusalem.

Preserving the wall

There are very specific problems involved in preserving major pre-Roman archaeological sites. Earth-based architecture (i.e. the brickwork structures) is quite fragile and, once exposed, can be almost completely obliterated in the space of just a few years. Another central problem is water which creates serious erosion on the artificial hillsides formed by the succession of human settlements.
The archaeologists' mission in Jericho was to develop effective solutions to these problems. The air-dried brickwork was reinforced using infiltrations of ethyl silicate. Once set in the brick, this would prevent rain water from washing away clay particles. The optimal formula was developed by Marco Squinzi and Pasquale Zaffaroni with the help of the Mapei Research and Development Laboratory which also supplied 100 kg of the material to test its effectiveness before launching a wider restoration and preservation programme at the site.
The archaeologists' final objective is to set up a National Archaeological Park covering the Jericho area and the other ancient sites near Tell es-Sultan. With this in mind, a request has been made to move the road which presently cuts the site in two, while structural renovation work will also have to be carried out in the area of the famous Neolithic tower which is threatened by the collapse of the reinforced cement platform above it which was built during the Israeli occupation. The bricks from the walls of Jericho consist of unfired clay worked while wet and then dried in the sun. Experiments were conducted both in the laboratory and in the field as part of the collaboration between Mapei and the Jericho archaeologists in order to ascertain just how suitable ethyl silicate would be to reinforcing unfired earth brick walls. During the first part of the study, the composition of the materials making up some of the brick samples was established, as was the reinforcing action of the ethyl silicate. After this, some sections of the walls were treated to test their response directly in situ. About four months after the reinforcement work was carried out, results varied from section to section. A new series of samples was taken and analysed in the lab to establish which processes and variables affect the success or otherwise of the treatment. Some important differences were found between the brick samples taken from the same sections of wall. On the basis of the test results, it was confirmed that the different response by the bricks to the silicate reinforcement work was closely linked to the nature and ratio of the materials contained in the bricks. The presence or lack of clay plays a fundamental role both in the intrinsic durability of the bricks themselves and in the effectiveness of the treatment. This is because when wet raw earth is being worked, the clay absorbs the intermolecular water and swells.
When the mixture dries, the clay particles provide excellent cohesion due to the superficial tension forces which are mainly electrostatic in nature.
Clay-type materials are also responsible for the interaction between the reinforcement material described above and the particles of the material, an action which results in a three dimensional continuous mesh (Figure A and B). It was also demonstrated that the mechanical properties of bricks containing adequate quantities of clay and formulated using correct raw material ratios remain more or less unaltered over time.





Laboratory results

If mixed in the right proportions and correctly worked, unfired earth has good mechanical resistance and durability properties. Proof of this came from the bricks from the walls of Jericho which were still in a generally good state of preservation when we received them. The nature of the raw materials used and the mix ratios of same play an essential role

in the quality of the final product. In-depth studies indicate that the sand-clay mixes with a ratio of between 4:1 and 3:1 (in terms of weight) result in optimum durability and mechanical properties when it comes to atmospheric agents. The lab tests told us that a sediment which was marine in origin had been used to make the Jericho bricks. The mixtures consisted of fragments of fossiliferous limestone, organic remains, and feldspar-quartz sand in a carbonate matrix, with a very small proportion of clay.
Six samples representing the various sections of the walls were examined. These turned out to be in varying states of preservation, an indication of the lack of homogeneity in the mixtures and thus limited mixing of the raw materials. In addition to this, it was found that in some samples, the clay mineral component was practically zero. Reinforcement using ethyl silicate showed very different results not only from sector to sector but also from brick to brick. Four months on, some of the treated bricks were showing signs of very severe deterioration while others which had not been treated but were subject to the same weather conditions were perfectly preserved. Of the tests performed, measuring the specific surface area (BET) can give a good picture of the physical changes in materials following treatment. The untreated samples had BET values up to 70 times greater than the treated ones. The reduction in the specific area is linked to the fact that precipitated silica occupies and saturates the porous spaces, especially the microporous ones, which have the greatest influence on the figure.
The precipitation of silica in the microporous structure of the mixtures was highlighted using UV microscopy when it was observed that spaces of over 300 microns in size remained accessible to the resin while the smaller ones were filled by silica in a continuous or filamentous mass.
The size of the reduction in BET and the presence of amorphous silica in the microporous structure do not, however, represent unequivocal parameters for the evaluation of the effectiveness of the ethyl silicate treatment. The presence or lack of clay in the mixtures does, however, seem to play a fundamental role.

Photo 11, work in progress, area F. Restoration expert Mohammed Diyab begins reinforcing an air-dried brick wall from 2500 BC.

Photo 12, restoration and reinforcement of the great brick tower belonging to the fort in area A, 1800 BC.

Tests on the monuments

Two walls were chosen to test the treatment on the basis of the results obtained. The ethyl silicate was injected into the wall using a container situated at a height of 1.5 metres fitted with a manifold capable of supplying six injectors simultaneously.
The process was monitored continuously and took several hours, requiring a large quantity of material to complete the parts of the walls selected, as indicated by the results of the sample tests.
The treated areas were then immediately covered with plastic sheeting. In one area, with the injectors inserted to a depth of 5-7 cm into the wall, the absorption rate was around 25 litres per 2 square metres (with complete reinforcement of the structure - including internally). By way of comparison, spray treatments were tried on some parts. This was faster but less effective because the material did not penetrate the brick mass to the same extent. And so this was how the 1800 BC brick fort in the southern part of the city was preserved in 1999. With regard to definitive results from the field, we will have to wait at least a year before we will have enough significant data or will even have had enough time to directly observe the state of preservation of the treated areas in comparison with the untreated ones.

Sealing cracks caused by erosion

All of the erosion-induced cracks in the famous air-dried brick walls were also filled in with MAPE-ANTIQUE LC, a sulphate-resistant binder, which was mixed with bits of original brick which had crumbled from the walls (this also kept the colour

Photo 13 and 14, restoration of building along wall, area B, 2300 BC.
Photo 15, restoration of a late Roman tank.

uniform).
The MAPE-ANTIQUE system is ideal for restoring historical buildings as it is sulphate and resistant to efflorescence and achieves dimensional stability quickly. These characteristics are a direct consequence of the low levels of lime present. Unlike normal binders where lime levels remain high for years, lime levels are negligible after just one week.


PHOTO 13


PHOTO 14

In 1999, extraordinary protection and evaluation work was done on the area of the 2300 BC building along the wall: the ancient walls, partly patched up with modern brick, were covered with a so-called sacrificial layer consisting of MAPE-ANTIQUE LC and earth, which perfectly protected the structure without changing the character of the monument itself.
In order to protect the monuments for as long as possible, some way will have to be found to drastically reduce the direct action of atmospheric agents. Only one solution is both practical and effective and that is to place covers over the excavations. Unfortunately, this would be expensive as it would require the careful planning, selection, and putting in place of the materials involved. The current expedition is also planning to cover the areas containing the most important finds. Special attention will have to be paid to the selection of the covering material as it will have to be resistant to quite high temperatures as well as guaranteeing sufficient light to the dig area.
A further problem is the preservation of Trench 1 with the famous Neolithic Tower dating from 8500 BC. This lies at a depth of 15 metres and is in a somewhat precarious state. It will be reinforced and protected under a specific Ministry of Foreign Affairs scheme. Last year, multilingual information boards were put up throughout the site, which is gradually being revealed to us thanks to years of hard work and commitment from a large team of enthusiastic archaeologists and technicians. The new boards should greatly help to explain its archaeology and history to the half million or so visitors that pass through it each year.

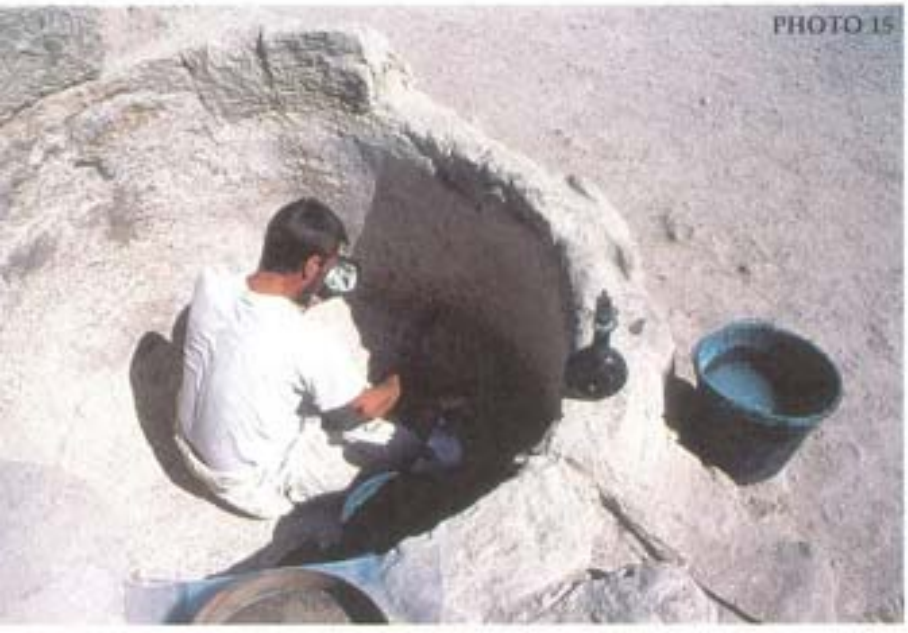


PHOTO 15

The MAPE-ANTIQUE LC technical Data Sheets can be found in Mapei binder no. 3 Building Line.

"Quaderni di Gerico 2 (2000)" (Jericho Notebooks 2 (2000)), a preliminary report on the second archaeological expedition to Tell es-Sultan, was published recently. Edited by Nicolo Marchetti and Lorenzo Nigro, it is available from: Missione Archeologica Italiana in Palestina, Dipartimento di Scienze Storiche, Archeologiche e Antropologiche dell'Antichita, via Palestro 63, I-00185 Rome; email: gerico@uniroma1.it.

See the Mapei Jericho pamphlet for further details. Available on request from: Mapei, fax +39 02 37673214, email: mapei@mapei.it