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Persepolis West: Evidence for a Pigment Production Site and its Connections with Achaemenid Royal-Official Buildings

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Abstract

This paper aims at elaborating the potential existence of craft production site(s) for manufacturing the colouring materials in the Persepolis area. In doing so, the paper discusses the colourful materials and elements used for decorating the Achaemenid royal-official buildings, the ancient contexts in which raw materials for colouring have been discovered and the parts of the Persepolis area in which the indication of possible craft production sites have been reported. Particular attention is paid to recently published archaeometric analyses which dealt with the scientific characterization of certain pigments unearthed in Persepolis West. By gathering all the aforementioned information, the author is able to confirm the production of raw pigments for colouring in the Persepolis West craft zone. Furthermore, the paper includes a detailed discussion on the exact functions of this craft production site and shows that Persia together with Egypt, Greece, southern Italy and eastern Anatolia was one of the few places in which the production of Egyptian blue is evidenced.

Keywords

Achaemenid Persia, Persepolis, royal-official buildings, craft production site, polychromy, pigments, raw materials for colouring, Egyptian blue

Introduction

The excavations of Ernst E. Herzfeld and Erich F. Schmidt in the 1930s at Persepolis marked the commencement of the scientific investigation of royal-official buildings at this site.[1] The collection of Persepolis royal-official monuments is by no means limited to the numerous structures erected by Darius I and his successors on the Persepolis Terrace. The Persepolis Citadel in addition to the Terrace includes – to say the least – the numerous palaces at Barzan-e Jonubi located in the southern field of

* The author wishes to thank Maria Letizia Amadori, Pierfrancesco Callieri and Wouter F. M. Henkelman for their useful comments on an earlier draft of this paper. All remaining errors are the author's alone.

[1] Herzfeld 1929; Schmidt 1939; 1953; 1957; 1970.

the Terrace (see the Southern Quarter in fig. 1).[2] The studies of various scholars over the past 40 years have shown that the Citadel was part of an Achaemenid settlement – hereunder referred to as the Persepolis area – spread over part of the Marvdasht plain and corresponded to a 'city' which housed a very high number of royal-official buildings.[3]

The investigations of the settlements of Achaemenid Fars or Persia in the current century demonstrated that the urban plan of these settlements corresponds to very large urban projects of several square kilometres and could be described as a mosaic of interweaving built and unbuilt (empty) spaces.[4] As a result, the density of buildings in most of the area within the sectors generally seems rather low; hence, recognizing the components and the limits of these settlements is not an easy task.[5] This explains also why the existence of an urban settlement next to the Terrace was ignored for so long.

The widespread settlement of Persepolis extended approximately six kilometres from the Terrace towards the north and the west (and the south?) (fig. 1). This settlement included various urban zones with different functions. The urban zones called Persepolis West[6] and Firuzi South are places originally housing a high density of archaeological materials which have suggested the interpretation of the two sites as built-up urban zones and might well correspond to everyday life of the settlement. On the contrary, the areas called the Citadel, Bagh-e Firuzi, Dasht-e Gohar and Naqsh-e Rostam (and Persepolis South?) included prestigious royal-official complexes and monuments as well as tombs built within green spaces.[7] The investigations suggest that the construction of part of the buildings was started even before the erection of the Terrace under Darius I.[8] The so-called Temple of Fratarakas located in the north of the Terrace ("Frataraka" Complex in fig. 1) indicates that the construction of royal-official monuments continued even in the post-Achaemenid period.[9]

While the aforesaid investigations have produced a multiplicity of new information about this settlement, they have not yet been considerably successful in finding the inhabitants' houses. What is nevertheless striking is the discovery of a large number of buildings of the royal-official nature outside the Citadel in the Persepolis area. It is worth noting here that the investigations of the sites

[2] Tadjvidi 1976; Mousavi 2012, 26-41.
[3] See Matin forthcoming with bibliography.
[4] Boucharlat *et al*. 2012; Gondet 2018; Matin 2020; Callieri 2022. This heterogeneous urban plan and alternation of built-up spaces with green areas of the Achaemenid era has been described as 'diffuse urbanism,' (Gondet 2018) stemming from the "Persian conception of urbanism" (Callieri 2022).
[5] It should be considered that the areas in which these settlements have been built include also structures of the earlier and later periods.
[6] Referred to also as Persepolis Northwest (see fig. 1).
[7] Boucharlat *et al*. 2012; Matin forthcoming.
[8] Tilia 1978; Matin 2018; Askari Chaverdi & Callieri 2020.
[9] Callieri 2003; 2007, 56-62; 2014; 2017, 391-392. A recent article based on the results of the geophysical surveys of the Iranian-Italian mission near the Terrace illustrates the presence of a building of about 80 × 20 m, north of the Terrace and the Temple of the Fratarakas (Gondet *et al.* 2018).

belonging to the Achaemenid period which started more than a century ago led to the discovery of numerous prestigious buildings usually referred to simply as Achaemenid. The concentration of various buildings in the Persepolis area raised the question whether all of these buildings must have been used directly by Achaemenid kings and whether all of them should be classified as imperial or royal.[10] What is important for the discussion at hand is that the architecture and also architectural elements of all these buildings could be categorized in the same group referred to as royal-official in this text.[11] The construction of these monuments definitely required access to various human and material resources.

The Achaemenid royal-official buildings were true testaments to the wealth of the empire: they were decorated with many prestigious materials and ornamented in various colours. This information, added to the long existence of Persepolis, demonstrates that there were numerous workshops involved in the construction of royal-official buildings over an extended stretch of time. Thanks to the royal inscriptions, administrative archives, and archaeological evidence, it is an established fact that a large number of craftsmen from different regions of the Achaemenid empire were involved in the construction activities.[12]

The main materials used for the construction of the Persepolis royal-official buildings are bricks and stone.[13] The largest part of the walls was built in mud-brick while baked bricks were mostly used for the pavement of the courts, canals and other structural elements associated to water. There were also decorated bricks – a number of which were in relief (fig. 2) – that bore decoration. The bricks were probably produced locally (see below). Stone, which is the most noted construction material in the Persepolis area, was utilized for various architectural elements such as thresholds, doorjambs and foundations as well as stairs and various reliefs have been carved on it. Intensive quarrying activities in the Persepolis area to provide the light grey stone used in the construction of the buildings have been documented.[14] The finer dark grey-black stone mostly opted for the decorated parts came from quarries in the Majdabad area, located 40 km west of Persepolis.[15] The high number of unfinished and unpolished stone structures and reliefs allowed the scholars to study the stone working at Terrace and to investigate the activities of the stonemasons in the buildings.[16]

[10] Matin 2018, 212-214.

[11] The category of these monuments – in some cases – could be understood from their context, e.g. there is no doubt that the buildings constructed on the Persepolis Terrace were imperial. In some cases, the iconographies and inscriptions belonging to these structures also help clarify their status: the Bardak-e Siah Palace located in the Dashtestan county of the Province of Bushehr (Southern Iran), could be suggested to be an imperial structure because of the similarity of its iconography and inscription to the imperial structures located in the Persepolis Terrace and in the royal complex of Pasargadae (Matin 2020, 20).

[12] Nylander 1979; Vallat 2013, 285-287; Henkelman 2017.

[13] Matin 2018.

[14] See Gondet 2015 with bibliography.

[15] Guidi *et al*. 2012, 389-393; Guidi *et al*. 2017, 26-32

[16] Tilia 1968, 75-95.

The remains of the royal-official buildings in the Persepolis area – especially the stone reliefs and architectural elements of the Terrace open to tourists – leave visitors breathless. Nevertheless, the most striking fact about the decoration of these buildings is that they were originally colourful through the use of glaze and painting materials. These substances, mainly employed to produce glazed bricks and add colour to the stones (and other materials), have been studied and analysed in detail (see below). However, scholars have so far been unable to understand how the Achaemenids could manage to obtain this large quantity of raw materials for colouring. The preliminary sources needed to provide the colouring agent would have to be processed by experts at specialised craft production sites which could roughly correspond to modern factories. Yet, it is not clear to date whether there were craft production sites in or near the Persepolis area to produce these substances or whether they were imported to Persia from other areas.

This paper, which is based on a review of the existing archaeological and archaeometric bibliography, aims at elaborating the potential existence of craft production site(s) for manufacturing the colouring materials in the Persepolis area. In doing so, the paper first describes the colourful materials and elements used for decorating the Achaemenid royal-official buildings. Next, a review of a number of ancient contexts in which colouring pigments have been found is presented thereby attempting to highlight the cases in which these coloured residues could indicate the local production of pigments. Subsequently, the parts of the Persepolis area in which the indication of possible craft production sites have been reported are identified together with a detailed analysis of the Persepolis West craft zone, the only well-investigated craft production site. With respect to the archaeometric investigations, particular attention is paid to a recent paper which dealt with the scientific characterization of some pigments unearthed in Persepolis West, published by a multidisciplinary research team led by Maria Letizia Amadori in which the author of this paper also participated.[17] The latter provides very important information on the production of raw materials for colouring in the Persepolis area. By gathering all the aforementioned information, the author is able to confirm the production of raw pigments for colouring in the Persepolis West craft zone. The present paper ultimately concludes with a detailed discussion of the exact functions of this craft production site.

1. Colourful Materials Used for Decorating Achaemenid Royal-Official Buildings

The Achaemenid buildings were colourful thanks to the use of various materials. Glazed bricks (fig. 2) have been used in the Persepolis area with decorative purposes. Besides these glazed bricks discovered during the excavation at the Terrace,[18] the recent discovery of a monumental gate at Tol-

[17] Amadori *et al*. 2021.
[18] Schmidt 1953, 77-78; Razmjou 2004.

e Ajori located 3.5 km northwest of the Terrace measuring approximately 30 × 40 m and decorated entirely with glazed bricks reveals the importance of this material as a true decorative system in the buildings of the Persepolis area.[19] The archaeometric analyses carried out on the bricks' body show that they have been produced with local soil and therefore in the nearby area even though ancient kilns have yet to be found.[20] In the present century, a wealth of information has been provided on the iconography and production of Achaemenid glazed bricks and also on the nature of the glazed materials used.[21] Nevertheless, the provenience of raw materials for colouring needed for the glazed faces of the bricks and the location where the vitreous materials were prepared are not known.

The surfaces of the Achaemenid buildings were also covered with various types of plaster (fig. 3) including coloured lime-based plasters found in not only Persepolis but also Susa and Babylon. These plasters have been used for covering the building's floor in the Treasury located at the Terrace. Furthermore, green plaster covers the mud-brick walls in Complex A of Barzan-e Jonubi at the southern field of the Terrace. Fragments of plaster with painted drawings were also found in some Achaemenid buildings (fig. 3). At Susa, at the Darius Gate, traces of blue and red paint were found on fragments of mud plaster.[22] Likewise, interesting figurative wall paintings on plaster have been discovered at Shawur palace at Susa (fig. 4).[23]

Achaemenid buildings were colourful also by the application of paint materials. While polychromy[24] has been used widely throughout the Achaemenid period, it has been documented particularly for painting stone reliefs (fig. 5, 6), architectural elements and royal inscriptions (fig. 7) in Persepolitan architecture.[25] The occurrence of pigments on the stones of the Terrace's buildings was described by not only certain ancient travellers but also early excavators who commented on the occasional presence of coloured pigments on the newly exposed surfaces.[26] Some traces of polychromy are still preserved on the stones of the monuments of the Terrace and Naqsh-e Rostam (fig. 5, 7).[27] The study of the polychromy of Achaemenid buildings was launched in the 1970s thanks to Judith Lerner and Ann B. Pettersson Tilia and resumed by Alexander Nagel in the last decade.[28] While the above researches have provided sizeable information about the original colours of the paint of stone reliefs and the chemical composition of the raw pigments used, the question of the process

[19] Askari Chaverdi *et al*. 2014; 2017.
[20] Amadori *et al*. 2017a; 2017b; 2018.
[21] Ramzjou 2004; Dauce 2013; Matin 2014; 2017; Aloiz *et al*. 2016: Amadori *et al*. 2017a; Holakooei 2013; Holakooei *et al*. 2017.
[22] Matson 1953; Tadjvidi 1976; Stronach 1978, 85, fig. 44 a-h; Stodulski *et al.*, 1984; Ambers & Simpson 2005, 2, fig. 3; Boucharlat 2009; 2013, 390; Chevalier 2013, fig. 55; Aloiz *et al*. 2016; Curtis 2020, 14-15.
[23] Boucharlat 2009; 2013, 390, fig. 434-435.
[24] For the description of polychromy, see Nagel 2013, 597-598.
[25] Also inlays of different materials were inserted to the reliefs (Tilia 1978, 29-69).
[26] Nagel 2013, 601-607.
[27] Tilia 1978, 29-69; Nagel & Rahsaz 2010.
[28] Lerner 1971; 1973; 1976; Tilia 1978, 29-69; Stodulski *et al*. 1984; Nagel 2010; 2013; 2018.

by which the craftsmen obtained the painting materials and the location where they were produced is still open.[29]

Persepolitan buildings were decorated by the aforesaid materials; accordingly, some of the craftsmen active in the Persepolis area certainly worked on pigments and painting. There is a group of foreign craftsmen in the Achaemenid written sources mentioned as *karsup*, that Wouter F. M. Henkelman has generally categorised, translating the Elamite word as 'painters': they could indeed be enamellers specialised in the production and application of colourful materials. Etymologically speaking, this word comes from the root *karsu-* which probably means to adorn and/or to decorate and could also describe the painting of walls or the colouring of various objects.[30] However, the existing textual sources do not help to understand whether these craftsmen brought the necessary raw paint materials from their homeland to Persepolis or if there were craft production sites for preparing the necessary pigments in the Achaemenid heartland.[31]

Previously, it was even suggested that the colour agent had probably been imported to Persepolis from other parts of the Empire.[32] Two of the Darius royal foundation inscriptions from Susa (DSf, DSz) mentioned that the materials with which "the terrace" was painted were brought from Ionia.[33] However, it should first be considered that the text belongs to the construction of a royal building at Susa and thus not to be attributed to all Achaemenid buildings within the Empire. Furthermore, it has been strongly suggested that while these actual inscriptions portray very well the organization and ideology of the Empire as a whole, the details of these inscriptions should be adopted in research with particular caution. Particularly due to the symbolic rather than administrative value of these texts, it has been specified that they do not indicate the exact origin of all the craftsmen who worked on each type of material and the exact provenience of the materials.[34]

2. Ancient Raw Materials for Colouring Discovered in the Near East and Mediterranean Areas

2.1. Contexts of the Discovered Raw Materials for Colouring: Workshops, Storages and Craft Production Sites

Coloured residues and raw pigments were found in several archaeological contexts over an extended period in the Near East and Mediterranean areas. These materials have usually been mentioned as pellets, lumps and sticks when they are smaller in size (fig. 8) while having been

[29] Nagel 2018, 380.
[30] Henkelman 2017, 278-280.
[31] The archaeometric articles mentioned above show that the colour agent used at Achaemenid buildings are those common in the ancient Near East.
[32] Matson 1957, 133-135.
[33] Vallat 2013, 283-289.
[34] Henkelman 2003.

considered as ingots or cakes when larger (fig. 9). They have also been found in potsherds, vessels (fig. 10) and boxes in different archaeological contexts.

The exact contexts of the pigments and the function of the areas in which they were found are not always clear. Nonetheless, as discussed in the following pages, three contexts are recognisable. Most of the sites could be considered as workshops where pigments were in use by craftsmen to make artefacts or were applied to different objects or elements. This is especially the case when they were found near artworks such as wall paintings, sculptures and reliefs. Tools, paint boxes, utensils and pottery shards used as palettes for mixing paint were usually found in these contexts. There is a smaller group characterised by spaces where materials were deposited, recognised as storages rooms or shops. In these cases, a very large amount of various pigments was often found which were pending to be used or exported.[35] The last group presents the craft production sites where the pigments were manufactured. These cases could be recognised with respect to their archaeological contexts in which the structures and tools necessary for pigment production were found and, through archaeometric analyses, colour residues from the various stages of production and unsuccessfully produced raw pigments (fig. 11) were identified.

2.1. Raw Materials for Colouring Discovered out of Achaemenid World

One of the most ancient examples in the Mediterranean area concerns the unearthing of several red lumps based on hematite and goethite in the Epigravettian site (starting from 11,400 BCE) at Riparo Dalmeri in north-eastern Italy. These materials were employed for different activities and characterised various occupation periods of the site, starting with their prevalent use for decoration purposes and for painting stones with geometric and naturalist subjects, in particular.[36] In the 14,000-year-old settlement of Wadi Hammeh 27 at Pella in Jordan, a large lump of yellow ochre probably applied to hand stones in preparing animal hides were discovered.[37] Lumps of red, yellow and brown ochres mixed with kaolinite and quartz were found near the Wadi Sura rock paintings (southwestern Egypt) dating c. 6,500 to 4,400 BCE.[38] Several colour lumps and various objects bearing colour residues such as grinding equipment, stone, bone, ceramic and wooden tools as well as painted items belonging to the Early-Middle Holocene were unearthed in the Takarkori site in southwest Libya (central Sahara). Following archaeometric analyses, hematite, goethite, kaolinite and jarosite were detected and it is suggested that the pigments were used for rock paintings, body care and decoration of personal ornaments.[39]

[35] In this regard see also Cavassa 2018, 20-21.
[36] Gialanella *et al*. 2011.
[37] Edwards 2012.
[38] Krause *et al*. 2013.
[39] Di Lernia *et al*. 2016.

In Workmen's Village of Amarna in Middle Egypt (14th century BCE), 70 specimens of pigments of different colour were found and identified as hematite, goethite, magnetite, Egyptian blue, chrysocolla and blue frit after investigation.[40] Considering the fact that no evidence of fritting kilns was obtained in Workmen's Village, it may well be that nearby industrial areas supplied the pigments. A number of indications of pigment production including numerous frits[41] representing all degrees of success and failure in manufacture were found in the industrial area.[42] Similar evidence in Egypt is attested in the New Kingdom period (c. 1,550-1,070 BCE) as well. Deir el-Medineh is attested to have been a village of the craftsmen working on the royal tombs in the Valley of the Kings at Luxor where plate- or bowl-shape raw pigments of turquoise and blue colour were unearthed.[43] Another example of the New Kingdom period belongs to 26 palettes containing colour pigments and ceramic sherd with resin residue found in the Pharaonic town on Sai Island in Upper Nubia which might have been utilized to decorate walls within the town.[44]

In Neo-Assyrian Nimrud (Iraq) at Fort Shalmaneser and the North-West Palace, Egyptian blue lumps and ingots have been found. It has been suggested that they were stored for the purpose of incrusting ivories and had been imported from the Levant.[45] A fragment of a blue ingot (fig. 9) was recently found at the palace of Sargon II at Karkemish (Turkey) dating to the end of the 8th century BCE. The archaeometric analyses suggested that the ingot was probably produced and imported directly from Egypt to Karkemish which may host a secondary workshop for the processing of raw materials.[46] In the Neo-Assyrian palace in Dur-Sharrukin (Khorsabad) in Iraq, lumps and cakes of blue and red pigments were unearthed, one of which weighed about 20 kg; they were probably linked to a workshop of painters and sculptors.[47]

In the Urartian fortress of Ayanis, located near Lake Van in Turkey, a number of glassy blue cakes and blue painted walls were found while the results of the archaeometric analyses show the local production of Egyptian blue[48] in eastern Anatolia in the 7th century BCE.[49] One of the peculiarities of Egyptian blue from Ayanis in comparison to those from Egypt and Mesopotamia is the absence of tin. This information demonstrates that in the Egyptian blue manufacturing process used in Ayanis instead of the usual bronze scrap or filings (see below), natural copper carbonates (malchite or azurite) or roasted copper sulphide ores as copper sources have been used. In addition,

[40] Weatherhead & Buckley 1989.
[41] For frit, see Miller 2007, 137.
[42] Spurell 1895, 233; Weatherhead & Buckley 1989, 203, fn. 5, 210.
[43] Pagès-Camagna & Colinart 2003, 638.
[44] Fulcher & Budka 2020.
[45] Mallowan 1966, 180, 408; Moorey 1994, 187.
[46] Zaina *et al*. 2019.
[47] Nagel 2013, 611; Nagel 2018, 382.
[48] For a discussion on the production of Egyptian blue, see 3-1-3 The Function of the Craft Zone.
[49] Ingo *et al*. 2013.

the analysis of Egyptian blue pigments from Ayanis and also a large part of the locally produced bronze artefacts found at this fortress revealed that zinc was used. This element has been related to the local metal ore sources exploited in ancient times which were not found in the analysed Egyptian blue from Egypt and Mesopotamia.[50]

It has been reported that a jar containing pigments was discovered during the excavations at the Parthenon of Athene. A shell containing blue pigment was also found in the Mausoleum of Halicarnassus (c. 350 BCE) in south-western Turkey while cakes of pigments were unearthed in undated tombs of Caria (western Anatolia) and Rhodes (Greece).[51] Another point worth mentioning is the evidence of a late Hellenistic production site located in the Agora of Kos Island in Greece. The existence of a production site here is confirmed by the high number of pigment lumps found in relation to a number of fire structures, the presence of successfully and unsuccessfully produced Egyptian blue pellets (fig. 11) and other kinds of pigments in the various stage of production and the findings of clear indications of metallurgical activities in the area. Investigations highlighting the relationship between pigment production and metallurgy showed that Egyptian blue fragments were produced locally.[52]

Several workshops were identified through the architecture of the Temple of the Winged Lions dating to the 1st century BCE to the 1st century CE in Petra (Jordan). In one of them, i.e, the Painters' Workshop which was built for activities related to the maintenance of the temple, some bowls containing pigments were discovered and analysed.[53] Important evidence from Rome belongs to a building of the 2nd to early 4th century CE, located in the Forum Boarium and identified as a pigment shop. This was one of the various shops built on the podium and is known as the only extant pigment shop from ancient Rome. The lump of raw pigments and powdered materials stored there were probably intended to be used for wall painting.[54]

2.3. Raw Materials for Colouring Found in the Achaemenid Era

Various pigments in Achaemenid buildings and workshops in the area have been found, some of which are described in this section. At Susa (located in the ancient Susiana), one of the 'royal residences' and 'administrative capitals' of the Achaemenid Empire, pottery fragments containing pigments have been excavated in the Tell d'Apadana and the Shawur Palace. The pigments found in

[50] Ingo *et al*. 2013.
[51] See Nagel 2018, 381-382 with related bibliography.
[52] Kostomitsopoulou Marketou 2019; Kostomitsopoulou Marketou *et al*. 2019; 2020.
[53] Shaer 2003, 125-128.
[54] Beeston & Becker 2013.

the latter could be related to the workshop working on the discovered wall painting (fig. 4).[55] Egyptian blue encrustation was recovered in a ceramic sherd in the site of Qaleh Kali, in western Fars.[56]

Similar examples have been discovered also in the Persepolis area. Egyptian blue encrustation and green pigment were found in a pottery fragment in Dasht-e Gohar Palace (fig. 1) which could be interpreted as the palette of the workshop responsible for applying polychromy on architectural elements.[57] Large lumps and heavy coatings of pigments were found in pottery bowls and sherds during the excavation in the southwestern corner of the Terrace wall and the investigations carried out on these materials detected hematite, cinnabar, Egyptian blue, malachite and azurite.[58] Near the Apadana (the Audience Hall), the most significant structure of the Terrace, green, red and blue lumps were found.[59] Egyptian blue was detected by Frederick R. Matson in sherd encrustation found in Apadana.[60] From the so-called Harem, a bowl with blue mass (fig. 10) and a large number of objects composed of Egyptian blue together with many glass pastes were unearthed.[61] Considering Achaemenid contexts, all pigments found so far seem to be related to the workshop applying polychromy:[62] archaeologists assumed that the pigments were presumably used by craftsmen working on monuments, especially to decorate architectural stone elements with paint.

On the contrary, 20 samples of colour residues (fig. 8) and one metal scrap which were unearthed in Persepolis West (fig. 1) and subsequently underwent archaeometric analyses seem to belong to a craft production site and serve contributory for the discussion at hand.[63] The mentioned samples were investigated to characterize them and to clarify both their origin and production techniques. The coloured residues were submitted to integrated investigations by portable X-ray fluorescence, digital and polarized light microscopy, scanning electron microscopy with energy dispersive X-ray spectroscopy microanalysis, X-ray diffraction, FT-IR spectroscopy and Raman spectrometry. Representative samples were collected in order to identify mineralogical and chemical constituents of the various colours and particular attention was laid on the attempt at clarifying the origin, the production technologies and – in terms of function – the possible link with the colour agent used for decorating royal-official buildings. Thanks to the integration of results obtained by different

[55] Boucharlat 2009; Nagel 2018, 379, fig. 1.
[56] Amadori *et al*. 2021, 2.
[57] Tilia 1978, 79.
[58] Tilia 1972, 245, fn. 8; 1978, 68; Stodulski *et al*. 1984.
[59] Nagel 2013, 610; Nagel 2018, 382-383.
[60] Matson 1957, 133-135.
[61] Nagel 2013, 605.
[62] Similar materials, including stone object covered with pigments and a basalt grinding bowl were discovered in the Treasury, part of which in Erich F. Schmidt's words have been used for the "ritualistic purpose" (Schmidt 1953, 185; 1957, 102, pls. 23-24). Alexander Nagel mentioning a number of pigment lumps recently discovered in front of the eastern staircase of Apadana stressed "I believe that these paint materials were deposited by the craftsmen themselves, intended as buried offering to the Apadana and the king." (Nagel 2018, 382-383).
[63] Amadori *et al*. 2021.

spectroscopic techniques, it has been possible to identify the pigments analyses as Egyptian blue, azurite, malachite, red and yellow ochre, the two latter cases were characterized by the presence of hematite and goethite, respectively. Organic material was only detected in a yellow lump.[64] The microscopic features of the lumps and their peculiar shape and the presence of the bronze scrap allowed to confirm a local manufacturing process (see below).

3. Proposed Craft Production Sites in the Persepolis Area

A recently published letter of Ernst E. Herzfeld shows that he have excavated a possible craft production site located in the immediate north of the Terrace. Herzfeld found a number of structures that he described as "houses and workshops of the workmen who built Persepolis".[65] In one of the excavated structures which he presented as a production site for gold material, he found a kiln, some technical facilities and a large number of gold jewellery and semi-precious stones. The discovery of a metal slag always to the north of the Terrace could be a very important sign of a craft production site and can perhaps help better understand the function of the area. However, as the results of these excavations have not been published, it is impossible to interpret the functions of this possible craft production site.

Two urban zones in the Persepolis area have been suggested to host craft production sites. The first one, Bagh-e Firuzi, is located almost 3.5 km towards the west/northwest of the Terrace (fig. 1) and extended on the southern side of the Polvar River. This is an area with a very low density of sites and includes a series of small isolated *tepe*s and surface sites spread out in the entire zone.[66] These sites have been only partially investigated and present royal-official buildings considered to be monumental gates and palaces.[67] William M. Sumner has suggested that besides the royal-official buildings, there was evidence of craft production sites in this area.[68] The prime foundation for his argument was probably mounted upon the fact that he believed that Tol-e Ajori *tepe* could belong to a place for producing glazed bricks. Nevertheless, as already mentioned, this *tepe* was identified through excavations of the Iranian-Italian Joint Archaeological Mission in Fars – directed by Alireza Askari Chaverdi and Pierfrancesco Callieri – to represent an Achaemenid monumental gate.[69] No trace of a craft production site was found at Bagh-e Firuzi during the geophysical survey by the Iranian-French mission – directed by Rémy Boucharlat and Kourosh Mohammadkhani – and the new topographic and surface survey conducted in the area by the Iranian-Italian mission within the

[64] Amadori *et al*. 2021.
[65] Nagel 2018, 384.
[66] Boucharlat *et al*. 2012.
[67] Tilia 1978, 71-92; Askari Chaverdi *et al*. 2014.
[68] Sumner 1986, 9, 12.
[69] Askari Chaverdi *et al*. 2014; 2017.

framework of "Land of Persepolis" project– led by Luca Colliva and Emad Matin.[70] Bagh-e Firuzi was recognised to be occupied by monuments built within green spaces[71] and recently suggested to be an urban zone hosting complexes with internal gardens.[72]

Another craft production site has been suggested to be located in Persepolis West (fig. 1). This urban zone located around 500 m towards the northwest of the Terrace and extending in the westward direction is the nearest urban zone to the Citadel. Sumner presented Persepolis West as a complex group of low mounds with a high density of pottery on a surface occupying at least 25 ha which he believed to have been a single mound originally or, put better, a dense cluster of contiguous mounds.[73] The border of Persepolis West with the Citadel is still not clear. However, the excavations of the Iranian-Italian mission in 2008 and 2009 have suggested that this urban zone had been separated from the Terrace by a belt of gardens which were protected by an enclosure wall.[74] As the results of the geophysical surveys of the Iranian-French mission, Iranian and Iranian-Italian missions suggested, the excavation of the Iranian-Italian mission confirmed that there was a "craft zone" in Persepolis West (this craft production site is explained in detail in the following pages).[75] As previously explained, important indications of raw pigment production have been discovered in this urban zone.

3.1. Persepolis West Craft Zone

3.1.1. Archaeological Context

As explained, the Persepolis West urban zone is separated from the Terrace by a garden and extends for about 1 km in a westward direction (fig. 1). The Persepolis West craft zone is located in the heart of this urban zone and lies about 1 to 1.5 km west of the Terrace.[76] Geophysical surveys carried out here by the Iranian-French mission had located the levelled remains of a settlement with mud-brick structures and its artefacts and an area of strong magnetism interpreted as an indicator of kilns and other craft activities (fig. 12, 13). The remains of a kiln would generally induce very high magnetic anomalies of a particular, identifiable shape.[77]

Five spots in the urban area of Persepolis West were selected by the Iranian-Italian mission and named Area A, B, C, D and E where 11 trenches were excavated (fig. 12). [78] In Area B located about

[70] Gondet 2011; Boucharlat *et al.* 2012, 265-268; Colliva & Matin forthcoming 2022.
[71] Sumner 1986; Boucharlat *et al*. 2012, 264-268; Askari Chaverdi & Callieri 2020.
[72] Matin in press.
[73] Sumner 1986, 8-9.
[74] Askari Chaverdi & Callieri 2012, 230-231, 238-239; 2017, 1-3, 286-288; Boucharlat *et al*. 2012, 259-264; Matin forthcoming.
[75] Askari Chaverdi & Callieri 2012; Boucharlat *et al*. 2012, 262; Aminpour *et al*. 2017; Askari Chaverdi & Callieri 2017.
[76] Askari Chaverdi & Callieri 2012, 230-231, 238-239; 2017, 1, 286-288.
[77] Boucharlat *et al.* 2012, 262, 266.
[78] Askari Chaverdi & Callieri 2012; 2017.

1.5 km to the west of the Terrace, two trenches near each other – Trench Tr. 4 and Trench Tr. 6 – were excavated, both related to the craft zone.

In Trench Tr. 4 (fig. 12), part of a horizontal downdraught kiln with the combustion chamber on the side of the firing chamber (and not below it) was excavated. The C14 dating of the sample which was taken from stratigraphic layers from this trench ranges from 400 BCE to 600 CE. However, the dated samples probably came from a later use of the kiln. The excavators stressed that the kiln should be older than the dated layers and had an earlier Achaemenid phase. This finding has also been confirmed by the excavation of the near Trench Tr. 6 (fig. 12, 13).[79] The exact function of the kiln is not clear but its structure should not have reached a temperature higher than 800-900°C.[80] In nearby Trench Tr. 6 – in addition to some indications of industrial activities such as metal slags and abundant ash –, numerous animal bones have been found, most of which were in a partially burnt state and located in a series of superimposed pits interpreted as places for the storage of raw materials and could be related to the kiln function in the various phases represented by the floor layers.[81] During the excavation of Trench Tr. 4, ashes with fragments of burnt animal bones were found at the bottom of the kiln suggesting that the bones found in Trench Tr. 6 should be linked to the kiln.

Certain recent investigations related to the Iranian-Italian mission conservation project on the stones of some Terrace's monuments have stated the existence of a whitish coating on some structures. Investigations indicate that the whitish layer in monuments built under Darius I was prepared using gypsum. In addition, it has been shown that a new technique was introduced during the reign of Xerxes since in the monuments erected from this period onwards, the whitish layer investigated is composed of fluorapatite with a smaller amount of calcite and was probably applied with the use of lime as a binder. The researchers assumed that the whitish layers were applied on purpose to give a lighter colour to the dark grey surface of the stone. They argued that it is also likely that the whitish layers were used as a preparatory coating for those carved and decorated surfaces that were intended to be polychrome. Fluorapatite, used for stone coating from the time of Xerxes onwards, is a white calcium phosphate containing fluorine. What is important for the interpretation of the function of the craft zone is that calcium phosphates can be obtained from the calcination of animal bones and it has been assumed that the bones found in the pits of Trench Tr. 6 of the craft zone are the raw material to create the whitish layer.[82] Another possibility is that the semi-combusted bones were used as fuel to nearby kilns.

[79] Askari Chaverdi & Callieri 2017, 286-287; Colliva 2017; Mercuriali 2017.
[80] Mercuriali 2017, 51.
[81] Colliva 2017, 69-70.
[82] Askari Chaverdi *et al*. 2016; 2018; Laurenzi Tabasso & Lazzarini 2017; Laurenzi Tabasso & Ridolfi 2017; Ridolfi *et al*. 2019.

Considering the characteristics of the kiln found in Trench Tr. 4, it is suggested that it might have been used for producing some plain and unglazed potteries which can be fired between 600-800°C. Yet, no evidence for such a function has been found during the excavations. Also, frit could be prepared by firing a mixture of silicates, fondants and sometimes colouring materials at the temperature of 650-800°C.[83]

Interestingly, the kiln which has been excavated corresponded in the geophysical survey carried out purposely by the Iranian geophysical survey to a minor magnetic anomaly and, as a result, the existence of the kiln in this location has not been predicted before the excavation. The aforementioned anomalies are quite different from the strong anomalies which the previous Iranian-French survey had located in Area B and interpreted as kilns (fig. 13).[84] Regarding the magnetic method used as the main method for geophysical investigation in Persepolis West, it must be stated that the accurate detection of the remains depends on their state of preservation, their buried depth and the difference between their nature and the surrounding soils. This method is also very sensitive to different types of environmental and human magnetic disturbances.[85] At any rate, this fact also shows that the craft zone could extend beyond the limits identified in Area B by the Iranian-French mission based on the existence of strong anomalies interpreted as having originated from kilns (fig. 12, 13). In other words, also other areas showing minor magnetic anomaly (besides the non-investigated areas) might be part of the craft zones and only future investigations could declare its exact limits.

3.1.2. Finds

Artefacts made of different materials such as metal, glass, stone, ceramic, shell, bone and gypsum were found during these excavations in the five areas which have already been published.[86] The finding of the aforementioned materials suggests that the craft zone included the production of various classes of artefacts. Between the numerous archaeological objects, there also are a number of implements and tools such as a bronze nail, some weights, an iron blade with curving profile, a bronze hook, flints and blade, stilt and astragals which may have been used by the craftsmen themselves working in the craft zone.[87] The terracotta tripod stilt (three-footed triangular support) found in Trench Tr. 4 probably used as a spacer during firing of some (ceramic?) materials and the six *caprinae* astragals discovered in Trenches Tr. 4 and Tr. 6 might have been applied in the polishing process of some materials produced in the craft zone.[88]

[83] Mercuriali 2017 with bibliography.
[84] Aminpour *et al*. 2017, 6, 14-18, fig. 3.
[85] Aminpour *et al*. 2017, 5.
[86] Colliva & Matin 2017.
[87] Colliva & Matin 2017, 255-272
[88] Colliva & Matin 2017, 272; Colliva 2019.

Besides the vessels, coins, arrowheads, ornaments and jewellery, the object group includes an interesting collection of architectural and sculptural elements of royal-official nature. Three stone architectural and decorative fragments were unearthed in Persepolis West, one of them showing a cornice with relief rings which was part of a larger scene. Furthermore, four eye beads were also excavated which were most likely produced to be inserted into reliefs and sculptures.[89]

Another group of architectural elements and decorations found during the excavation in Persepolis West are three fragments of the glazed bricks of different kinds.[90] One of them is akin to the typical siliceous Achaemenid glazed bricks produced probably from the Darius I period onward.[91] Precisely the nearest comparative evidence for this fragment is the glazed bricks used for decorating monuments of the Terrace.[92] The two other fragments of clayey bricks instead find the nearest comparison with the materials discovered at the Early Achaemenid monumental gate of Tol-e Ajori.[93] The discovery of the three fragments of glazed bricks raised the question whether the bricks of the monuments of the Terrace and Tol-e Ajori might have been produced in the craft zone (see below).[94]

While the mentioned finds suggest that the craft production zone served for preparing materials of different kind – including architectural elements – and taking into consideration the fact that the number of materials of each class is limited and they do not come from secure and clear stratigraphic contexts in most cases, it is impossible to indicate the exact function of the craft zone. It should be noted that it is not clear how these materials arrived to the site and the excavations carried out in Persepolis West to date reveal that soil movement linked to field levelling for agricultural purposes has also shifted archaeological materials.[95] The fact that part of the finds came from the excavation of Area D which corresponds to the area of the enclosure garden might confirm that the objects were not found in their original position.[96]

What is of crucial importance for the purpose of this paper are the pigments and colourful residues discovered during the excavations at Persepolis West (see above). These pellets and lump (fig. 8) have been found in Areas B, C, D and E (Trenches Tr. 6, Tr. 7, Tr. 8, Tr. 9, Tr. 10 and Tr. 11) of the excavation (fig. 12), and therefore, like other finds (see above), seem not to have been found in their original position. In any case, they have been found near a craft zone and the archaeometric

[89] Colliva & Matin 2017, 234-236, 237-238.
[90] Colliva & Matin 2017, 253-254.
[91] Razmjou 2004; Dauce 2013, 307-310.
[92] Schmidt 1953, 71, 77-78,122, 263, figs. 35, 107 i.
[93] Matin 2014; 2017; Amadori *et al*. 2018.
[94] Colliva & Matin 2017, 253.
[95] Askari Chaverdi & Callieri 2017, 286; Callieri 2022.
[96] The study of the Persepolis Fortification tablets offers much evidence about craft production at Pārsa (Persepolis). Particularly relevant are the references to craft production in places identified as plantation (partetaš) indicating that it cannot be completely ruled out that some of the production activities may have been done in the gardens (personal communication with Wouter F. M. Henkelman).

analyses (as explained in detail in the following pages) attested that the pigments were manufactured locally.[97]

3.1.3. Function of the Craft Zone

As previously explained, the results recently obtained by archaeometric analyses on the pigments found during the excavation at Persepolis West allowed to identify Egyptian blue, azurite and malachite as well as red and yellow ochre characterized by the presence of hematite and goethite, respectively. The researchers proposed that the pigments represent the raw materials used to paint the stones of the monuments of the Terrace and Naqsh-e Rostam, such as Egyptian blue, malachite, azurite, cinnabar, hematite, goethite, limonite, the rare mineral tyrolite and tenorite, a mixture of calcite with a trace of yellow ochre and realgar/orpiment thus supporting the hypothesis that in the Persepolis West craft zone, there were also laboratories for the production of pigments to decorate the buildings.[98]

Not only does the context in which the pigments were found and their relation with the Persepolis West craft zone strongly suggest that the pigments were produced in this area, but the mineralogical composition and microscopic features of the analysed pigments have also common characteristics with local raw materials indicating a possible use of close sources.[99] However, it is possible to obtain much more information through the presence of Egyptian blue pigments among the analysed samples.

The term Egyptian blue is a modern term to denote a special artificial pigment composed of copper, silica, alkali and lime and fired at about 850-1000°C.[100] There are varieties in the Egyptian blue materials which can be attributed to the production method itself as well as to the raw materials.[101] It was apparently used for the first time at the beginning of the third millennium BCE in Egypt mainly to make beads, seals, amulets and various small objects as well as vases or statuettes and seems to be the main blue pigment employed for murals in antiquity.[102]

Various objects composed of Egyptian blue were found in Persepolis;[103] many of them – mainly sculptural fragments – were described by Erich F. Schmidt as "blue composition" objects.[104] An interesting tile-like Egyptian blue object was excavated at the Terrace by Ali Sami.[105] Belonging to

[97] Amadori *et al*. 2021.
[98] Stodulski *et al*. 1984; Moorey 1994, 327; Laurenzi Tabasso & Ridolfi 2017, 106-107; Amadori *et al*. 2021
[99] Amadori *et al*. 2021, 11.
[100] Moorey 1994, 186-189; Nagel 2010, 252; Cavassa 2018, 15; Amadori *et al*. 2021, 10.
[101] Oudbashi & Hessari 2021, 246.
[102] Cavassa 2018, 18, 20; Oudbashi & Hessari 2021, 246.
[103] Moorey 1994, 188.
[104] Matson 1957; Schmidt 1957, 66-75.
[105] Qaheri 2020, 60. For a catalogue of a number of Egyptian blue objects found in Achaemenid contexts see Qaheri 2020, 56-60, 170- 175.

this group are also a 'knob' (fig. 14)[106] found during the excavation directed by Alireza Askari Chaverdi in the drainage canals built in the Terrace foundations[107] and another 'knob' found in Barzan-e Jonubi by Ali Akbar Tadjvidi.[108] As Erich F. Schmidt hinted and Gian Pietro Basello well-demonstrated, these 'knobs', of which there are more in the National Museum of Iran and in the Oriental Institute of Chicago, are actually wall-pegs and continue a long Mesopotamian and especially Elamite tradition.[109]

One of the most interesting finds from the excavations at Persepolis West is a fragment of moulded decoration representing the right wing feathered in Egyptian blue (fig. 15) which could be produced by the craft zone located in this area.[110] Some new archaeometric analyses on a number of Achaemenid blue objects depict that they were all made by Egyptian blue.[111] In addition, Egyptian blue pigments were one of the elements found frequently on the architectural stone elements of the Terrace and Naqsh-e Rostam.[112]

Previously, the discovery of the traces of blue pigment had raised the question whether Egyptian blue had been produced locally or had been exported to Persepolis and whether local workshops were responsible only for applying the colour on the structures. It should be considered that the presence of lumps, pellets or ingots and cakes of Egyptian blue itself does not necessarily indicate the existence of a primary local craft production site and that they could be a sign of a workshop manufacturing object or working on polychromy; to make Egyptian blue objects, the already produced ingot might be first powdered and then mixed with water so as to make a soft and malleable paste to be pressed afterwards in a mould or be shaped by hand, then dried, and finally (re-)fired and re-melted in glass phase in order to make the baked hard artefacts.[113] Frederick R. Matson who did the first analyses on the materials excavated by the Oriental Institute of Chicago at the Terrace suggested that Egyptian blue had been imported to Persepolis from other areas in the form of lumps or powder which in

[106] Rahsaz 2019.
[107] Personal communication with Alireza Askari Chaverdi.
[108] Tadjvidi 1976, 102. The author was able to visit the former 'knob' twice in the Persepolis Museum storage, thanks to the kindness of colleagues from Persepolis World Heritage site. The first time in May 2019 – while preparing the translation of Hassan Rahsaz's paper – it was confirmed that the object is made of blue compound and not stone (Rahsaz 2019, 754, fn. 9). The following autumn, the author asked Maria Letizia Amadori to accompany him to see the object and using portable XRF, she was able to confirm that the object is composed of Egyptian blue; the author wishes to thank her for this. The latter 'knob' has only been described by Ali Akbar Tadjvidi who mentioned that the object "was made by moulding and then fired in oven", and therefore was probably made from Egyptian blue (Tadjvidi 1976, 102; Rahsaz 2019, 753-754, fn. 7).
[109] Schmidt 1957, 50, 74; Basello 2012.
[110] Colliva & Matin 2017, 236; Mercuriali 2017, 59.
[111] Dadashzadeh *et al*. 2017; Oudbashi & Hessari 2021.
[112] Stodulski *et al*. 1984, 148-149; Nagel 2010, 252-256; Laurenzi Tabasso & Ridolfi 2017, 106-107.
[113] Cavassa 2018, 20-21; Oudbashi & Hessari 2020, 253.

Persepolis would have been powdered and mixed with water or a binder to be used for making objects or as paint colour.[114]

The group of researchers working on the pigments excavated at Persepolis West argued that for the following various reasons, the analysed Egyptian blue sample have been produced locally. First of all, the different crystal sizes observed in the samples suggested diverse stages of production including the primary stages. In addition, the presence of pyroxenes – especially diopside – identified in two samples has a particular meaning. These minerals are formed during the production process and during the reaction of silica-rich glass and carbonates at a high temperature. Diopside does not usually appear within Egyptian blue artworks whilst it is typically found as a kiln coating and therefore indicate a local production of this material. The third reason regards the presence of Egyptian blue crystals identified in the only bronze scrap analysed by the team that recalls the use of bronze waste or corrosion products as a source of copper in the production of this substance.[115] Copper or bronze scraps were recycled in ancient Egypt to produce the blue pigments.[116] As previously mentioned, the late Hellenistic production site of Kos island, the pigments were found in the same space with metallurgical remains and the investigations highlighted the relationship between pigment production and metallurgy and showed that Egyptian blue fragments were produced locally.[117]

What is indeed very important is that, despite the fact that traces of Egyptian blue objects or pigments have been found in various sites, craft production sites of Egyptian blue with solid evidence have so far been reported only in Egypt, Greece, southern Italy and eastern Anatolia and in each case, only a very low number of sites have been found.[118] The very limited list of discovered Egyptian blue production sites is probably due to lack of sufficient multidisciplinary investigations especially in the Near East.[119] Therefore, the results of the new investigations at Persepolis West show that Persia should be added to the list of the areas of Egyptian blue production. The necessity of Egyptian blue production in Persepolis (instead of exporting raw materials) could be easily explained by the large number of Egyptian blue objects discovered and the various reliefs and stone elements covered with this material in Persepolis.[120]

[114] Matson 1957.
[115] Amadori *et al.* 2021, 10-11.
[116] Jaksch *et al*. 1983; Scott 2016, 5-8; Rademakers *et al*. 2017.
[117] Kostomitsopoulou Marketou 2019.
[118] Ingo *et al*. 2013; Cavassa 2018, 22-34.
[119] Notice for example the Fort Shalmaneser (9th century BCE) in Nimrud (Iraq), one of the sites in which Egyptian blue ingots have been found (Mallowan 1966): as Peter R. S. Moorey highlighted the "stick of very bright hyacinth blue chalky material" found at the site might have been used as a colourant (Dayton 1978, 32; Moorey 1994, 187).
[120] Tilia 1978, 29-69; Moorey 1994, 188; Nagel 2013, 601-609; Dadashzadeh *et al*. 2017; Oudbashi & Hessari 2021.

The most fascinating and easiest reconstruction is to assume that some craftsmen, such as the Egyptian painters mentioned in the Persepolis Archives[121] were brought from Egypt to Persepolis to produce Egyptian blue (and other pigments?) in the Achaemenid heartland. It is worth mentioning that Egyptian blue objects bearing hieroglyphic signs as masons' marks have been unearthed on the Terrace.[122] However, there is no reason to exclude the possibility that this technology was delivered to Persia by means of other cultures, considering that Egyptian blue was known in the Near East and the Mediterranean area long before. Recently, Omid Oudbashi and Morteza Hessari mentioned that the characteristics of a number of Egyptian blue fragments from Persepolis show more similarities with examples from Nineveh and Nimrud than those from Egypt.[123] However, the number and variety of analysed samples from each site is very limited and it is impossible to reach a conclusion from this observation.

The use of the pigments for decorating the stone sculptures and elements is not absolutely surprising. The stone sculptures and relief were decorated with polychromy in the Greek world at least from the Archaic period.[124] The earliest traces of colour decoration of sculptures made from various materials in the ancient Near East date back to the 9th millennium BCE.[125] Painting stone elements was common as well in this region and the use of this method is specifically documented in Neo-Assyrian reliefs.[126] The polychrome reliefs are the fruits of the close relationship between painters and sculptures and the archaeological evidence from Khorsabad suggests that there was a workshop in which both painters and sculptors operated in close collaboration.[127] It is also noteworthy that, as Wouter F. M. Henkelman has pointed out, Egyptian stone masons and painters assigned to Tamukkan[128] in two separate tablets of the same year of the Persepolis Fortification Tablets belong to the same dossier.[129]

Polychromy could have been used in different materials such as ceramic, wood and jewellery and such pigments like those excavated in Persepolis West could be used for painting various objects and surfaces.[130] Achaemenid painted wooden tomb chambers have been found in Phrygia (fig. 16),[131] and in Susa, an Achaemenid wall painting has been discovered (fig. 4, see above). The raw materials used in various kinds of painted architectural decoration and the process of applying the painted

[121] Henkelman 2017, 278-280.
[122] Qaheri 2020, 54-59; Zehbari 2021, 67-68.
[123] Oudbashi & Hessari 2021, 253.
[124] Kiilerich 2016.
[125] Nunn & Piening 2020.
[126] Verri *et al*. 2009; Thavapalan *et al*. 2016; Thavapalan 2019.
[127] Moorey 1994, 36; Nagel 2013, 598; 2018, 382.
[128] Located in Dashtestan county of the Province of Bushehr (Southern Iran) and in the Persian Gulf region (Matin 2020 with bibliography).
[129] Henkelman 2017, 278.
[130] Nagel 2013.
[131] Summerer 2007; 2010.

colour to them are very similar as it has been confirmed also in the case of the first millennium Near East.[132] New archaeometric analyses carried out on a building floor fragment from the Terrace showed that it was finished with a lime plaster covered with two layers of hematite-rich paint. In addition, Egyptian blue, malachite and red ochre were the pigments used for painting the plasters from Palace P of Pasargadae (fig. 3).[133] Therefore, while the pigments found in Persepolis West correspond perfectly to the various polychromy used for covering the reliefs and the architectural stones elements, the colour raw materials produced in the craft zone could have been applied also on other materials or used in other ways.[134]

As explained, it was proposed that also the fluorapatite necessary as a substance to bleach the greyish limestone surface of Terrace monuments could have been produced in the Persepolis West craft zone.[135] This information suggests that different materials necessary for workshops working on the stone structures of the Terrace were produced here. The three fragments of architectural stone and the eye beads found during the excavation may indicate that the craft zone could have also been employed to produce small architectural elements in stone and other materials to be inserted into sculptures and reliefs.

Considering the glazed bricks, archaeometric analyses of the body of bricks from Tol-e Ajori show an affinity with local raw clays in the Marvdasht plain and it has already been suggested that the glazed bricks found on the Terrace must have been produced in the nearby area.[136] As explained, the discovery of the three fragments of glazed bricks of different kinds raised the question whether the bricks of the monuments of the Terrace and Tol-e Ajori might have been produced in the Persepolis West craft zone.[137]

Contrary to expectations, none of the Persepolis West pigments analysed matches the dyes and colourants used for glazed bricks. The opacifiers and colouring agents used in the glazed bricks of the Terrace were characterized by certain scholars. A group of them found lead antimonate and briziite (sodium antimonate) used, respectively, as yellow and white opacifiers. Briziite was found incorporated in white, green and turquoise glazes associated with lead antimonate and calcium antimonate.[138] Other researchers suggested that the glazed brick fragments from the Terrace were decorated with alkaline glazes using lead antimonite for yellow ones, magnesium and iron for grey

[132] Nagel 2013, 598-599 with bibliography.
[133] Aloiz *et al*. 2016, 2-6.
[134] It has been suggested that hematite was also used to create guidelines for builders placing stone (Aloiz *et al*. 2016, 5). If so, the hematite produced in the craft zone may have also served this function.
[135] Askari Chaverdi *et al*. 2016; 2018; Laurenzi Tabasso & Ridolfi 2017; Laurenzi Tabasso & Lazzarini 2017; Mercuriali 2017, 48; Ridolfi *et al*. 2019.
[136] Schmidt 1957, 93.
[137] Colliva & Matin 2017, 253.
[138] Holakooei *et al*. 2017.

ones and copper for green ones.[139] The archeometric investigations on Tol-e Ajori glazed bricks suggested the use of calcium antimonate for white colour, lead antimonate and iron oxides for both yellow and orange, copper carbonate for green colour, and copper and cobalt and iron oxides for the blue colour.[140]

Although the three fragments of glazed bricks, three fragments of glass bracelets and a fragment of a glass vessel discovered in Persepolis West[141] can in no way be a proof that these materials were produced in the craft zone, we still cannot exclude the possibility that glass and glazed materials and pigments were produced by this craft production site. What indeed could be argued here is that the craft zone does not seem suitable for brick production. The kiln necessary for firing bricks is huge – much larger than the one excavated in Persepolis West – and it should be considered that producing a large number of bricks in such a huge kiln creates a large amount of fumes and smell, which could also disrupt the activities and ceremonies in the Citadel. The clay of the bricks of Tol-e Ajori, in addition to some samples from the area of Bagh-e Firuzi, shows an affinity with the active clay quarry of Kushk located roughly 6.5 km southwest of the Terrace;[142] all this demonstrates that the bricks of Tol-e Ajori could be produced also out of the Persepolis area. It is worth mentioning that, as attested by a number of Mesopotamian administrative texts, some contracts were signed for the baked bricks delivering for the construction of the North Palace to Babylon,[143] strongly suggesting that the bricks were produced outside the city.

Another question about the craft production site discovered in Persepolis West is over the areas which were supposed to receive the artefacts produced there. One might suggest that the craft zone provided the pigments and materials necessary for all workshops working on the royal-official buildings located in the Persepolis area, even those further away such as Naqsh-e Rostam. Nonetheless, it is not just a matter of distance but also chronology as the new investigations manifest that the Persepolis area had been built in more than one phase;[144] furthermore, the point of the commencement of the activities of the craft zone is not clear. Considering the dating of the craft zone, there are few indications available only. The C14 analyses of samples taken during the excavation confirm the function of the area in late and post-Achaemenid periods.

The presence of the fluorapatite substance for whiting the greyish limestone surface of the monuments of the Terrace has been evidenced in the buildings dated to Xerxes' reign and beyond.[145]

[139] Aloiz *et al*. 2016, 6-8.
[140] Amadori *et al*. 2017a.
[141] Colliva & Matin 2017, 224-225, 252.
[142] Amadori *et al*. 2017b; 2018.
[143] Beaulieu 2005, 59-60.
[144] Matin 2018; Askari & Callieri 2020; Matin & Colliva forthcoming 2022.
[145] Ridolfi *et al*. 2019.

However, considering that the production of the glazed bricks of Tol-e Ajori in the area is not confirmed, it is impossible to say for the moment if this craft zone also provided the workshops working on Early Achaemenid urban zones of the Persepolis area[146] such as Bagh-e Firuzi and Dasht-e Gohar with the necessary raw materials or not. As explained above, a ceramic fragment with a crust of pigments was found at Dasht-e Gohar and the application of polychromy for covering the different architectural elements of Gate R and Palace P of Pasargadae have been reported.[147] This information not only substantiates that polychromy had been used in the Early Achaemenid style buildings, but also raised the question if the aforementioned craft zone provided the pigments for other settlements of the Achaemenid Persia – like Pasargadae – or not. Future multidisciplinary investigations might answer these questions.

Conclusion

For a long period, there were huge construction programs to erect royal-official buildings in the Persepolis area and various workshops were active within these projects. These monuments were decorated with numerous colours and, evidently, some of the craftsmen were working on pigments and painting. As elaborated in this paper, the colouring pigments needed to paint the various architectural elements of royal-official buildings were produced locally.

For the moment, the Persepolis West craft zone is the only investigated production site in the Persepolis area and its surroundings and based on our current information, it is impossible to indicate the limits of this craft zone. Regrettably, intensive agricultural activities which started following the construction of the Dariush Kabir Dam have seriously damaged the ancient landscape of the area.[148] Also, the excavations carried out in Persepolis West to date, particularly in Area A next to the green belt (fig. 12), offer evidence that soil movement linked to field levelling for agricultural purposes has shifted archaeological materials too.[149] As a result, pigments and artefacts in the area have been found in various zones of the excavation and out of their original context. Therefore, the spots in which these materials have been found could not be used for locating the limits of this craft production site. On the other hand, as explained earlier, the excavated kiln was not located in the geophysical map in the area showing very high magnetic anomalies belonging to artisan activities, thus demonstrating that the craft zone was not limited in the craft area defined by the geophysical surveys (fig. 13). Under the circumstances, we can conclude that the craft zone – to say the least – was located in Area B and

[146] Matin 2018.
[147] Stodulski *et al*. 1984, 149; Moorey 1994, 327; Nagel 2013, 604; Aloiz *et al*. 2016, 2-6. In addition, the group of Egyptian 'painters' assigned to Tamukkan (see above) where Early Achaemenid style monuments have been discovered may have worked on polychromic reliefs.
[148] Boucharlat *et al*. 2012, 255-256.
[149] Askari Chaverdi & Callieri 2017, 286; Callieri 2022.

its vicinity (fig. 12). In addition, the craft area reported by Herzfeld indicates that there were other craft production sites in the area near the Citadel.

The exact function of the Persepolis West craft zone is not clear and the various finds in the area suggest that the area could serve for producing different materials. However, it is confirmed that the craft zone was responsible for producing the raw materials used to colour royal-official buildings. The pigments excavated in Persepolis West are in agreement with the raw materials for colouring used in Achaemenid buildings, especially those used in polychromatic reliefs and stone elements. The craft zone is also one of the very few production sites in which the production of Egyptian blue has been recorded, showing that Persia together with Egypt, Greece, southern Italy and eastern Anatolia was one of the places in which this blue substance was produced.

It is not clear when the activities of the craft zone started and which areas its productions served. Nonetheless, it seems reasonable to hypothesize that the craft zone existed at least from the beginning of the construction of the Terrace and it was close enough to have conventionally served the needs of the Citadel. The excavators pointed out that this craft production site was simultaneously separated by a garden and, hence, the Citadel could have been protected from fumes and odours.[150]

[150] Colliva 2017, 70.

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Figures

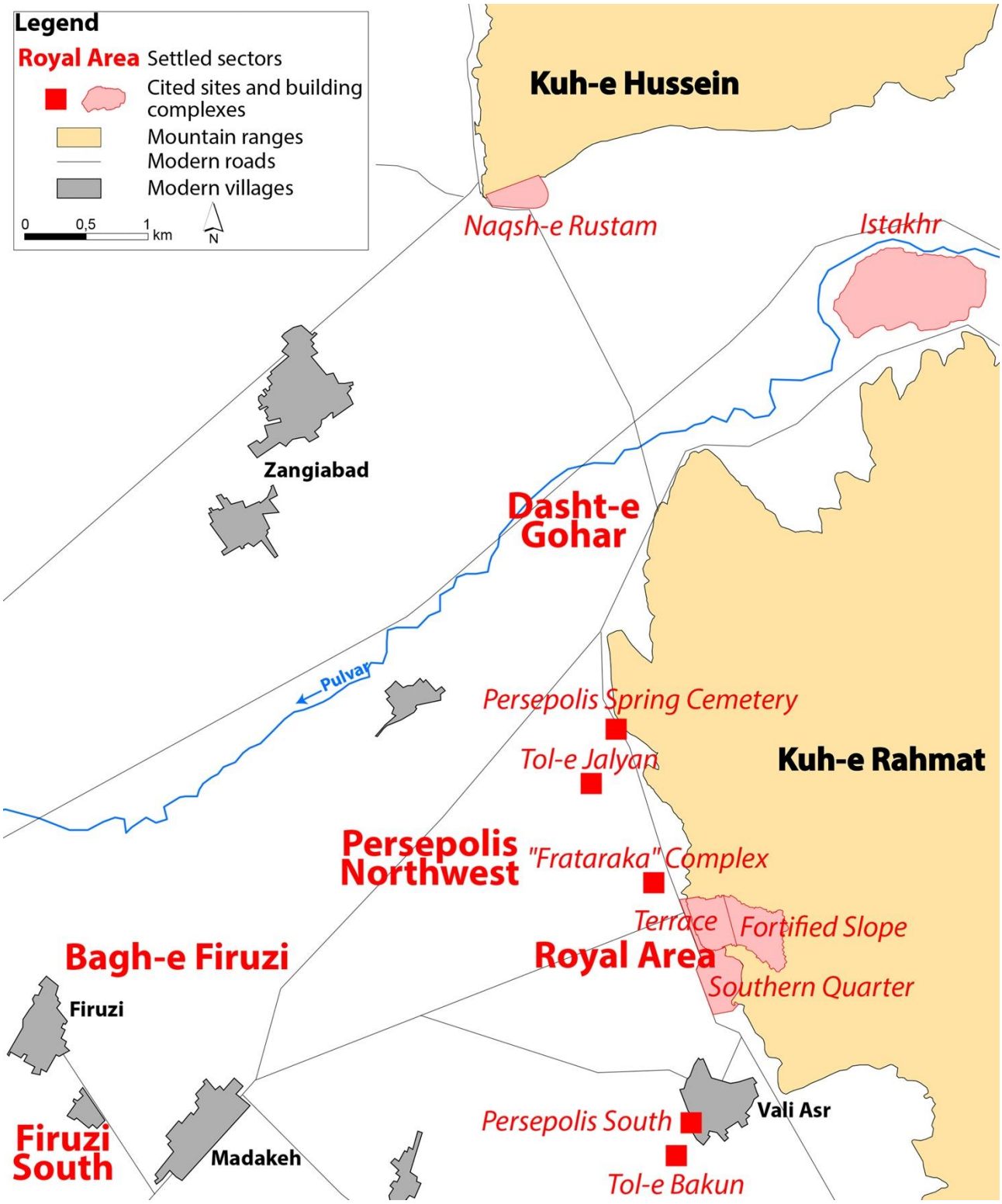

Fig 1 Location map of the Persepolis area (after Gondet *et al*. 2018, fig. 8).

Fig 2 Fragment of clayey brick from Tol-e Ajori with relief glazed decoration (GB00503) showing part of a bull hoof to right (after Askari Chaverdi *et al*. 2014, fig. 16; photo D. M. Meucci). ©Iranian-Italian Joint Archaeological Mission in Fars.

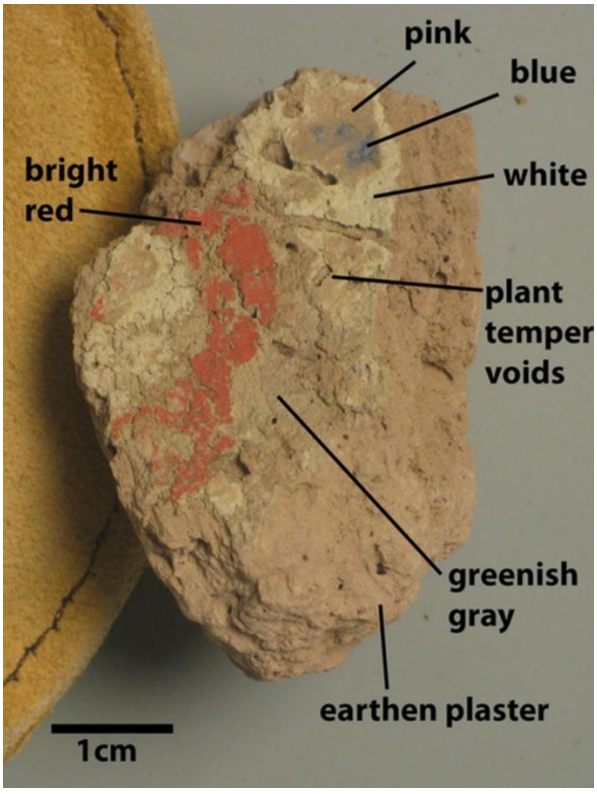

Fig 3 Fragment of earthen plaster decorated with paints found at Palace P at Pasargadae (after Aloiz *et al*. 2016, fig. 3).

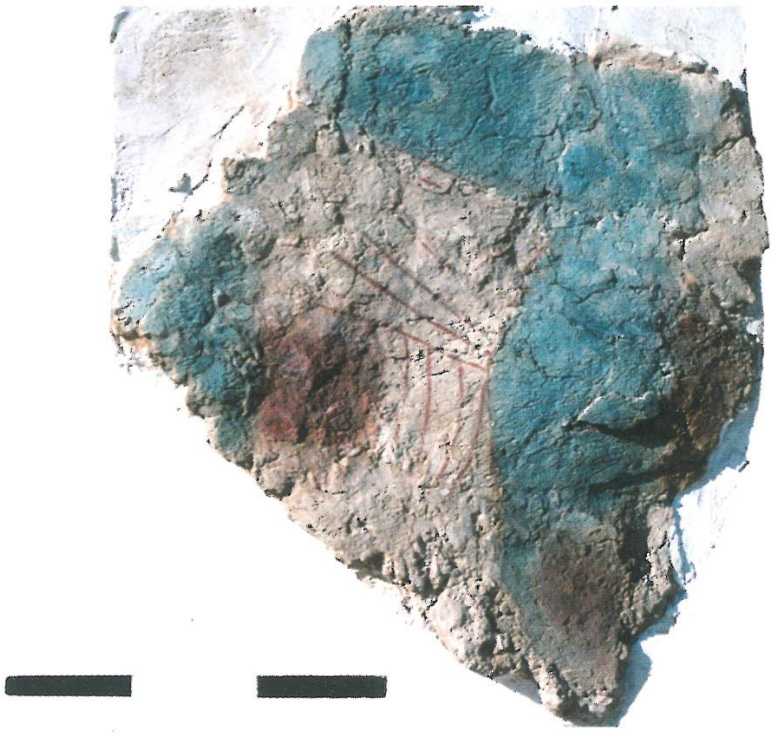

Fig 4 Fragment of restored wall painting of about 50 cm found at Shawur palace at Susa, showing a head covered with a *bashlyk* (after Boucharlat 2013, fig. 434).

Fig 5 Traces of blue pigment on relief of Darius depicted at his tomb at Naqsh-e Rostam (after Nagel & Rahsaz 2010, fig. 4).

Fig 6 Tentative colour reconstruction of the winged symbol on western jamb of northern doorway in the Persepolis Terrace Council Hall, following the investigations of the IsMEO Persepolis Restoration Mission (after Tilia 1978, pl. B).

Fig 7 Traces of blue pigment on the DNe inscription in Naqsh-e Rostam (after Nagel & Rahsaz 2010, fig. 5).

Fig 8 Pellets and lumps of material for colouring excavated in Persepolis West (after Amadori *et al*. 2021, supplementary fig. 3). ©Iranian-Italian Joint Archaeological Mission in Fars.

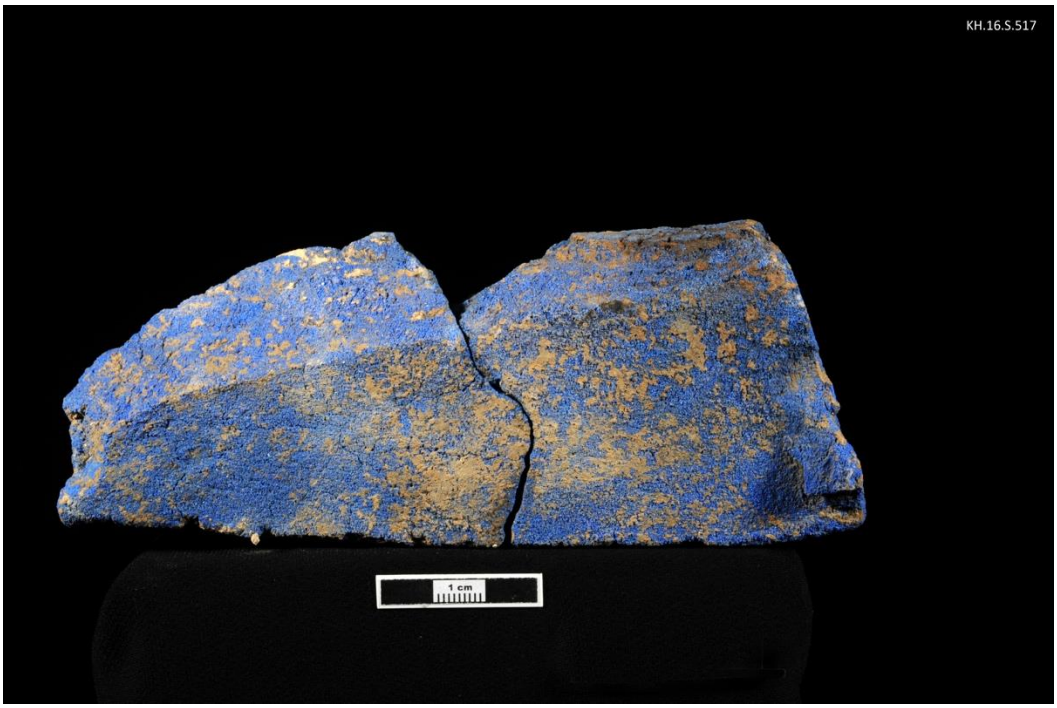

Fig 9 The Egyptian blue ingot fragment (KH.16.S.517), found in Palace of Sargon II at Karkemish (after Zaina *et al*. 2019, fig. 2). Courtesy of the joint Turco-Italian expedition at Karkemish.

Fig 10 Bowl containing Egyptian blue (A19384), found in the so-called Harem at the Persepolis Terrace. Courtesy of the Oriental Institute of the University of Chicago.

Fig 11 Successful, partially successful and unsuccessful pellets of Egyptian blue from the late Hellenistic production site located in the Agora of Kos Island in Greece (after Kostomitsopoulou Marketou 2019, fig. 20).

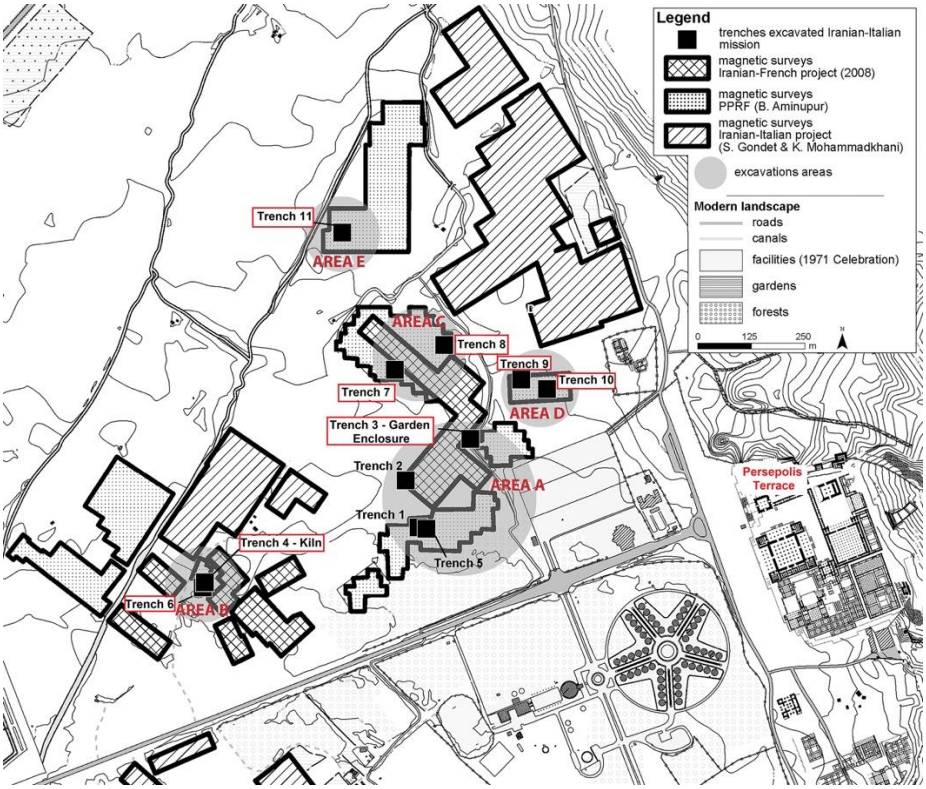

Fig 12 Overview of the Persepolis West showing excavation areas A-E and areas surveyed with the geophysical method (after Amadori *et al*. 2021, supplementry fig. 2). ©Iranian-Italian Joint Archaeological Mission in Fars.

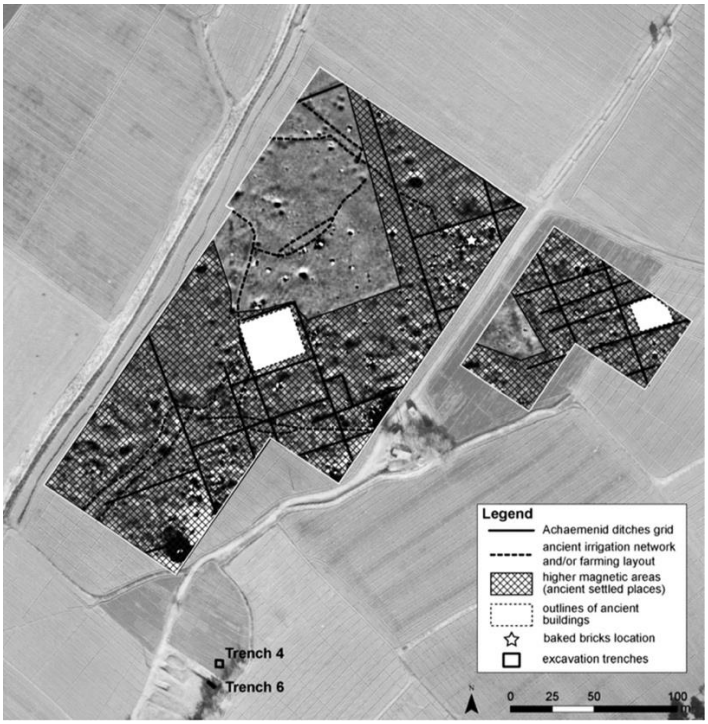

Fig 13 Interpretative sketch drawing overlaying the Area B of Persepolis West magnetic map, showing the Trenches Tr. 4 and Tr. 6 and the area with very high magnetic anomalies (after Aminpour *et al*. 2017, fig. 11). ©Iranian-Italian Joint Archaeological Mission in Fars.

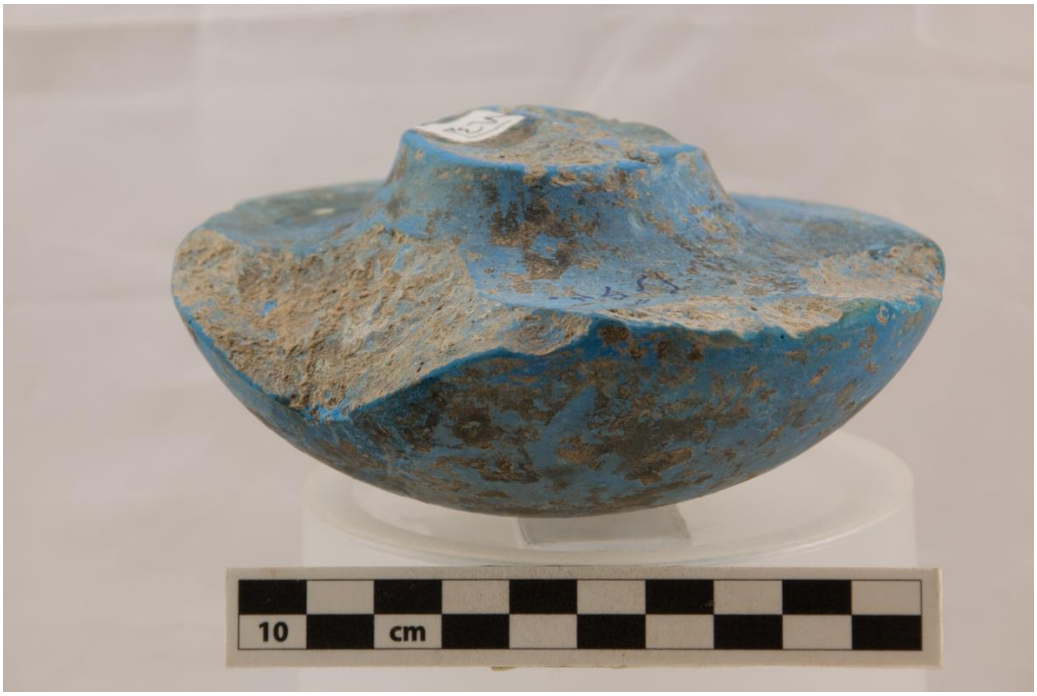

Fig 14 The Egyptian blue ‘knob’ found during the excavation in the drainage canals built in the Persepolis Terrace foundations (after Rahsaz 2019, fig. 7; photo D. Andreucci). Courtesy of the Persepolis World Heritage Site.

Fig 15 Fragment of moulded decoration representing the right wing feathered in Egyptian blue (PW Inv. 35), excavated in Persepolis West (after Colliva & Matin 2017, 236). ©Iranian-Italian Joint Archaeological Mission in Fars.

Fig 16a Details of one of the paintings of the Achaemenid wooden tomb chamber from Tatarlı in Phrygia, showing a Persian killing an enemy (after Summere 2010, fig. 7).

Fig 16b Reconstruction of one of the paintings of the Achaemenid wooden tomb chamber, from Tatarlı in Phrygia, showing a battle scene (after Summere 2010, fig. 3).