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# ANCIENT QUARRIES AND BUILDING SITES IN ASIA MINOR

Research on Hierapolis in Phrygia  
and other cities in south-western Anatolia:  
archaeology, archaeometry, conservation

*edited by  
Tommaso Ismaelli and Giuseppe Scardozzi*

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*E S T R A T T O*

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EDIPUGLIA  
Bari 2016

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# ANCIENT CONSTRUCTION SITES IN HIERAPOLIS: NEW DATA ON STRATEGIES, MATERIALS AND TECHNIQUES

*Tommaso Ismaelli, Sara Bozza*

**ABSTRACT** - As part of the Marmora Phrygiae Project, a specific line of enquiry was the reconstruction of the technical and socio-economic aspects of the building sites of Hierapolis. An integrated approach, encompassing architectural, art-historical and archaeometric aspects, was applied to the public monuments, to highlight the procedures employed in the construction process, the strategy for selection and procurement of the materials, the management of the workforce, and the specific roles of figures operating in the construction. This objective was achieved thanks to the research into the city's ancient architecture carried out in the last decade, and the recent archaeometric investigations aimed at characterising the marbles and mortars. The paper presents some of the results of this research into the "archaeology of construction", focusing on the supply and management of building materials. Their use in the Imperial era building sites, restoration and reuse, assembly systems and revetment techniques are discussed.

**KEYWORDS:** architecture, building site, marble supply, restoration, reuse, assembly system.

## **Premise**

As part of the research activities conducted for the Marmora Phrygiae Project, a specific line of enquiry aims to reconstruct the history of the technical and socio-economic aspects of the building sites of Hierapolis. This objective is being achieved thanks to the research into the city's ancient architecture carried out in the last decade, and the recent archaeometric investigations aimed at characterising the marbles and determining their provenance. The large size of the investigated areas and the good state of conservation of the monuments of Hierapolis guarantee the representativeness of the documentation provided by this case study for the reconstruction of the various aspects of the ancient building sites.

This integrated approach, with its architectural, art-historical and archaeometric aspects, makes it possible to highlight the complex range of procedures employed in the construction process, such as establishing the guidelines of the project, the economic assessment of the resources, the strategy for selection and procurement of the materials, the planning and organisation of the work's phases, and the application of specific technological solutions in response to the logistical needs of the building site. At the same time, it enables reflection on the various figures that operated in the construction, including the authority commissioning the work, the architect, the building site foreman and the craftsmen, highlighting their functions and interactions<sup>1</sup>.

As is already known, these building site dynamics are the subject of a lively and contemporary field of studies known as "archaeology of construction", within which multiple lines of research have sought to illustrate the distinctive features of individual monuments and to pursue specific issues by means of comparative analysis of contexts<sup>2</sup>. In the case of Hierapolis, integrated assessment is being conducted of numerous monuments, both those for which descriptions have already been published and those which are still being studied. Taking account of their differing chronology and type, this assessment makes it possible to identify the specific characteristics of the local context in the framework of the architecture of the eastern Provinces. It also helps to recognise the lines of diachronic development from the 2<sup>nd</sup> century BC to the 4<sup>th</sup> century AD, contributing to a robust historical evaluation of construction processes.

In this general framework, the paper presents some of the results of our research into the "archaeology of construction" in Hierapolis: among the many aspects of the ancient building sites, it was decided to look at issues linked to the procurement of building materials, the main focus of the Marmora Phrygiae Project.

T.I., S.B.

<sup>1</sup> On the various professional figures involved in ancient building sites according to the epigraphical evidence, see FRÉZOULS 1995; RUFFING 2008; BORGIA 2012, esp. 54-64. For an archaeological approach, see ISMAELLI in this volume (339-364).

## Methodology

The reconstruction of the dynamics of the ancient building sites of Hierapolis required the integration of various methods. The art-historical approach, i.e. the chronological and typological study of the architectural decoration, was fundamental, serving to determine the phases and duration of the construction, and the artistic background, composition and organisation of the craftsmen involved in the execution of the projects. Equally indispensable was the systematic study of the traces left by the construction processes, such as carving and assembling the blocks and the technological solutions adopted for the movement and installation of the architectural elements<sup>3</sup>. Given this premise, the first step was a review of the data already acquired for previously published monuments, and an investigation of the city's other public buildings, preparing a catalogue and graphic and photographic documentation of the evidence, so as to obtain a complete picture of the architecture of the Phrygian city.

The interpretation of the data arising from these two approaches was enhanced by the graphic reconstruction of monuments and the assessment of their phases of life. Exemplary in this sense is the case of the Sanctuary of Apollo, where the various buildings that form this composite sacred space, from the temples to the porticoes, were the object of systematic analyses that enabled a well-founded architectural reconstruction and a precise chronological description of their development from the Hellenistic to the late Severan periods<sup>4</sup>. Indeed, it is widely accepted that only examination of the individual elements in their original architectural context can provide the interpretative key for deciphering both the morphological-stylistic characteristics of the decoration and the traces left by the construction process.

For a more complete reconstruction of building site dynamics, knowledge of the materials used, both mortars and stone, was considered fundamental. This knowledge was acquired via an extensive campaign of archaeometric analyses, which made it possible to determine the provenance of the building stone used and to highlight its chemical-physical characteristics. This in turn made it possible to investigate whether and how the various qualities of the materials were assessed in the ancient building sites. Specifically, the degree of knowledge of the archaeometric data achieved in the Marmora Phrygiae Project makes it possible to reflect on the selection criteria and procurement strategies that characterised not only the urban context as a whole but also the individual monuments<sup>5</sup>.

## Marble procurement strategies

In the Augustan period, marble began to acquire an increasingly important role in the public architecture of Hierapolis. As the archaeometric analyses conducted as part of the Marmora Phrygiae Project have demonstrated, demand for this material, driven by the Imperial-era building programmes, was largely met by quarries situated within the territory of the city itself, in the districts of Hierapolis-Gök Dere, Marmar Tepe and Thiounta, while the procurement of white marbles from other extraction areas was extremely limited<sup>6</sup>. Knowledge of the actual use of these resources in various contexts represents the starting point for the historical reconstruction of the socio-economic phenomena associated with construction processes. Indeed, in Hierapolis, in the absence of exhaustive epigraphical documentation on either the jurisprudence governing ownership of the quarries<sup>7</sup> or the administrative procedures governing public works (patrons, funding, duration and costs)<sup>8</sup>, the integrated study of monuments, quarries and

<sup>2</sup> CAMPOREALE, DESSALES, PIZZO 2008; CAMPOREALE, DESSALES, PIZZO 2010; CAMPOREALE, DESSALES, PIZZO 2012; BONETTO, CAMPOREALE, PIZZO 2014; INGLESE, PIZZO 2014; INGLESE, PIZZO 2016. Among the most recent papers on the eastern Mediterranean that tackle the technological aspects of ancient building sites, see DEMİRTAŞ 2006; KADIOĞLU 2006, 147-150; QUATEMBER 2011, 39-48; HENNE-MEYER 2013, 34, 90-94; ROCCO 2013, 135-156; KOENIGS 2015, 30-51.

<sup>3</sup> In the case of Hierapolis, on this combined art-historical and technological approach applied to the Sanctuary of Apollo, Marble Stoa and Gymnasium, see ISMAELLI 2009a; ISMAELLI 2012a; ISMAELLI 2016a; ISMAELLI 2016c; ISMAELLI 2016d; ISMAELLI 2017a. On the Theatre, see SOBRÀ, MASINO 2010; SOBRÀ 2012; SOBRÀ 2016.

<sup>4</sup> For a summary on the Sanctuary of Apollo, with bibliography, see ISMAELLI in this volume (329-338).

<sup>5</sup> On the archaeometric analyses of the Imperial-era mortars, see CANTISANI *ET ALII* in this volume (589-608); on the characterisation of the marbles in the monuments of Hierapolis, see QUARTA *ET ALII* in this volume (183-230); for a diachronic analysis of the use of marbles in the city, see SCARDOZZI in this volume (421-436).

<sup>6</sup> SCARDOZZI in this volume, 421-436.

<sup>7</sup> FORTINGUERRA in this volume, 459-469.

<sup>8</sup> For a preliminary reconstruction of the economics of the building site of the Marble Stoa, see MASCHKE in this volume, 393-402. For an up-to-date study of the data on patrons and donors in Hierapolis, see RITTI 2017.



1. - Hierapolis, examples of marble procurement strategies; A: only one type of marble is used (North Agora, lateral stoai, by J.-Cl. Golvin); B: marbles from various quarries are used for different sectors (Ploutonion, Tholos, by M. Limoncelli); C: marbles of differing provenance are selected for specific types of architectural element (Doric north portico in the Sanctuary of Apollo, by M. Limoncelli); D: marbles from various quarries are used for the same type of block (Stoa-basilica, central body, by M. Limoncelli).

relative archaeometric data constitutes the only means by which a historical reconstruction of the marble procurement strategies can be achieved. The initial results, discussed below, may provide a basis for developing further research aimed at resolving the numerous issues that have arisen so far.

In concrete terms, in the analysed contexts, four different approaches to the selection and procurement of marble can be recognised (Fig. 1).

1. All the stone for the construction was supplied from a single quarry. A striking example is provided by the three stoai that delimit the North Agora (Hadrianic-Antoine period), made entirely of marble from Hierapolis-Gök Dere (Fig. 1, A), including both the external Ionic and internal Corinthian colonnades<sup>9</sup>. The same procurement strategy may have been followed for the construction of Temple A (Julio-Claudian period)<sup>10</sup> and the Hadrianic Dodekathion<sup>11</sup>, for which the most plausible source of the material used was the quarries of Marmar Tepe.

2. Marbles from various quarries were used for the different sectors of an architectural complex in the same phase of construction. This strategy is exemplified by the Augustan phase of the Ploutonion, where the central Tholos (Fig. 1, B), from the crepidoma to the roof, is entirely made of marble that is at first attributed to the quarries of Thiounta, unlike the long balustrade below, which was made of marble from Marmar Tepe<sup>12</sup>.

3. Inside the same monument, materials of differing provenance were selected for specific types of architectural element. This solution seems to have been adopted for the Doric porticoes of the Sanctuary of Apollo and the Marble Stoa. On the south side of the temenos of Apollo, the entire structure might be made of stone from Marmar Tepe, except for the more finely sculpted Doric-Ionic capitals, which are made of marble from Hierapolis-Gök Dere. On the north side, the pillars with half-columns and the entablature (made of marble from Hierapolis-Gök Dere) are positioned on a stylobate perhaps attributable to the quarries of Marmar Tepe (Fig. 1, C). This varied origin of

<sup>9</sup> ISMAELLI, SCARDOZZI in this volume, 277-286.

<sup>10</sup> ISMAELLI in this volume, 329-338.

<sup>11</sup> ISMAELLI, SCARDOZZI in this volume, 414-416.

<sup>12</sup> D'ANDRIA, ISMAELLI, PANARELLI in this volume, 365-372. Considered as an isolated building, the Tholos reflects strategy 1.



the marbles is also plausibly the case with the Marble Stoa, where Marmar Tepe is used for the stylobate and Thiounta for the colonnade<sup>13</sup>.

The Severan scaenae frons of the Theatre is also composed of sectors made of various materials. The frieze-architraves of the three orders have been provisionally attributed to the quarries of Marmar Tepe. The column shafts of the first order are made from marble from a number of quarries (Dokimeion, Denizli, Marmar Tepe) to obtain differing chromatic effects, while their Corinthian capitals are of uncertain attribution (Thiounta/Marmar Tepe)<sup>14</sup>.

The same logic of selection can also be recognised in the Stoa-basilica, especially in the lateral stoai, which plausibly correspond to separate construction lots. In particular, they seem to be made of marble from Marmar Tepe, with the only exception being the Ionic capitals, made of marble from Hierapolis-Gök Dere, following a logic similar to what has been proposed for the Doric south portico of the Sanctuary of Apollo.

**4.** Inside the same monument, marbles of differing provenance were used together for the same type of blocks. This is the case of the Stoa-basilica central body, where the capitals of the attic gallery, the figured capitals with bulls and lions and the modillion cornices appear to have been chiselled using local stones from different quarry districts<sup>15</sup>.

It should be pointed out that only comprehensive sampling of the architectural blocks of the cited monuments can confirm or further clarify what are currently recognised as tendencies, which in some cases can be explained with reference to the logic of the building site.

In general, the circulation in the building sites of blocks derived from previous extractions (whether left over from other construction projects now finished or from the reworking of more ancient artefacts) cannot be ruled out. However, it is clear that quarrying stone to order, to supply material for specific projects, was the standard practice, as indicated by the cases cited for strategies **1** and **2** above. This practice was certainly followed in the case of monuments of large dimensions and those characterised by architectural elements that were of uncommon shape and size, such as the façade of the Stoa-basilica, prompting reflection on the reasons and circumstances that determined the specific choice of the quarry. Considering the Augustan Tholos and the Julio-Claudian Temple A for example, built within decades of each other, for what reason was one built entirely of Thiounta marble and the other entirely of stone from Marmar Tepe? A key factor might have been the projects' budgets, affected by a possible difference in the costs necessary for transporting the material from the two different extraction districts<sup>16</sup>. Another reason may be linked to the identity of the patron: a public building project would have benefited from the use of municipal quarries, while a private donor may have been influenced by his personal relationship with the quarries' owners/managers<sup>17</sup>.

In buildings characterised by a combination of different marbles (strategy **3**), further reasons linked to the project itself come into play, for example factors linked to the size and complexity of the configuration and decoration of the architectural blocks. The extraction of exceptionally large pieces, such as certain blocks of the entablature of the Stoa-basilica and the Theatre, must have required an assessment of the ability of the various quarry faces to meet the project's specifications<sup>18</sup>. In the same way, blocks intended to have rich decoration will have been selected with reference to the marble's compactness and grain size: for example, again in the Stoa-basilica, the figurative capitals were made of stone from Hierapolis-Gök Dere (Ionic capitals with Blattmaske in

<sup>13</sup> On the porticoes of the Sanctuary of Apollo, see ISMAELLI in this volume, 329-338; on the Marble Stoa, see ISMAELLI in this volume, 385-392.

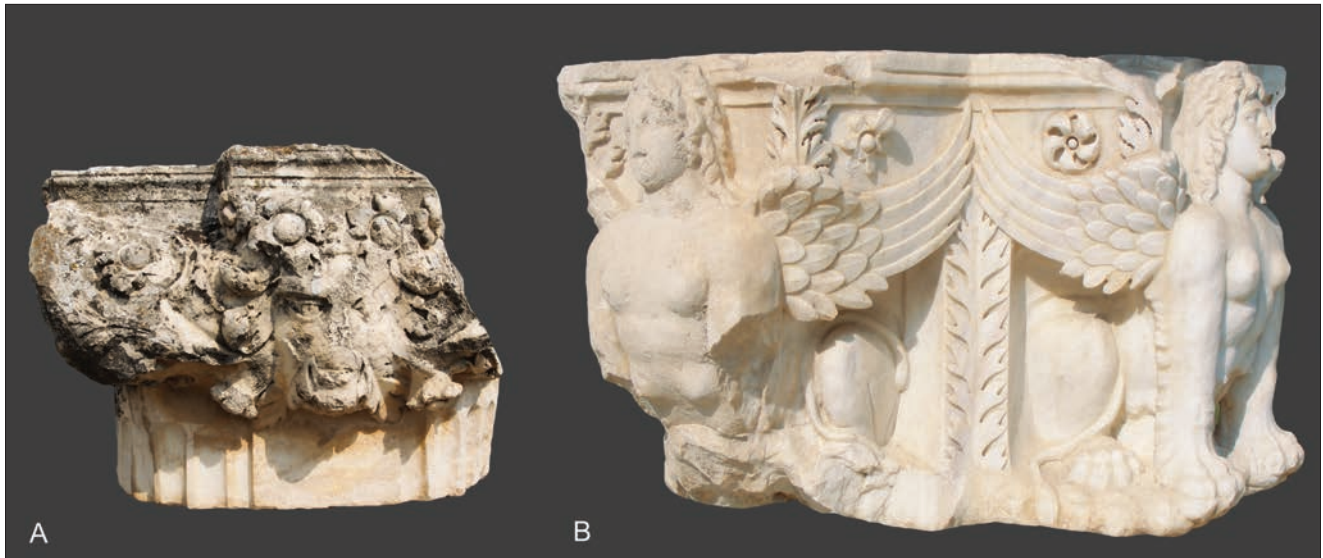
<sup>14</sup> ISMAELLI, SCARDOZZI, SOBRÀ in this volume, 305-328.

<sup>15</sup> ISMAELLI, SCARDOZZI in this volume (277-286).

<sup>16</sup> For a proposed reconstruction of these costs, see MASCHKE in this volume (393-402).

<sup>17</sup> For other contexts in Asia Minor, it has already been pointed out that access to certain qualities of marble was enabled by social relations and the political position of the patrons. This was especially the case with large-scale building projects such as the Trajaneum in Pergamon and the Library of Celsus in Ephesos. See BARRESI 2003, 96-97, 102-103; PENSABENE 2010, 82-85; PENSABENE in this volume (671-680).

<sup>18</sup> For an assessment of the quarries' productive capacity in the case of Aphrodisias, see LONG in this volume (681-692), with an examination of the maximum size of the blocks that could be extracted from each sector.



2. - Stoa-basilica: capital from the Ionic stoai (A) and block with crouching sphinxes of the central body (B).



3. - Sanctuary of Apollo, Temple A: detail of the podium revetment made of differently coloured marble slabs.

the lateral stoai) and a finer-grained variety of the marble from Marmar Tepe and Thiounta (capitals with sphinxes and lions attacking bulls in the central body). Indeed, it was not only a question of choosing between different districts but also of selecting specific sectors inside the same quarry, especially Marmar Tepe, in which the stone varied widely in terms of colour, consistency and granulometry (Fig. 2)<sup>19</sup>.

Lastly, the presence of a number of active building sites, as was the case in the Hadrianic-Antonine period, had implications for the construction of the porticoes and the Stoa-basilica in the enormous North Agora.

Considering the subdivision of the work into individual lots assigned to a number of contractors, it would have been logical to differentiate the sources of materials: the distribution of the huge orders of material across a number of extraction districts would have enabled the suppliers to deliver the orders on time, resolving the restrictions imposed by the limited size of the extraction faces in each quarry<sup>20</sup>.

#### *Criteria for selecting the marble in terms of quality and integrity*

As described above, almost all of the marble used for the public monuments of Hierapolis came from quarries located in the territory of the city. The material they provided seems to have varied considerably in terms of granulometry and colour. The quarries of Hierapolis-Gök Dere contained fine-grained marbles, while those of Marmar Tepe and Gölemezli yielded coarse-grained stone. All districts produced white marbles, white marbles with grey, blue and yellowish veining, and grey marbles. How was the availability of these various shades exploited in the city's building sites? Most of

<sup>19</sup> See BRILLI *ET ALII* in this volume (101-118).

<sup>20</sup> For example, for the Hellenistic Didymaion, the introduction of Thasian alongside Milesian marble has also been attributed to the need to accelerate the completion of the colonnade of the pronaos, see BORG 2001, 89-90; BORG, BORG 2002, 275-276. For the time required for extraction of the blocks, see the cases in MARANO 2012, 417-418, and MASCHEK in this volume (393-402).





**4. - Sanctuary of Apollo: the pavement slabs of veined marble from Denizli (A) enhance the white walls of Temple A; grey slabs of Marmar Tepe quality support a metal fence around the oracular Monopteros, visually marking the boundaries of this sacred area.**

<sup>21</sup> See for example a cornice of the attic characterised by a broad grey-bluish band (H13\_044); see ROSSIGNANI, SACCHI 2007, 372, fig. 17; 402, fig. 42.

<sup>22</sup> ISMAELLI 2017a.

<sup>23</sup> See below 447-449.

<sup>24</sup> ISMAELLI 2009b, 136, figs. 6-8. A good example of the use of dark marble to emphasise a passageway is the Propylaea of Mnesikles, where a step made of grey Eleusinian marble marks the boundary of the sacred space, at the same time functioning as the threshold of the five gates; see SHOE 1949, 346-347, pl. 46, 1. In the temple of Apollo in Klaros, a variety of black marble is used for the paving slabs of the naos and the corridors that lead from the pronaos to the crypt

where the oracle was consulted, marking the special religious status of these areas; see ROBERT 1989, 534-535; MORETTI 2014, 38.

<sup>25</sup> ISMAELLI in this volume (329-338); LIMONCELLI 2017.

the contexts investigated show the simultaneous use of varieties that were plain white or white with light veining, with some cases where great care was clearly taken to ensure the homogeneity of the material, as in the upper portico of the Sanctuary of Apollo. Sometimes the use in the same monument of batches of marble with different tones, or of blocks with strong chromatic discontinuities, does not seem to have been considered a problem, for example in the Stoa-basilica<sup>21</sup> and the Severan phase of Temple A<sup>22</sup>. Indeed, in this latter context, the key factor in the selection of the material was the need to reuse the marble from previous constructions<sup>23</sup> (Fig. 3).

Within this general situation, however, specific cases show the deliberate search for particular chromatic effects by using selected varieties of stone that served to **1.** highlight boundaries, **2.** emphasise, by means of contrast, the architectural components made out of the more common white marble, and **3.** highlight focal points and visual pathways. Exemplary of the first strategy is the perimeter fence around the oracular Monopteros in the Sanctuary of Apollo, a quadrangular area paved with white marble and enclosed by a metal railing embedded in slabs of grey marble. These were chosen precisely in order to chromatically highlight the controlled access to the oracular structure<sup>24</sup> (Fig. 4, B). Also in the Sanctuary of Apollo is an example of the second selective strategy: here, the broad lower terrace is entirely paved with slabs of a marble from Denizli similar to greco scritto, with complex patterns arising from the dense and abundant grey-bluish veining. These chromatic characteristics, sharpened by the accurate cut and polishing of the surfaces, emphasise by contrast the three white temples that faced on to the broad space<sup>25</sup> (Fig. 4, A). Lastly, in accordance with a strategy that is widely documented in other scaenae, the choice of the marbles for the column shafts of the Severan scaenae frons of the Theatre reflects a precise plan.

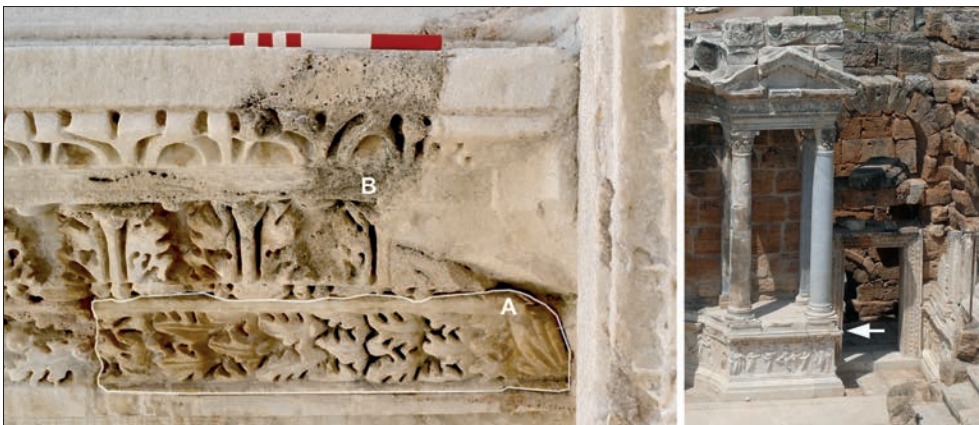
where the oracle was consulted, marking the special religious status of these areas; see ROBERT 1989, 534-535; MORETTI 2014, 38.

<sup>25</sup> ISMAELLI in this volume (329-338); LIMONCELLI 2017.





5. - Sanctuary of Apollo, Temple B, drum with cramps used to repair a crack (A); Nymphaeum of the Tritons, cornice with a natural cavity that was reshaped to hold a replacement part (B).



6. - Theatre, inner corner of the northern podium (white arrow): a replacement part (A) was inserted where a travertine vein (B) prevented the marble from being carefully chiselled.

On the median axis of the first order, dominated by the sumptuous *porta regia* and the relief celebrating the Imperial family, the observer's attention is drawn to the two central shafts in pavonazzetto. These are flanked by four columns in densely veined marble (Hierapolis-Gök Dere or Denizli), perhaps intended as imitations of pavonazzetto, while these in turn are flanked by eight columns in the more usual slightly

veined local white marble (Marmar Tepe or Thiounta): the centripetal logical of the architectural scheme is thus also implemented by means of the skilful use of colour<sup>26</sup>.

As for selection of the material on the basis of its physical qualities, many of the monuments in Hierapolis show rather high standards, with blocks of marble that are perfectly whole with a homogeneous texture. Indeed, blocks affected by imperfections are seen only occasionally, as in the case of a column drum of Temple B in the Sanctuary of Apollo (H13\_147)<sup>27</sup>, where a vertical crack was repaired with two Π-shaped cramps on the upper face, so as to not be visible (Fig. 5, A). In a cornice of the Nymphaeum of the Tritons, the problem of the broad elliptical hole that prevented the completion of the modillions was resolved by inserting a replacement part after having straightened the margins of the cavity<sup>28</sup> (Fig. 5, B). A similar solution is seen on a block of the crown of the first podium from the north of the Theatre, crossed diagonally by a vein of travertine (Fig. 6, B), in which the decoration is still carved, except for a small portion where it was necessary to insert a replacement part (Fig. 6, A). Both of these examples suggest that the use of material affected by defects was strategically limited to sectors of the monuments that were not easily visible, such as internal corners and the higher parts.

Within this general framework, the building site of the Stoa-basilica stands out due to the greater use of materials affected by structural and chromatic discontinuities<sup>29</sup>. In addition to the above-mentioned cornice of the attic, where the front is marked by thin yellowish veins (H13\_044; Fig. 7, A), a curved architrave of the central body

<sup>26</sup> ISMAELLI, SCARDOZZI, SOBRA in this volume (305-328).

<sup>27</sup> On the columns of Temple B, see SACCHI, BONZANO 2012, 331-334.

<sup>28</sup> On the architecture of the Nymphaeum of the Tritons, see CAMPAGNA in this volume (287-304), with bibliography. The same solution with a replacement part is seen in other monuments in the city, for example on a block of the semicircular tympanum of the third order of the Theatre, on which a crack plausibly affected the front of the geison. On this repair, see CANTISANI *ET ALII* in this volume, 619-624.

<sup>29</sup> In general, on the Stoa-basilica, see ROSSIGNANI, SACCHI 2007; ROSSIGNANI, SACCHI 2011; D'ANDRIA, ROSSIGNANI 2012.





7. - Stoa-basilica: cornice from the attic, with a yellowish vein on the front face (A); curved architrave crossed by two travertine veins on the bottom face (B).

(H13\_035) is crossed by two wide bands of travertine, yellow and reddish in colour, full of cavities, which did not prevent the block from being used<sup>30</sup> (Fig. 7, B). While the larger band is near the lateral margin of the architrave, and therefore hidden by the pillar capital below it, the smaller band remained in view and must have made it difficult to carve the scroll patterns of the soffit. This monument even saw the use of defective and cracked materials, which needed to be reinforced with metal cramps. A striking example is the upper drum of a pillar in the central body made from a block with a highly heterogeneous texture, affected by a large vertical crack that was repaired with three large Π-shaped cramps on the lower face<sup>31</sup> (Fig. 8). Two of the pillars with double half-columns in the lateral stoa show similar repairs to serious cracks, both horizontal and vertical (Fig. 9, A-B). Again these defects, which could have seriously compromised the load-bearing function of the vertical supports, were resolved by means of cramps, either in view or hidden on the lower face of the blocks<sup>32</sup>. In addition to these specific considerations, general observation of the surviving materials of this enormous building site indicates that the batches of marble used were characterised by poor structural homogeneity (Fig. 9, C-D): unlike other monuments in the city, the precarious state of conservation of the blocks today reveals the widespread presence of cracks, discontinuities and impurities in the material.

Despite the absence of specific knowledge of the key figures in this construction project and the ways in which it was executed, the archaeological evidence of the Stoa-basilica makes it possible to reflect on the functioning of what was the largest building site in Imperial Hierapolis. The extensive use of imperfect materials does not seem to be attributable to the negligence of the building site foreman, who at the moment of construction either did not notice the defects or took no steps to ensure they were concealed. Rather, it may arise from a deliberately planned approach that started with

<sup>30</sup> ROSSIGNANI, SACCHI 2007, 369-370, figs. 11-12.

<sup>31</sup> Upper drum of one of the pillars of the central body, no published description available (no. M735-419). Of the three recesses for cramps, the one in the internal corner has no horizontal channel, raising doubts as to whether it was actually used.

<sup>32</sup> Blocks for which no published description is available.





8. - Stoa-basilica, central sector, upper part of a pillar: metal cramps (B-D) were used to secure the block, along the fissure produced by a travertine inclusion (A).

<sup>33</sup> On the prescriptions in Hellenistic public documents concerning the use of intact building materials, not cracked or broken (ὀγύης), see HELLMANN 1992, 34-35.

<sup>34</sup> The fact that non-intact products could be sold on the market is also demonstrated by the discovery in the quarries of cracked monolithic column shafts, repaired with cramps and ready to be sold and transported to the building sites: see PENSABENE 1995, 73, no. 17; 99, figs. 121-123, no. 37; 264, figs. 295-297, 304, 305; PENSABENE 1998c, 313, 315, fig. 1, pls. 6, 3-4; 8, 1; 10, 1-2, with particular reference to the quarry of Kyliandroi on the Island of Karystos.

the quarry: as a result of agreements between the suppliers, contractors and representatives of the city authorities, the use of poor-quality material was admitted<sup>33</sup>. This hypothesis is demonstrated by the fact that stone with evident defects, instead of being discarded in the quarry, was extracted, roughed out and sent to the building site<sup>34</sup>. This practice may have been due to inadequate funding, or to the fact that the available quarries were unable to produce blocks conforming to the normal qualitative standards, especially considering their big size and the extraordinary number of architectural elements that this huge project required.

T.I.

#### Restoration of the marble architecture

The careful management of the material resources in ancient building sites was not limited to the selection and quarrying of the marble, but was also reflected in the long life of the monuments, as shown by the conspicuous series of restorations attested in the public architecture of Hierapolis. Recent research shows that architectural restoration was a widespread practice in the Phrygian city, and its traces are to be found in almost all the known buildings<sup>35</sup>. However, the specific reasons for the archaeologically documented measures need to be considered case by case, via a contextual analysis of the evidence. Repairs conducted during the initial assembly of the pieces were common, depending on the care taken in working and moving the blocks inside the building site, and the quality of the material used, as seen with the Stoa-basilica. For this type of intervention, the cases identified in Hierapolis are similar to those found in other towns of Asia Minor in the Imperial period. In addition, an exceptional number of large-scale reconstructions have been documented in the

monuments of Hierapolis, which can be explained with reference to the geomorphological situation of the Phrygian city, built over a fault<sup>36</sup>, and the repeated seismic events occurring throughout its history.

Indeed, numerous seriously damaged buildings were the object of complex restoration operations, which envisaged more or less extensive dismantling of the elevations, selection of materials to be reused, repair of damaged blocks and replacement of those that could not be recovered. Examples of these full-scale attempts at “ancient anastylosis” can be recognised in the Marble Stoa and the Gymnasium<sup>37</sup>, in which the proto-Byzantine restoration even entailed the removal of the original foundations before proceeding with the complete reassembly of the portico. The complexity and difficulty of these operations reached their peak with the Theatre, during the restoration

<sup>35</sup> For an overview of the theme and cases in Hierapolis, see ISMAELLI 2013a.

<sup>36</sup> On the geomorphological framework, see MARABINI, SCARDOZZI 2015.

<sup>37</sup> On the Gymnasium, see ISMAELLI 2016d, 564-569; on the Marble Stoa, see ISMAELLI 2016a, 254-262.





9. - Stoa-basilica, A: Ionic stoa, double half-column restored with a metal cramp on the side; B: Ionic stoa, double half-column restored using two cramps on the bottom face; C: central sector, cornice showing a travertine vein along the inner face; D: Ionic stoa, double half-column drum showing imperfections and a travertine vein.

of the scaenae frons in the reign of Constantius II, as we know from the commemorative inscription. Carved on the architrave of the second order, the text celebrates the restoration of the monument, which was accomplished in just two years (AD 350-352)<sup>38</sup>. It involved the removal of the structure with aediculae of the third and second orders, with the deployment of a large workforce and the use of cranes, indispensable for moving blocks belonging to a structure more than 20 m high (Fig. 10).

The apparently widespread and continuous nature of these restoration operations must have required highly specialised local stonemasons, able to deploy a series of techniques and logistical expedients when working on damaged buildings. This know-how was employed not only to recover the stability and functions of the monuments, but also to restore the formal unity of the architecture, working expertly on the decoration. This particular type of intervention emerges clearly in the upper portico of the Sanctuary of Apollo (Fig. 11), which can be seen to have undergone extensive and thorough work aimed at recovering the aesthetic integrity of the blocks<sup>39</sup>. Specifically, this objective was pursued by repairing the protruding and most delicate parts of the mouldings. Damaged fillets between flutes, tips of acanthus leaves and volutes were carefully removed in order to be substituted with suitable replacement parts, held in place by metal dowels and cramps, as well as by mortars and glue<sup>40</sup>.

S.B.

<sup>38</sup> For an analysis of the text, see RITTI 2007a, 415-417; RITTI 2017, 587-620. For a preliminary assessment of the impact of this restoration, see DE BERNARDI FERRERO 2007, 77.

<sup>39</sup> On the restorations in the upper portico of the Sanctuary of Apollo and the Ionic portico of the Ploutonion, see BOZZA 2016 and BOZZA in this volume (373-384).

<sup>40</sup> On the archaeometric analyses of the binders, see CANTISANI *ET ALII* in this volume (619-624).



10. - Theatre, second order: upper and rear face of a frieze-architrave repaired during the 4<sup>th</sup> cent. AD restoration of the scaenae frons.

### Reuse

The careful management of the building stone included the practice of reuse, which substantially reduced the time and costs of quarrying and transport of the blocks. In Hierapolis this practice is widely attested, above all in the 3<sup>rd</sup> century AD, although examples dated to the early Imperial age can be found. The most ancient case consists of the reuse of marble and travertine architectural blocks and statue bases in the foundations of the Augustan Tholos of the Ploutonion (Fig. 12, A). It is also seen in the foundations of the Ionic portico of the same sanctuary, not by chance built soon after the earthquake of AD 60, which is believed to have caused the collapse and abandonment of other more ancient buildings<sup>41</sup> (Fig. 12, B).

In addition, in the Sanctuary of Apollo, two acanthus scroll friezes from Temple B represent an early example of the reworking of blocks to obtain new elements for the elevation<sup>42</sup> (Fig. 13). The two friezes are carved from Ionic columns that probably belonged to the same temple, on which building work had begun in the Augustan period. The stylistic features of these blocks also enable their attribution to two distinct moments, the Julio-Claudian and Flavian periods, confirming the long duration of the building site, perhaps also affected by the numerous earthquakes occurring in the previous decades<sup>43</sup>.

The practice of reuse became systematic in the Severan period, which in Asia Minor was characterised by intense construction. In Hierapolis in particular, the reign of the Severan Emperors saw the complete reconstruction of monuments built in the Julio-Claudian period, with the consequent opportunity to reuse a huge quantity of blocks for the new buildings. Thus the refurbishment of the scaenae frons and cavea of the Theatre made extensive use of the ancient travertine steps for the walls and the arch-

<sup>41</sup> On the foundations of the Tholos and the materials reused to create them, see ISMAELLI 2016b, 322-323, 345-346, 349, figs. 1, 18; PANARELLI 2016, 299-300, figs. 7-8, 12.

<sup>42</sup> SACCHI, BONZANO 2012, 399, figs. 10-11.

<sup>43</sup> ISMAELLI in this volume (329-338); ISMAELLI 2017a.





11. - Sanctuary of Apollo, Corinthian upper portico: replacement parts were used to restore damaged flutes, leaves and volutes.

es of the logeion, as well as using the marble elements of the original scaenae frons as a source of new podium slabs and blocks for the entablatures<sup>44</sup> (Fig. 14). In the late Severan phase of Temple A, the phenomenon reached even greater proportions: at least half the marble (by volume) used for the podium and the cella was definitely obtained from previous structures of the same Sanctuary of Apollo (Fig. 15). The monolithic columns and imposing raking cornices may have been the only elements that required the specific quarrying of new material<sup>45</sup>. In detail, part of the marble was recovered directly from the dismantling of the Julio-Claudian phase of Temple A, and from furnishings in the sacred space such as statue bases and blocks bearing inscriptions. An even larger quantity of marble was obtained from the entablature of the adjacent Temple B. Even the detritus from the reworking of the marble blocks was put to use in the Severan building site, to make the bedding mortar destined to fill the joins and gaps in the cella and podium walls<sup>46</sup> (Fig. 16, B).

From the overall analysis of Temple A (Fig. 16), it emerges that the strategy of reuse not only satisfied the above-mentioned need to economise on the quarrying and transport operations, but above all made it possible to dispose of large quantities of marble that would otherwise have littered the central area of the city. Reuse was therefore planned from the beginning as part of a dialogue between the municipal authority, the patron and the architect, and for this reason it influenced both the design of the monuments and the practices of the building site. Indeed, concerning the design it can be demonstrated that the dimensions of the friezes decorated with acanthus leaves and flutes of the Severan temple (Fig. 16, A, 1; E) were established on the basis of the size of the architraves of Temple B, in order to facilitate their reuse. In practice, on the building site, the architraves were turned 90° (Fig. 16, C) and re-sculpted only on their original upper face, thereby obtaining the front face of the new frieze (Fig. 16, D-E), with

<sup>44</sup> D'ANDRIA, RITTI 1985, 4-7; SOBRÀ, MASINO 2010, 389; MASINO, SOBRÀ 2012b, 217, fig. 16; MIGHETTO 2012a, 238, fig. 4; see also ISMAELLI, SCARDOZZI, SOBRÀ in this volume (305-328).

<sup>45</sup> ISMAELLI 2017a.

<sup>46</sup> Archaeometric analyses of the bedding mortars of Temple A have indeed demonstrated that the lime used was derived from burnt marble. See CANTISANI *ET ALII* in this volume (589-608).





12. - Ploutonion, Tholos (A): travertine Hellenistic frieze (1) and marble statue basement (2) reemployed in the Augustan-era foundations; Ionic portico (B), the inner face of the Neronian foundation wall showing various blocks from demolished structures.

a height consistent with the general proportions of the Severan temple. This and other cases attest that the conversion of the blocks to be reused sought mainly to achieve the best result in terms of the optimal use of materials and labour<sup>47</sup>. In conclusion, reuse was a practice characterised by a high level of rationalisation, which required special attention on the part of the architect and specialised skills on the part of the workers charged with reworking the blocks.

T.I.

### The use and management of metals on the building site

The use of metal in Greek and Roman construction is today at the centre of varied and extensive research that is seeking to reconstruct the complex technological solutions adopted for monumental architecture. Metal cages, bars and struts were responses to engineering challenges arising from the design of ceilings, domes, etc.<sup>48</sup>. The use of these materials for building with concrete has been extensively studied, but their use in the stone architecture of the eastern Mediterranean deserves a new look. Specifically, as well as shedding light on the implications of using metal in terms of material and labour costs, it may help to achieve a more robust reconstruction of the technological aspects and building site practices, especially with reference to the procedures commonly adopted to ensure the horizontal and vertical connection of the architectural elements<sup>49</sup>. Can a uniform practice, constant over time, for the assembly of the blocks by means of metal cramps and dowels be recognised? What impact did the geomorphological context, the size and type of the monument and the materials used have on the quantity, morphology and measurements of the metal connecting elements? Is it possible to recognise specific building site practices, both in a diachronic sense and within the same time frame?

<sup>47</sup> ISMAELLI 2017a.

<sup>48</sup> Of the most recent, see SCAPIN 2007; LOISEAU 2012; AMICI 2011; AMICI 2015; AMICI 2016.

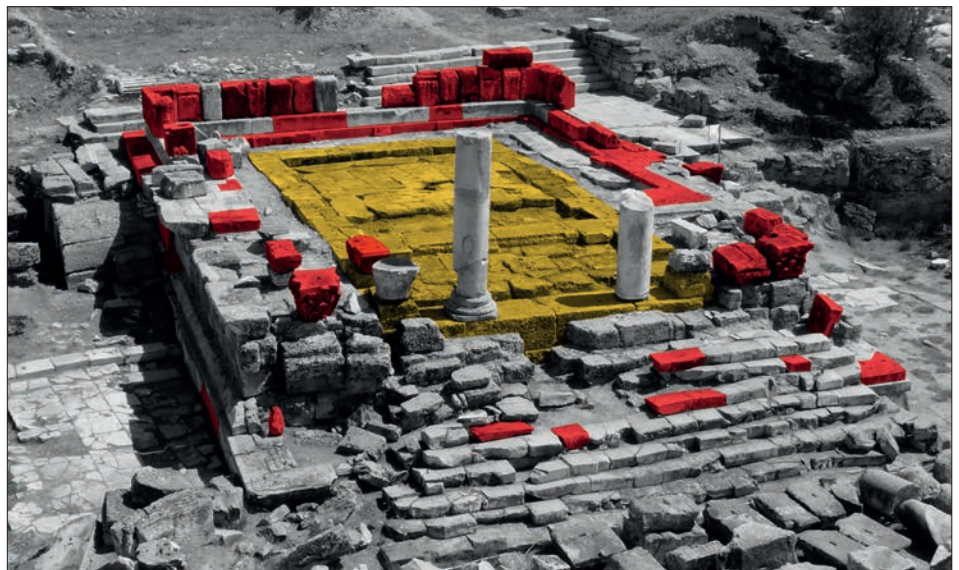
<sup>49</sup> Of the many available, see MARTIN 1965, 238-296; ORLANDOS 1968, I, 111-121; II, 99-122; HELLMANN 2002, 93-95.



13. - Sanctuary of Apollo, Temple B: an acanthus- scrolled frieze carved in Neronian or Flavian times from a column shaft probably belonging to the same temple.



14. - Theatre: a cornice of the early-Imperial scaenae frons, reemployed as wall frieze in the Severan building.



15. - Sanctuary of Apollo, Temple A: the Severan phase incorporated the Augustan-Tiberian phase (yellow) and reused inscriptions, statue bases and many other blocks from other buildings (red).





16. - Sanctuary of Apollo, Temple A: reconstruction of the Severan building (A, by M. Limoncelli); B: thin section showing a marble fragment only partially burnt inside the mortar; C: the architrave of Temple B was sculpted only on the upper face and rotated to obtain a fluted wall frieze; D-E: Ionic architrave of Temple B reused as a fluted wall frieze.





17. - Ploutonion: the Ionic façade in front of the sacred cave (A); the upper faces of an Ionic capital and the adjacent wall slabs, with iron cramps in situ and a dowel hole (B).

#### *Connection systems*

To answer these questions, systematic investigation was conducted of the public monuments dated to the Hellenistic and Imperial periods in the city of Hierapolis, recording data on the number, morphology, dimensions and position of the recesses destined for metal connecting elements. Cramps and dowels that were still conserved in their original positions provided further information.

The survey highlighted various combinations regarding the use of metal connecting elements in horizontal and vertical series. First of all, in public architecture built with travertine blocks, dowels and cramps are almost never used, as attested by Hellenistic and Imperial examples, concerning both walls in opus quadratum and trilitic structures. Exemplary of this lack of metal connecting devices are the Doric façades of the plateia and the external portico of the Sanctuary of Apollo<sup>50</sup>. Although this was common practice, it was not the case with the travertine façade of the Ploutonion (Fig. 17): given its position on the rocky edge of the seismic fault and its architectural configuration, composed of a series of pillars with half-columns linked by slabs only about 15 cm thick<sup>51</sup>, it was necessary to use cramps and dowels in order to prevent potential movement and rotation as a result of seismic forces.

As for trilitic structures in marble (Tab. 1), extensive use of metal elements to connect architectural blocks, both horizontally and vertically, is seen in the Augustan Tholos, the Neronian Ionic portico of the Ploutonion and the Julio-Claudian Temple A, all

<sup>50</sup> ISMAELLI 2009a, 38 (Sanctuary of Apollo), 216-217 (façades of the plateia).

<sup>51</sup> On the façade with Ionic half-columns of the Ploutonion, see D'ANDRIA 2013, 173, figs. 17, 20-21.

Imperial monuments in Hierapolis	Vertical assembly with iron dowels										Horizontal assembly with iron cramps				
	Stylobate with base or shaft	Base with shaft	Drums each other	Shaft with capital	Capital with architrave	Capital with architrave-frieze	Architrave-frieze or frieze with cornice	Architrave with frieze	Architraves	Friezes	Architrave-friezes	Cornices			
Ploutonion, Tholos	X	✓	Unclass.	Unclass.	-	Unclass.	✓	-	-	Unclass.	✓				
Julio-Claudian Temple A	✓	✓	Unclass.	✓	✓	-	X	Unclass.	✓	-	✓X				
Ploutonion, Ionic portico	✓	✓	✓	✓X	-	✓	X	-	-	✓	✓				
Sanctuary of Apollo, Doric portico	✓	-	✓	✓	-	✓	X	-	-	✓	X				
Gymnasium	✓	-	✓	✓	X	-	X	✓	✓	-	X				
Marble Stoa	✓	-	✓	✓	✓X	-	X	✓	✓	-	X				
Sanctuary of Apollo, Corinthian portico	✓	✓	✓	✓	-	✓	X	-	-	✓	X				
Dodekathemon	✓	Unclass.	-	✓	-	✓X (entablature in one block)	-	-	-	-	✓ (entablature in one block)				
Stoa-basilica, central body	Unclass.	✓	✓	✓	X	-	X	Unclass.	✓	-	✓				
Stoa-basilica, lateral stoa	Unclass.	✓	✓	✓	-	✓	X	-	-	-	-				
North Agora, stoa	✓	✓	✓	✓	✓	-	X	Unclass.	Unclass.	-	X				
Nymphaeum of the Temple, first order	✓	✓	-	✓	-	✓	X	-	-	✓	Unclass.				
Nymphaeum of the Temple, second order	Unclass.	Unclass.	-	✓	-	✓X	X	-	-	✓	Unclass.				
Theatre, scaenae frons, first order	✓	✓	-	✓	-	✓	X	-	-	✓	✓				
Theatre, scaenae frons, second order	✓	Unclass.	-	✓	-	✓	X	-	-	✓	✓				
Theatre, scaenae frons, third order	X	Unclass.	-	✓	-	✓X	X	-	-	✓	✓				
Nymphaeum of the Tritons, first order	✓	✓	-	✓	-	X	X	-	-	✓	✓				
Nymphaeum of the Tritons, second order	Unclass.	Unclass.	-	✓	-	X	X	-	-	✓	Unclass.				
Severan Temple A	✓	✓	-	✓	X	-	X (one dowel on the north-west corner)	✓	X (one dowel on the north-east corner)	✓	X				

✓ = attested; X = not attested; - = architectural element not present.

Table 1. Various uses of dowels and cramps in the monuments of Imperial-era Hierapolis: combinations 1 (yellow), 2 and 2+ (pink), 3 (green).

Ploutonion, Tholos	Julio-Claudian Temple A	Ploutonion, Ionic portico
Nymphaeum of the Temple, first order	Theatre, frons scaenae, first order	Theatre, frons scaenae, second order
Sanctuary of Apollo, Doric portico	Sanctuary of Apollo, Corinthian portico	North Agora, stoa
Theatre, frons scaenae, third order	Nymphaeum of the Tritons, first order	<p>X not used  ? unclassifiable  ] cramp    dowel</p>
Gymnasium	Marble Stoa	

18. - Various uses of dowels and cramps in the monuments of Imperial-era Hierapolis: combinations 1 (yellow), 2 and 2+ (pink), 3 (green).



<sup>52</sup> On the Ionic portico of the Ploutonion, see BOZZA in this volume (373-384); on the Tholos, see ISMAELLI 2016b, 323-330; on Temple A, of the Julio-Claudian period, see ISMAELLI 2017a. In the case of Temple A, a further reason lies in the monument's architectural configuration, i.e. a pseudomonopteros with columns separated by thin slabs.

<sup>53</sup> COULTON 1976, 296; HELLMANN 2002, 296.

<sup>54</sup> On the Doric portico of the Sanctuary of Apollo, see ISMAELLI 2009a, 38, 40; on the Gymnasium, see ISMAELLI 2016d, 556-562; on the Marble Stoa, see ISMAELLI 2009a, 136; ISMAELLI 2016a, 250.

<sup>55</sup> While in the Dodekathion of the Hadrianic period (MASINO, SOBRÀ 2011; MASINO, SOBRÀ 2012a) the arrangement of the blocks on the ground currently prevents verification of the recesses, in the Stoa-basilica this difficulty is compounded by the more complex architectural structure of the façade.

<sup>56</sup> No full description of the stoai of the North Agora has yet been published.

<sup>57</sup> Our current state of knowledge of the second order of the Nymphaeum of the Temple is not sufficient for an assessment of the use of metal elements. On the Nymphaeum of the Temple, see CAMPAGNA, SULFARO, TERRANOVA 2016; on the Theatre, see bibliography in ISMAELLI, SCARDOZZI, SOBRÀ in this volume (305-328), although a systematic analysis of the techniques of assembly has not yet been conducted.

<sup>58</sup> An exception is the north-west corner of the pronaos, where the cornice and the frieze were attached with dowels. This solution is not however adopted in the south-west corner. To the rear of the temple, this attachment is seen between the architrave and frieze on the north-east corner, but not between the frieze and the cornice. These inconsistencies indicate that the work did not proceed in accordance with a constant logic. On the building site of the Severan Temple A, see ISMAELLI 2017a.

built along the seismic fault <sup>52</sup> (**combination 1**; Fig. 18). In these buildings the components of the trilithic system are always connected to each other. In the Tholos in particular, even the frieze-architraves are attached to the cornices by metal dowels: this unusual solution is not seen anywhere else in Hierapolis and was perhaps adopted due to concerns about building stability, given the radial structure of the beams, which sloped so steeply as to exert strong pressure on the entablature of the peristasis <sup>53</sup>.

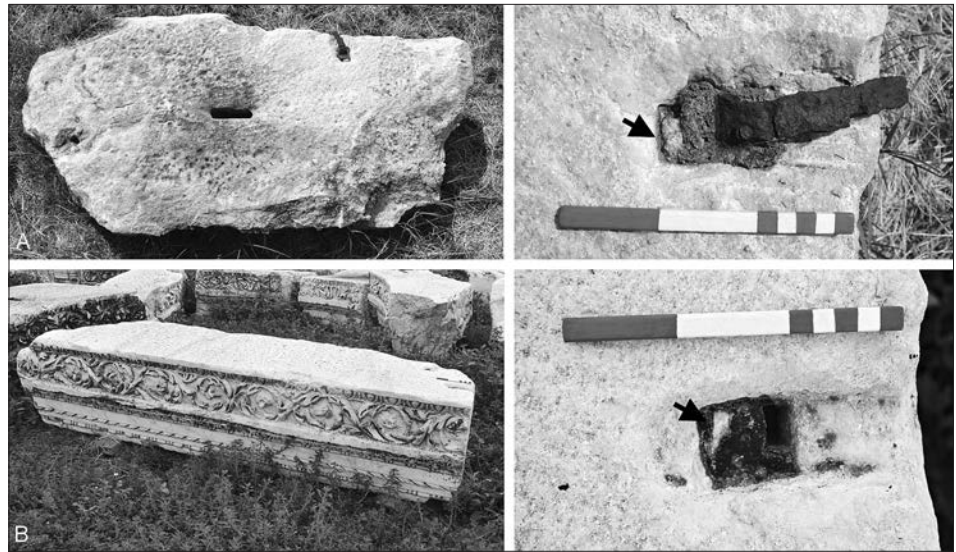
Early Imperial monuments of similar type and dimensions exhibit a variety of solutions (Fig. 18). Close attention to the cohesion of all pieces is seen in the marble Doric portico and the upper portico of the Sanctuary of Apollo (**combination 2**), where only the cramps between the cornices are missing. In the Gymnasium and the Marble Stoa the capitals are not systematically attached to the entablature (**combination 3**) <sup>54</sup>.

For the middle Imperial period (Fig. 18), an equally precise assessment is hindered by both the state of the research and the greater complexity of the monumental architecture, characterised by more orders, arched structures and additional block layers above the cornice <sup>55</sup>. This framework is expected to become clearer as the research unfolds, but it can however be observed that the stoai of the North Agora <sup>56</sup> display the same arrangement of dowels and cramps seen in the porticoes of the Sanctuary of Apollo (**combination 2**).

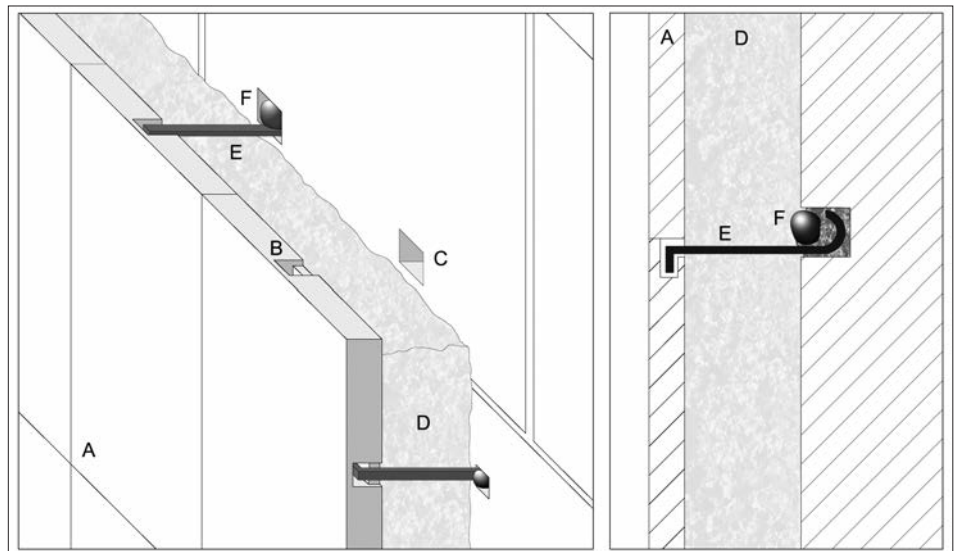
As for façades with aediculae, despite the same load-bearing structure, a variety of solutions are seen. The first order of the Nymphaeum of the Temple and the first two orders of the Theatre <sup>57</sup> reveal considerable attention to both vertical and horizontal connections between the elements (**combination 1**). It is interesting to note that in the third order of the scaenae frons, the deployment of dowels and cramps seems to be less consistent, since the connection of the vertical supports to the podia below and the frieze-architraves above becomes episodic (**combination 2+**). A similar situation is seen in the first order of the Nymphaeum of the Tritons, which differs only in the use of dowels to anchor the bases to the stylobate and the absence of connections between the capitals and the entablature (**combination 2+**).

Lastly, **combination 3** is seen in the Severan Temple A, where the elements of the vertical supports are all attached to each other with dowels, but not to the overlying architraves. In the rest of the entablature, the architraves and friezes are connected horizontally <sup>58</sup>, while the cornices of both the pediments and the long sides were not attached with either dowels or cramps. This combination cannot be attributed to a desire to economise on the costs of the metal elements and associated labour, since the walls of the cella display extensive and systematic recourse to cramps and dowels. More probably, this approach was more the result of a number of factors linked to the configuration of the roof, including: (i) the use of a simple truss system to cover the cella, in which the horizontal thrust of the rafters was contained by the joists and did not threaten the cornices; (ii) the roof itself, consisting of thin metal plates, with a lower weight than the usual roof with clay or marble tiles; (iii) the considerable mass of the cornices with respect to the protruding portion of the blocks, considered sufficient to avoid the risk of toppling over.

A general assessment of the issue makes it possible to affirm that in the same period there coexisted various practices, characterised by several possible combinations in the use of cramps and dowels. These were handed down through the years, constituting long-lived technical and craft skills that were used in top-level architecture. The various systems that have been recognised are not linked to either the building's functions or dimensions. Indeed, other factors seem to have had a greater weight in guid-



19. - Small marble fragments embedded in the lead securing the iron cramps: Nymphaeum of the Tritons, first order, cornice (A); Theatre, third order, architrave-frieze (B).

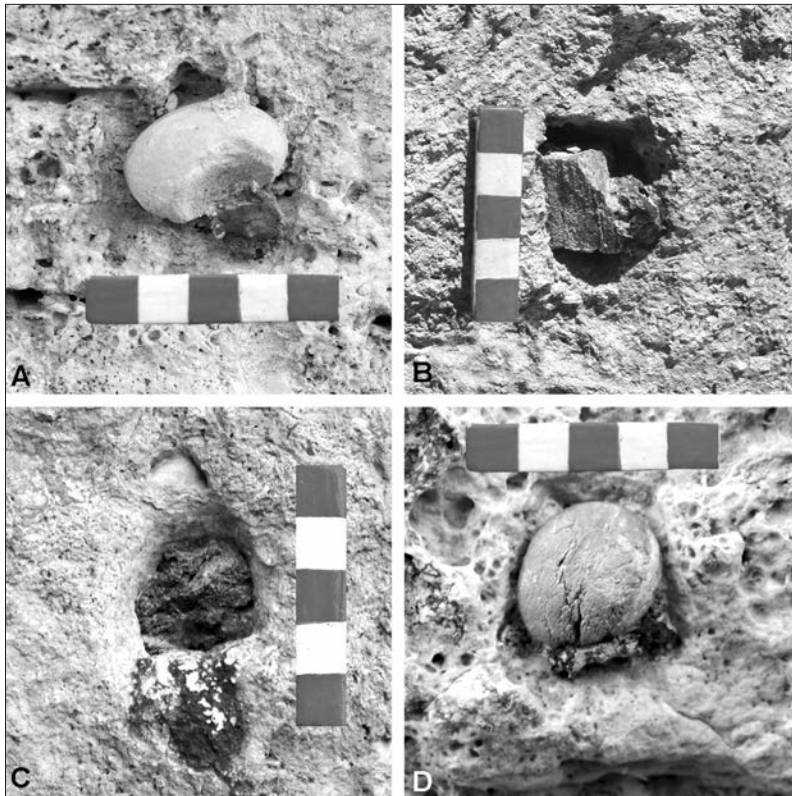


20. - Sketch drawing of the wall revetment technique (A: marble slab; B-C: recesses for metal cramps; D: mortar; E: metal cramp; F: pebble).

ing the choice of solutions during the assembly of the blocks, such as the geomorphological situation of the terrain, the configuration of the roof, the position in the façades with multiple orders, and the stability of the entablature considering the protruding portions of the blocks. These criteria were affected by other conditions arising from the work schedule and budget of the building site, which dictated the specific solutions to be adopted case by case.

#### *Expedients for saving material*

The need to economise on the materials may also explain another interesting and unusual technique, attested by a number of recesses for dowels and II-shaped cramps in which the iron element was inserted and the remaining space was then filled with small pebbles and fragments of marble. Subsequently the limited space remaining was filled with lead, in a smaller quantity than would normally be necessary. The effectiveness of this system in fixing the cramps and dowels is shown by the conservation of the fragments, still in place, encased in lead. This technique is documented in cor-



21. - Pebbles and stone chips used to fasten the metal cramps for wall revetments: Sanctuary of Apollo, wall of the lower terrace, south of the Temple A (A); Theatre, logeion (B); Nymphaeum of the Tritons, back wall of the façade (C); Cathedral, Baptistery (D).

<sup>59</sup> With reference to the materials of the assumed third order, CAM-PAGNA 2012, 557, explains the existence of a series of frieze-architraves bearing signs of having been reworked by introducing the possibility that the second order was also restored.

<sup>60</sup> On the dismantling of the blocks in the restoration, see DE BERNARDI FERRERO 2007, 77.

drilled in the walls, generally made of travertine in opus quadratum. In order to assess this use of metal, an analysis was conducted of those walls in the city which had originally had marble cladding. Many of these contexts still conserve traces of the slabs' bedding mortar and the holes into which the cramps were inserted. In some cases, the cramps are still partially conserved in their original position. The metal elements were held in place by inserting river-bed pebbles, small stones and flakes of schist, which can still be found in the holes today. As well as jamming the metal cramp in position, the pebbles served to ensure the adhesion of the binder (mortar, or in some cases lead) to the bottom of the hole<sup>61</sup> (Fig. 20). This use of improvised materials is attested from the early Imperial age, as in the large wall on the western side of the Civil Agora and the terraces of the Sanctuary of Apollo, particularly the wall to the south of Temple A (composed of both the bedrock and opus quadratum) and the boundary walls of the median terrace (Fig. 21). Other examples are found in monuments of the Severan period, such as the Nymphaeum of the Tritons (back wall) and the Theatre, where the pavonazzetto slabs of the logeion and the slabs of the scaenae frons (no longer in place) were attached using this specific technique. Lastly, the use of pebbles and stone chips over a long period is shown by the numerous perfectly conserved cases in the wall of the Baptistery adjacent to the Cathedral<sup>62</sup>, which is believed to have been built in the 6<sup>th</sup> century AD.

Given the widespread and long-lived use of this technique, it appears to have been a specific expedient used by local workshops as an alternative to specially carved marble wedges, which are widely documented in the wall revetments of Rome and elsewhere in Italy, but also in the public and private monuments of Asia Minor<sup>63</sup>. The reasons for using such random materials still need to be clarified – obviously, offcuts of marble were not in short supply, since they would also have been generated by cut-

nices of the first order of the Nymphaeum of the Tritons, perhaps pertaining to the original building site<sup>59</sup> (Fig. 19). Other examples are seen in Corinthian capitals from the Theatre and the frieze-architraves of the second and third orders of the frons scaenae. Since, as already mentioned, the blocks were removed and reassembled during the restoration carried out under Constantius II, it is clear that this expedient is linked to the proto-Byzantine reconstruction<sup>60</sup>. In the restoration building site, the metal parts recovered from the Severan blocks were plausibly remelted and reused, further reducing the need for lead by adopting the unusual solution described above.

#### Wall cladding

Metal connecting elements were also used to attach the marble slabs used for cladding walls. In Hierapolis as elsewhere, the marble slabs were held in place by L-shaped iron cramps, inserted in special holes



ting the cladding slabs. Whether the use of improvised materials in the framework of building site practices saved time and labour costs in the buildings' final phases of completion still needs to be ascertained.

S.B.

<sup>61</sup> The use of lead has been found in the Nymphaeum of the Tritons and in the wall cladding of the lower terrace of the Sanctuary of Apollo. On a similar case in the Marmorsaal in Dwelling 6 of Hanghaus 2 in Ephesos, see İLHAN 2014, 827, pl. 437, fig. 64.

<sup>62</sup> On the Baptistry, see CIOTTA, PALMUCCI 2002, 188-191; ARTHUR 2006, 140.

<sup>63</sup> On the technique for attaching the marble wall slabs by means of metal cramps and stone wedges, see BITTERER 2013, especially 42-49, 69-71, pls. 3-4, 6, 13, 28, with an extensive bibliography. The use of various materials (andesite, limestone and marble) for the wedges is seen for example in the north portico of the Asklepieion of Pergamon; see HOFFMANN 2011, 65.

The observations made thus far regarding the strategies for procurement and management of construction materials have yielded numerous new points for reflection on the historical reconstruction of ancient building sites. However, only a few aspects of the complex range of procedures adopted in construction were tackled in detail, while other central questions remain to be studied in greater depth. These include the economic assessment of the building works, the interactions between the various figures active in the construction process, the techniques adopted in the phases of transport, assembly and decoration, and the organisation of the work phases. Light may be shed on these issues by the rich corpus of evidence already gathered from the monumental heritage of Hierapolis, thanks to its exceptional conservation. Only the continuation of this research will make it possible to fully understand the monumental architecture of Hierapolis, in which unsophisticated building site procedures are found alongside bold engineering solutions in the context of an elaborate and original architectural culture, that was responsible for grandiose monuments of extraordinary visual impact, such as the Theatre and the Stoa-basilica.

T.I., S.B.

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