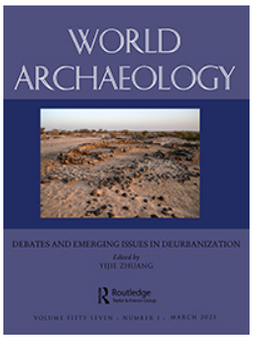

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Stone workshops between petrography and iconography: a preliminary study on Iron Age basalt carvings

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ABSTRACT

The flourishing of sculptural series on orthostats, protomes and statues, which decorated the so-called Syro-Hittite city-state citadels, represents a unique phenomenon in stone production during the pre-classical period (12th-7th centuries BC) in the Syro-Anatolian region. Since the first discoveries of these sculptural cycles, archaeological and art-historical research has primarily focused on problems related to style, dating and production, mostly through an iconographic approach. However, the matter of the workshops (from quarrymen to sculptors) has not been fully explored, nor has the integration of geological aspects (such as the identification of quarries) and the production process. This article presents preliminary results from a broader project that addresses this issue through iconographic and petrographic analysis of basalt samples from sculptures found at Syro-Hittites sites. This study aims to introduce an interdisciplinary approach, seeking to bridge the existing gap between workshops, quarries and the Syro-Hittites political entities that commissioned these monumental artworks.

KEYWORDS

Iron Age; basalt; Syro-Anatolian; petrography

Introduction

The aim of this paper is to provide some preliminary results about the ongoing research that focuses on stone workshops operating during the Iron Age Period (12th-7th centuries BCE) in the cross-border region between southeastern Türkiye and northwestern Syria.[1]

This paper forms part of a broader initiative aimed at studying and enhancing the archaeological and cultural heritage of the region, contributing to the rehabilitation and museographic renewal of the Aleppo National Museum. Since 2021, an international programme led by the University of Florence, in collaboration with the General Directorate of Antiquities and Museums (DGAM) and supported by the Ministry of Foreign Affairs and International Cooperation (MAECI), the University of Florence, and the ALIPH Foundation, has focused on securing the museum building and its collections. Initially conceived as an emergency intervention, this initiative evolved – especially after the 2023 earthquake – into a comprehensive effort combining restoration, conservation, and archaeological research (Pucci 2024).

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The aim of this research, as presented in this article, is to address this gap in our understanding of production processes, the location of basalt quarries, and the craft workers or sculptors involved in creating the monumental artworks decorating the so-called Syro-Hittite city-states citadels. Since most studies[2] on the subject rely primarily on an art-historical perspectives, a significant disconnect in understanding remains between craft workshops and the quarries supplying the raw materials. This paper addresses this using a dual methodological approach. On the one hand, traditional archaeological and art-historical methods provide the basis for analysing the iconography and stylistic features of the sculptures within the socio-economical structures of the Syro-Hittite city-states. On the other hand, the compositional characterization of basalt-sampled from statues currently stored at the National Museum of Aleppo and originating from various sites across Syria, including the regions of Hama (south-central), Aleppo (north), and Al-Hasakah (northeast) is integrated to broaden the analytical framework of this study.

The Iron Age political setting

The term 'Syro-Hittite[3] city-states' refers to a group of Iron Age political entities (ca. 1200–600 BCE) located between south-central and south-eastern Anatolia and northwestern Syria, spanning both sides of the Taurus/Amanous mountain range (Osborne 2021). These polities can be defined as relatively small territorial units with a fortified capital exercising political and economic control over a surrounding hinterland settlement network (Hawkins 1982). Generally independent and ruled by local dynasties, they underwent a formative phase between the twelfth and tenth centuries BCE, followed by a floruit in the ninth and eighth centuries BCE, before being progressively incorporated into the Neo-Assyrian Empire between the eighth and seventh centuries BCE. Within this fragmented socio-political and ethno-linguistic landscape (see Figure 1), monumental stone artworks - such as

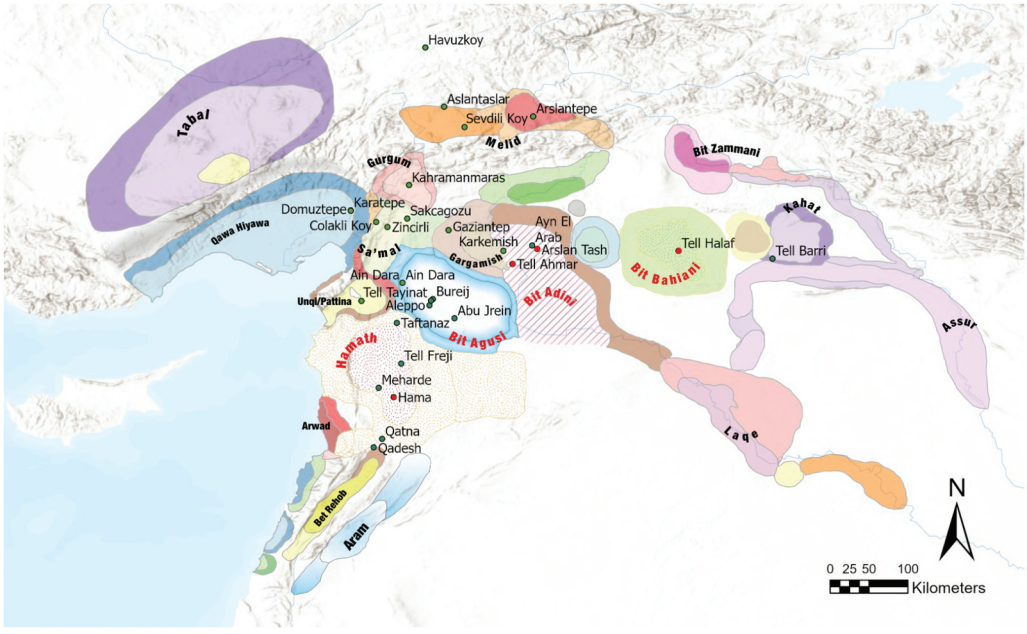

Figure 1. Location of the monumental sculptures' findspot (green and red dots); locations of the Syro-Hittite settlements (red dots). Legend colours indicate the possible extent of Syro-Hittite territorial entities (map by the author, after Novák 2016, fig. 1).

orthostats, protomes, statues in the round, stelae, and reliefs, deployed on citadels and in prominent public spaces, constituted a distinctive and well-documented expression of shared urban practices across the region (Herrmann 2017).

Workshop practices and stylistic variability

From an archaeological perspective the development of monumental art in this period and geographical area emerged shortly after the collapse of the Late Bronze Age Great Empires, around 1200 BCE, when local rulers began promoting urban development in their cities and the reconstruction of citadels, decorating public buildings with reliefs and sculptures. The political fragmentation of the area influenced the cultural and artistic trajectories of these Syro-Hittite centres, which exhibit diverse stylistic languages in monumental art.

Determining the activities of stone workshops in this context, is particularly challenging. It is generally assumed that the output of a single production unit, whether an individual artisan or a workshop, would exhibit a degree of homogeneity across one or more attributes, such as raw materials, specific production techniques, form, and/or visual appearance (i.e. style or iconography). In this context, the term 'workshop' should be understood as a more 'virtual' entity - a group of artisans trained in a range of skills, possibly including apprentices working under more experienced masters- rather than as a structured and permanent physical space akin to the ateliers of the Medieval or Renaissance periods (Di Paolo 2014).

Moreover, the absence of signatures or marks on the sculptures denoting specific artisans or workshops, makes the identification of individual production groups particularly complex. Distinct stylistic elements have been observed (Mazzoni 2009; Winter 1982) in the depiction of recurring iconographic subjects and are commonly attributed to the work of distinctive workshops active at individual centres.[4] These 'idioms' may circulate across different media (e.g. from ivory to stone). At the same time, the marked stylistic variability in repeated subjects (such as lions, genies, sphinxes, bulls, deities, and human figures) points to multiple workshops active at different centres, likely connected through the transmission of shared conventions and motifs (e.g. between 'Ain Dara and Karkemish, and between Hama and Zincirli) (Mazzoni 2013).

Quarrying and raw materials supply

Closely connected to the organizational structure and working methods of the workshops is the issue of quarry identification and the sourcing of raw materials. To date, only Yesemek (southeastern Türkiye, Duru 2004) and Sikizlar[5] (north-western Syria, Mazzoni 1984) can be identified as two certain quarry sites exploited at least by one workshop. This is supported by the presence of roughly shaped blocks and unfinished statues still *in situ*, as well as evidence of continuous exploitation over time. The intended destination and final appearance of these sculptures remain uncertain (Mazzoni 1986, 2022), as do the methods used for moving and transporting the blocks. It has been suggested that the sculptures were roughly shaped on the quarry site and subsequently refined at their final location.[6] This approach would have allowed artisans, whether quarry workers or other members of the workforce, to avoid transporting excess material/stone. Moreover, any damage of an unfinished sculpture in transit would need to be repaired at the final destination.

Study materials and context

Sampling strategy and selection criteria

Several aspects of workshop activity remain unresolved, making a preliminary archaeological approach essential to justify the need for compositional analyses of the statues. Combining stylistic and geochemical data, though still partial, offers a useful multidisciplinary method for understanding sculptural production, workshop mobility, and the connections between patrons, artisans, and basalt extraction areas.

The statues were selected based on the opportunity to study the Syro-Hittite collection of the Aleppo Museum within the *Still Standing* project, the documented archaeological contexts, the variety of object types, and the proximity of the statue location to basaltic areas previously studied from a geochemical perspective.

Sites and sculptures analysed

The nine samples presented in this section originate from nine basalt sculptures (see Figure 2) recovered from four sites of the modern Syria: Tell Ahmar, Arslan Tash located in the Aleppo Governorate, Hama in the Hama Governorate and Tell Halaf located in Al-Hasakah Governorate.

Tell Ahmar (ancient Til Barsip/ Kar-Shalmaneser), is located about 20 km south of Karkemish. Occupied from the sixth millennium BCE through the Late Bronze Age, the site became a regional capital in the Early Iron Age and an Assyrian centre after 856 BCE. The settlement is organized around a tell, its earliest and principal sector, which later served as the acropolis. During the Iron Age, the acropolis appears to have contained at least three official buildings: one with a pebble-mosaic courtyard, the *bâtiment est*, and a third structure later incorporated into the Assyrian palace. In the early first millennium BCE, the settlement expanded westward into the 'Middle Town', and at the beginning of the Assyrian period, a further expansion created the eastern 'Lower Town'. Also, the Acropolis was completely re-organized, and a royal palace was built, replacing the eldest buildings. Two sculptures from the site have been sampled, although their exact original locations remain unknown. The first is a stele (sample 7496) depicting a woman and child. It dates to the early first millennium BCE and was found by the French expedition in 1936 in an area between the modern village and the modern western cemetery (Bunnens 2022). The other one is the statue of an Assyrian dignitary (sample O.1007). It was discovered fragmented in several pieces (the feet are missing) in the so-called Middle Town which is part of the semicircular urban layout likely established during the Assyrian domination (856–750 BCE). The statue was found near the entrance shaft of a monumental tomb, buried alongside a limestone slab with a central hole, possibly intended as its pedestal (Bunnens 2022, 130–131).

The site of *Arslan Tash* (Hadattu) is located about 30 km north-east of Tell Ahmar, near the Syrian Turkish border. During the excavation of the Iron Age levels, the archaeologist brought to light several buildings, including the entrance to the Assyrian Temple, the East Gate and the West Gate. The first lion protome (sample 7519) was discovered near the façade of the so-called Assyrian Temple. According to Thureau-Dangin[7] (1931), the sculpture likely marked the entrance to the cella or sanctuary, where its original placement may still be identifiable on a perpendicular (to the façade) wall. The lion sculpture-sample XXX6 *(Lion Nord)* was found, along with its southern counterpart, near the towers, at the end of the East Gate fortification. The last sculpture (sample 7523) is an orthostat with a depiction of a military parade and was not recovered in situ. Its provenance is uncertain.[8]The city of *Hama* (ancient Hamath) is located about 50 km north of Homs. Archaeological investigations at

the site revealed a long occupational sequence comprising twelve main levels, among which the Iron Age strata (Periods F – E) are the most extensively represented and best preserved from an architectural perspective. Structures dating to this period are situated on the so-called citadel and include a monumental gate complex (*Batiment I*) as well as monumental palatial-type buildings arranged around a large open courtyard (*Batiment II, III, and IV*) (Hawkins 2000). Basalt sample 8148 derives from a small lion sculpture discovered in the so-called 'great plaza', an open area bordered by Buildings I, II, III, and IV to the southeast, southwest, east, and northwest respectively. The statue was located approximately 5 metres east of a basalt basin and was found lying on its side. Its spatial and contextual relationship to the other objects from the same area remains uncertain (Fugmann 1958).

Tell Halaf (ancient Guazana,) is located close to one of the sources of the Khabur river, approximately 140 km northeast from Arslan Tash in a straight line. The Iron Age contexts included a fortified citadel located on the tell, to the north, and a large lower town surrounding it to the west, south and east. The three sampled sculptures came from different areas of the site, and all were found *in situ*. In the northwestern part of the citadel, the 'West-Palace', or Hilani, is characterized by a tripartite plan (Novák 2016). A group of orthostats-*Kleinen Orthostaten*- (including sample 7561 decorated the base of the southern outer wall and the southern sections of the western and eastern walls of the building, forming a continuous band of alternating grey basalt and red limestone slabs. In addition to the *Kleinen Orthostaten*, other sculptural elements adorned the structure: a portico with sculpted columns in the form of caryatids defined a sort of recessed entrance niche. On the walls to the right and left of the freestanding sculptures of the entrance portico are the so-called 'large orthostats'. Placed symmetrically, these consist of two stone slabs bearing reliefs of lions: Ba 4 (sample 7532), located on the right side of the Hilani façade, and Ba 3, on the left wall (Von Oppenheim 1955). The last sculpture is a funerary statue of a seated woman (sample 7536) found in situ in a structure later covered by a mudbrick platform, at the main entrance of the mound (Pucci 2008, 91–94).

Figure 2. Statues sampled in this study. Numbers indicate sample ID and Aleppo Museum inventory number; 'XXX' plus a sequential number was assigned when no official inventory number was available (Photos by the author).

Geological setting and potential procurement zones

Syria is located along the northern portion of the Arabian Plate, within the boundary zones between this plate and the African and Anatolian plateaus. The boundary between the Arabian and African Plates is defined by the Dead Sea Transform Fault. In a broader regional framework, Late Cenozoic basalts across Syria and the Middle East are associated with the development of a new oceanic domain -the Red Sea Rift- and the related volcanic activity that accompanied its opening.

Late Cenozoic basalts are widespread throughout Syria and the adjacent territories of Türkiye up to the Taurus Suture. They were produced by mantle-derived volcanic eruptions that occurred at different times (starting from approximately 20 million years ago to the Holocene), forming successive superimposed flows. These basalts generally originated from the eruption of small volcanic cones, the remnants of which can still be recognized within the basaltic fields.

The largest of these basaltic provinces is in southern Syria and it is known as the Harrat Ash Sham. Other, less elevated and less extensive basaltic fields include the Shin basalt field near Homs. Basaltic flows also occur throughout the Aleppo Plateau, near the cities of Hama and Aleppo, and continue northwards to the area of Kahramanmaraşh (Türkiye). Additional basaltic fields are present along the northern margin of the Mesopotamian Foredeep, where they merge with the wide basalt field in the neo-tectonic province of southeastern Anatolia (Eastern Taurus-Upper Mesopotamia).

From a geochemical perspective, the composition of Late Cenozoic Syrian basalts is broadly comparable to that of basalts in adjacent regions of the Arabian Plate, consisting predominantly of alkaline mafic volcanic rocks with high TiO_2 contents and, more rarely, transitional or tholeiitic basalts (Brew 2001a, 2001; Lease 2000; Rukieh et al. 2005; Sharkov 1998; Trifonov et al. 2010, Ma et al. 2013).

The archaeological sites discussed here, from which the sampled statues originate, fit well within this geological framework. Tell Ahmar and Arslan Tash are located near basaltic fields of the Aleppo Plateau which are primarily dated to the Pliocene; Hama lies east of the Nusayriyah Mountains/Jabal al-Ansarriyya where basaltic lava flows date to the Upper Miocene; while Tell Halaf is in the northern portion of the Mesopotamian Basin, above the Halabiyeh lava field which is dated to the Early-Middle Pleistocene (see Figures 3).

However, as illustrated in the map below (see Figure 4), these sites lie at a considerable distance from the only known and securely identified quarrying areas: Yesemek[9] and Sikizlar. This makes it reasonable to hypothesize that other, more accessible basaltic fields may have been exploited as sources of raw materials. Tell Halaf provides a relevant example: although it is located close to local basalt outcrops and the nearby El Kbize volcano was long considered the source of the blocks used in its architecture and sculptures (Von Oppenheim 1931), Drüppel et al. (2011) now argue that the basalt more likely originated from the Ard Esh Sheikh plateau, 57 km to the south, based on geochemical and petrographic comparisons of artefacts and geological samples from both Syria and Türkiye. This is noteworthy given the high-quality basalt available immediately around Tell Halaf.[10]

Methods

Stylistic and iconographic protocol

The nine sculptures analysed here form part of a broader analytical set (c. 40 samples). For the purpose of this paper, the stylistic and iconographic assessment is restricted to the recurring lion

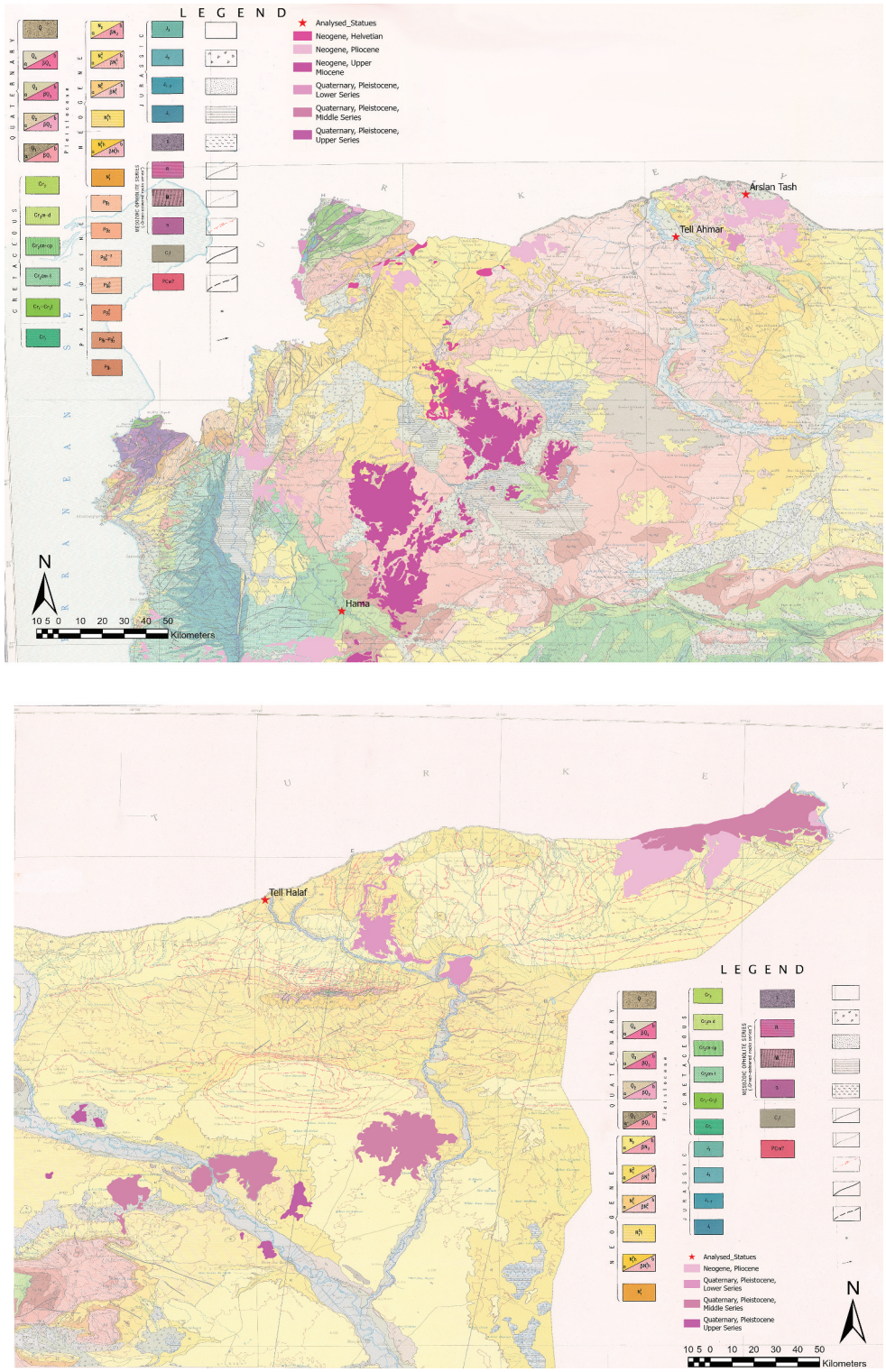

Figure 3. Illustrate the geological framework of the studied contexts; highlighted polygons indicate basaltic lava fields (map by the author, after Ponikarov et al. 1964. See the supplementary material for the full legend).

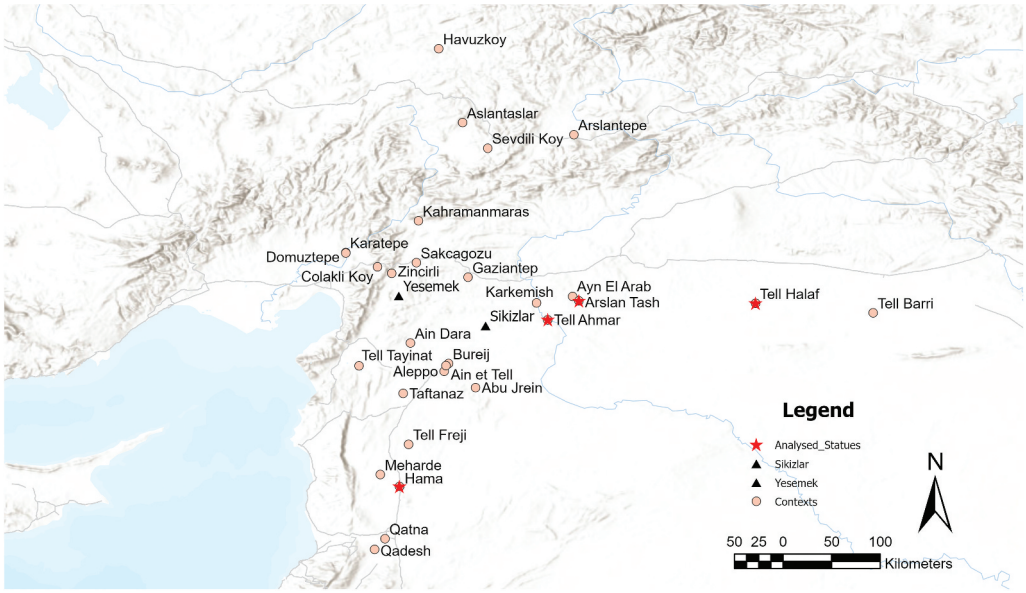

Figure 4. Distribution of Syro-Hittite archaeological contexts (pink dots); provenance of sampled statues (red stars); quarry contexts of Yesemek and Sikizlar (black triangles). Distances between the quarry sites and the archaeological contexts are as follows: Yesemek – Arslan Tash, 150 km; Yesemek–Tell Ahmar, 125 km; Yesemek–Tell Halaf, 294 km; Yesemek–Hama, 195 km; Sikizlar – Arslan Tash, 83 km; Sikizlar–Tell Ahmar, 51 km; Sikizlar–Tell Halaf, 223 km; Sikizlar–Hama, 178 km.

figure represented on different object types from the four sites under study, these were contextualized against a comparative corpus of 54 lion sculptures from Syro-Anatolian Iron Age contexts.[11]

The analysis followed three steps:

(1) ***Classification of the support and object type***. Each piece was first recorded according to the morphology of the carved block, as block shape constrains function (e.g. protome carved on a portal jamb, column base, freestanding sculpture, relief-carved orthostat). Three categories were used: A flat parallelepiped; B squared block; C fully three-dimensional block.
(2) ***Iconographic feature coding***. A set of recurrent variables was recorded for each specimen: stance (standing static / in motion), seated, crouching; jaws (open / slightly open / closed); ears (laid back / upright); tail (between the legs / behind the legs / raised). Where preservation affected visibility, variables were coded as 'not observable'.
(3) ***Stylistic assessment and grouping***. Stylistic traits were recorded following a standardized set of diagnostic criteria illustrated in Table 1, which defines the attributes underpinning the six stylistic categories used here: Style I Absolute Naturalistic; Style II Relative Naturalistic; Style III Geometric/Linear; Style IV Harmless Animal; Style V Karatepe Style[12]; Style VI Elbistan Style[13]. In addition, potentially workshop-diagnostic markers -whether recurrent or less common- were systematically recorded for each piece (Table 2 and Figure 5). Where classification was ambiguous, assignments were made on the basis of the majority of diagnostic traits defined in Table 1.

Finally, the spatial distribution of stylistic groups was examined in relation to provenance. Using ArcGIS Pro, the groups were plotted to visualize their occurrence across sites and contexts.

Table 1. Lion sculptures analysed: 'unique ID' indicates the code assigned to each artwork, and the key stylistic features observed are listed and used to assign each sculpture to a specific stylistic group.

STYLISTIC GROUP	DISTINCTIVE FEATURES	UNIQUE ID
I. Absolute Naturalistic	open jaws-roaring pose-closed jaws, defined dentition-upper/lower canines, mane-small/dense/wavy locks, legs-musculature/tendons, claws-represented	CH3, CH2, H1, H4, H5, H7, HD1, HD3, HD5, TT1, TT2, SG1, SG2, Z3, Z4, Z6, Z10
II. Relative Naturalistic	same as style I, plus some specific peculiarities (dog style muzzle/rhomboid locks or no mane)	HD2, HD4, TA1, TA2, M1, M2
III. Geometric/ Linear	no depicted mane/rounded, big eyes/fine parallel incisions as whiskers/cord-like element outlining the head/schematic paws	CH1, DT1, DT2, H2, H3, H6, HV1, Z5, Z7, Z8, Z1, Z2, Z9
IV. Harmless Animal	tongue protruding from the mouth/rounded-up ears/ 'flame-like' /spiral motif locks mane	AD1, AL1, AL2, AT1, AT2,
V. Karatepe Style	reduced overall dimensions / elongated legs / a protruding muzzle section with whiskers / shortened body	KT1, KT2, KT3, KT4, KT7
VI. Elbistan Style	no massive blocks, bulky head deep into the torso, wide/rounded/no details jaws, no mane, narrow and closely set legs, few details carved in shallow relief	ATH1, ATH2, SK1, GT1

Table 2. Distinctive stylistic features/markers analysed for each lion sculpture. 'Unique ID' indicates the code assigned to each artwork[14].

SCULPTURES UNIQUE ID	NOTABLE STYLISTIC ELEMENT (MARKER)	
	DESCRIPTION	POSITION (LION'S BODY PART)
SG1, SG2, Z4, Z6 Z10, HV1	Incision, X-shaped motif	Shoulder; void left for the mane
Z3, Z4, Z6, H1, H7	*Flame-mark*	Thigh; animal's hindquarters
HD1, HD2, HD4,	'button' motif, double concentric circle	Legs; joints, near the claws
HD1, HD2, HD3, HD5, TA1, TA2?	Incision, inverted tulip	Forelegs, outer side
H2, HV1	Incisions, 'triangles'	Head; base of the mane
CH1	Relief, single claw	Hind legs; claws
AL1	'Flat claws'	Forelegs; claws
HD2, HD4	Incision, rectangular shape	Muzzle; whiskers

Figure 5. Stylistic markers (highlighted in yellow) (see Table 2.) along with the unique ID. The photographs show selected examples of the sculptures listed in the table. All photos are from Hittitemonuments.com (© 1999–2025 Tayfun Bilgin), except for 7561, XXX6, and 7519 (photos by the author) and TA1 (photo courtesy of Hassan Yayha).

Geochemical characterization protocol rationale analytical strategy

This study explores the feasibility of geochemical characterization of basalt used for Iron Age monumental sculpture, with the aim of building a preliminary dataset to support hypotheses on raw material provenance and potential compositional grouping based on major and minor elements. Analyses were carried out at the CNR-ISPC laboratories in Milan and the techniques employed were powder X-ray diffraction (XRD) and portable X-ray fluorescence (pXRF).

- ***X-ray diffraction (XRD)***

Diffractometric analyses were performed on powder samples using a Panalytical X'Pert PRO X-ray diffractometer with ϑ-ϑ goniometer geometry. The spectra were recorded between 3° and 75° 2ϑ with a scanning speed of 0.21°/sec, using Cu Kα radiation, a PW 3040/60 generator at 40kV (tube) and 40 mA (filament current), and a PW3015/20 X'Celerator solid-state multi-detector with Ni filter. The analyses were performed using slits 1 and ½ relating respectively to the anti-scatter slit and the divergence slit, and mask no. 15. The samples were prepared by pulverizing them with an agate mortar until they were reduced to a fine, homogeneous and representative powder. The powder samples were placed in the diffractometer sample holder (see Table 3).

Comparing the diffraction patterns: a clear correlation can be identified between all the powders analysed. The relative abundances are comparable, confirming a diffraction analogy among the mineralogical phases identified. Considering these initial data, which obviously require further confirmation, it can be hypothesized that these are basalts with a compositional volume attributable to Ol-Plag-Cpx-Opx (silica-saturated basalts), also known as olivine-tholeitic basalts.

- ***Portable X-ray Fluorescence (pXRF)***

XRF spectroscopy was performed using a portable XRF analyser (pXRF), Elio (Bruker), equipped with a Rh-target X-ray tube (10 kV – 50 kV, 5 μA – 200 μA, 4 W), and an SDD detector (17 mm^2 active area) with CUBE technology, featuring an energy resolution of <140 eV for Mn Kα, and a 1 mm collimator. The detectable elemental range spans from Mg (Z = 12) (with helium purge) to U (Z = 92). The instrument includes two positioning lasers (axial and focal) for alignment. The analyser is mounted on a motorized XY stage (travel range 100 mm × 100 mm) allowing for 2D mapping. The measurement head dimensions are 170 mm × 265 mm × 170 mm (W × D × H). Data acquisition is managed through the ELIO software package (see Figure 6).

Preliminary results and perspectives

Stylistic assessment and workshop hypotheses

The stylistic assessment of the lion corpus tentatively points to at least three sculptural/workshop traditions. In the current sample set, one tradition appears to be shared between Arslan Tash and Tell Ahmar, whereas distinct traditions are suggested for Hama and for Tell Halaf.

For Arslan Tash and Tell Ahmar, the leonine sculptures indicate familiarity with Assyrian visual models. The lions from East Gate at Arslan Tash and those from the Lion Gate at Tell Ahmar have been linked to the turtānu Šamšī-ilu; under his authority, Ninurta-bēl-uṣur - named in the inscription

Table 3. XRD results (xxx = main component; xx = secondary component; x = minor component).

	Feldspars					Piroxenes				
SAMPLE	labradorite	bytonite	sanidino	anortoclasio	anortite	augite	pigeonite	enstatite	olivine	forsterite
7519	xxx	xxx	xxx			xx	xx	xx	x	
O.1007	xxx	xxx	xxx			xx	xx	xx	x	
7523	xxx	xxx	xxx			x	xx	xx		x
7532	xxx	xxx		xxx		x	xx	xx		x
7536	xxx	xxx	xxx				xx	xx	x	
XXX6	xxx	xxx	xxx			xx	xx	xx		x
7561	xxx	xxx	xxx		xxx	xx	xx	xx	x	
7496	xxx	xxx	xxx		xxx	xx	xx	xx		x

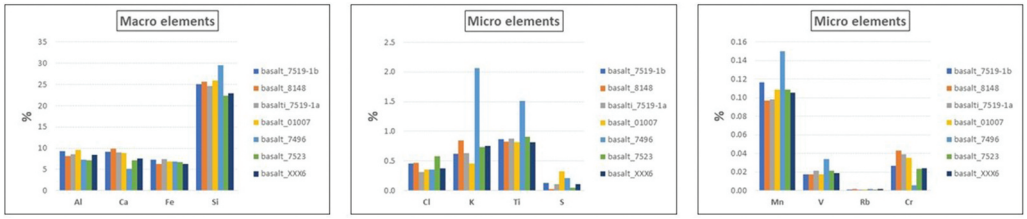

Figure 6. % content of the macro and micro elements: considering that Elio is not sensitive to Na content it is possible to observe that the samples analysed are quite similar except for 7496, and that the data acquired corroborates XRD results. Each measurement was performed in triplicate, with the mean value reported. The standard deviation for the lighter elements (Al, Ca, Si, Cl, and K) was less than 7%, while for the other elements, it was below 3%.

on one of the lions (sample XXX6) - served as a eunuch (Bunnens 2009; Orthmann et al.2013; Bonatz 2014).

At Hama, Riis and Buhul (1990) interpret the citadel lion protomes as reflecting different chronological phases and stylistic traditions. Ranging from archaizing treatments to more naturalistic renderings of higher technical quality. Within the framework adopted here, sample 8148 is best assigned to the archaizing tradition.

A further local workshop tradition may be proposed for Tell Halaf, where the chronology of the relevant production remain debated (Pucci 2008). Irrespective of its association with the so-called 'Flame and Frond Group', workshop specific traits are particularly evident in the figures carved on the so-called 'large orthostats' (Bonatz 2014, 217–221).

Geochemical patterns and implications for provenance

From the geochemical point of view, as indicated by the elemental concentration plots (macro and minor elements) and supported by comparison between diffractometric traces (see Supplementary Materials), the analysed samples generally form a centred cluster. Furthermore, observing the bivariate plot diagram (see Figure 7), it is not possible to identify a clear correspondence with the cluster of data literature, and therefore it is difficult to hypothesize with certainty a correlation between a specific archaeological context and its possible source of stone material. Sample 7496 represents an exception: given its position distinctly outside the main cluster in the Si–K bivariate plot, it is consistent with the elevated Si concentration observed in the elemental plots and histograms. This suggests a chemical composition that clearly differentiates this sample from the rest of the dataset, and particularly from the other samples from the same archaeological site (O.1007).

This data is particularly noteworthy because, as mentioned above, stele 7496 was not recovered *in situ*, but in a secondary context. It is also worth noting the presence of another stele, virtually identical from both iconographic and stylistic point of view (except for a groove at the centre of the relief, likely intended for reuse) which was likewise found out of context near the Turkish village of Germish, approximately 15 km west of the site of Karkemish (see Figure 8). In light of the considerations discussed above, it may therefore be suggested that the original context of stele-sample 7496 was not the site of Tell Ahmar.

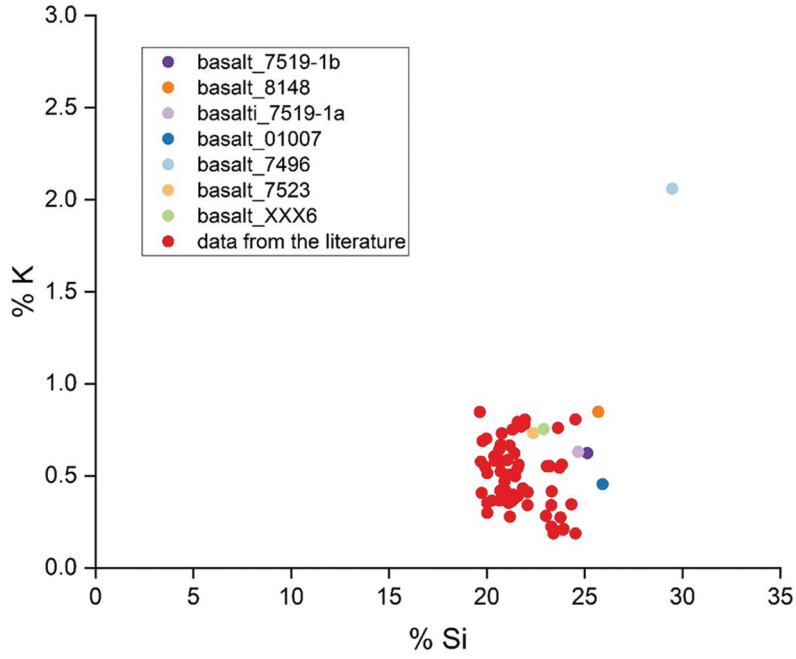

Figure 7. Coloured dots represent sculpture samples, plotted with published data (red dots group): Al-Mishwat and Dawod (2021), Novitskii, A. G., and Novitskii and Efremov (2013), Sharkov et al. (1994), Sharkov et al. (1996), Krienitz et al. (2006), Ma, George S-K., et al. (2013).

Figure 8. Comparison between the two stelae: 7496, left (photo by the author), stele from Germish, right (photo adapted from hittitemonuments.com © 1999–2025 Tayfun Bilgin).

Limitations and next analytical steps

Overall, the combined stylistic and analytical results underscore the need to broaden the evidential base to refine workshop attribution, assess possible workshop mobility, and clarify the relationship between production traditions and basalt procurement. Future work will therefore expand the dataset at a regional scale. Trace-element analyses (ICP-MS), coupled with multivariate statistics (including PCA), will be applied not only to the samples previously analysed by XRD and pXRF, but also to the remaining corpus. Where feasible, comparative geological basalt samples will also be incorporated. This integrated strategy applied in the PhD research will strengthen hypotheses grounded in both geochemical and archaeological evidence and will reduce speculative inferences regarding material acquisition, workshop mobility, and labour organization.

Notes

1. The subject of this contribution is currently under investigation within the framework of Cristiana Biancalani's doctoral research at the University of Florence (UniFi) and the National Research Council (CNR).
2. Mazzoni 1998 but also Abou 1990, and Özyar 2021.
3. Mazzoni 1984, Mazzoni 1997 and following; Bonatz 2000; Pucci 2008, 2015; Gilibert 2011, Herrmann 2017; other authors have employed different labels, such as: Neo-Hittite, Hawkins 2000; Late-Hittite, Orthmann 1971; Syro-Anatolian, Osborne 2021 or Nord-Syrian, Winter 1982; or Luwio-Aramean, Bonatz 2014.
4. See also Barnett (1957); Hermann (1989); Affanni (2009); Manuelli and Pittman (2018) for discussions of the origin and transmission of the *Flame and Frond School* models and the media employed.
5. In addition, a possible quarry area for the basalt used in the Temple of the Weather God on the Aleppo citadel has been identified 12 km southeast of Aleppo, near the villages of Arana and Safira. Cut marks and a roughly shaped block matching the temple's dimensions have been found there (Kohlmeyer 2020, pp.49–53).
6. See for example: Rockwell 1993, pp. 89 and following.
7. The Thureau-Dangin excavations were not completed in several areas of the site, and there's a lack of clear stratigraphy.
8. Albenda (1988, 27, note 2) suggests it may belong to the orthostats noted and documented by Hamdy Bey in 1883 and later described as undecorated by Thureau-Dangin et al. (1931, 78)
9. According to Prof. Dr Engin A. (pers. comm.) pXRF analysis were carried out on some sculptures from Yesemek and Zincirli in the attempt to understand whether the basalt stone used for Zincirli sculptures may have originated from Yesemek quarry.
10. Using a comparable method, Kelling et al. (2020) analysed sculptures from Karatepe-Aslantaş and Domuztepe. Their petrographic and microchemical study suggests that the Plio-Quaternary basalts used at Karatepe were transported along the Ceyhan River from a quarry area east of Domuztepe.
11. The results of the stylistic-iconographic analysis derive from a systematic approach developed during Cristiana Biancalani's MA thesis and through the study of all lion sculptures from Syro-Hittite Iron Age contexts.
12. This topic is still a matter of debate: Winter 1979; Çambel and Özyar 2003; Mazzoni 2008
13. Note that all the 4 sculptures belonging to this group appear to be damaged or eroded or not finished: all carved in limestone blocks. For a further discussion on this topic see: Manuelli, Di Filippo, 2021
14. The inverted tulip is intended here as an upside-down simplified tulip figure depicted in relief on the forelegs of the lion statues from Arslan Tash and Tell Ahmar.

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References

Abou, Assaf A. 1990. *Der Tempel Von ʿAin Dara (DaF3)*. Mainz am Rhein: Verlag Philipp von Zabern in Herder.

Affanni, G. 2009. "Ivories from the North West Palace at Nimrud." *Syrian and Phoenician Ivories of the Early First Millennium BCE: Chronology, Regional Styles and Iconographic Repertories, Patterns of Inter Regional Distributions*, 9–11 Dicembre 2004, Pisa.

Albenda, P. 1988. "The Gateway and Portal Stone Reliefs from Arslan Tash, in Bulletin of the American Schools of Oriental Research." No. 271 (Agosto 1988), 5–30.

Al-Mishwat, Ali T., and Safwan S. Dawod. 2021. "Geochemistry and Petrogenesis of Basaltic Rocks and Enclosed Xenoliths from the Ghab Pliocene Volcanic Field in Northwestern Syria." *International Journal of Geosciences* 12 (8): 667–688. https://doi.org/10.4236/ijg.2021.128038.

Barnett, R. D. 1957. *A Catalogue of the Nimrud Ivories: With Other Examples of Ancient Near Eastern Ivories in the British Museum*. London: Trustees of the British Museum.

Bonatz, D. 2000. *Das syro-hethitische Grabdenkmal: Untersuchung zur Entstehung einer neuen Bildgattung in der Eisenzeit im nordsyrisch-südostanatolischen Raum*. Mainz am Rhein: Philipp von Zabern in Herder.

Bonatz, D. 2014. *The Arameans in Ancient Syria, Section 1, the Near and Middle East VII, Art*, edited by Niehr Herbert, 205–253. Leiden, The Netherlands: Brill

Brew, G. E. 2001. "Tectonic Evolution of Syria Interpreted from Integrated Geophysical and Geological Analysis, Dissertation, Cornell University. January.

Brew, G. E. 2001a. "Structure and Tectonic Development of the Ghab Bain and the Dead Sea Fault System, Syria." *Journal of the Geological Society*, 665–674. Vol. 158.

Bunnens, G. 2009. "Assyrian Empire Building and Aramization of Culture as Seen from Tell Ahmar/Til-Barsib Syria." *Tome*, 86:67–82. https://doi.org/10.4000/syria.513.

Bunnens, G. 2022. *Tell Ahmar on the Syrian Euphrates, from Chalcolithic Village to Assyrian Provincial Capital*. Oxford and Philadelphia: Oxbow Books.

Çambel, H., and A. Özyar. 2003. "Karatepe-Aslantaş: Azatiwataya." Die Bildwerke, Mainz.

Di Paolo, S. 2014. "The Historiography of the Concept of 'Workshop' in Ancient Near Eastern Archaeology: Descriptive Models and Theoretical Approaches (Anthropology vs. Art History)." In *Critical Approaches to Ancient Near Eastern Art*, edited by M.H. Feldman and B. Brown, 111–132. Berlin: Walter De Gruyter.

Drüppel, K., A. Kratzig, G. Franz, H. Brätz, L. Martin, and S. Geismeier. 2011. "Aramaic Basalt Statues from Tell Halaf, Syria: Locating the Ancient Quarries." *Archaeometry 53*, Vol. 3, 441–468. https://doi.org/10.1111/j.1475-4754.2010.00549.x.

Duru, R. 2004. *Yesemek, the Largest Sculpture Workshop of the Ancient Near East*. Istanbul: TURSAB Kultur Yayinlari.

Fugmann, E. 1958. *Hama, Fouilles Et Recherches 1931-1938, II L'Architecture Des Périodes Pré-Hellenistiques*. Copenhagen: Wendt & Jensen.

Gilibert, A. 2011. *Syro-Hittite Monumental Art and the Archaeology of Performance, The Stone Reliefs at Carchemish and Zincirli, in the Earlier First Millennium BCE*, edited by Excellence Cluster Topoi. Berlin: De Gruyter.

Hawkins, J. D. 1982. "The Neo-Hittite States in Syria and Anatolia." In *The Cambridge Ancient History*, edited by J. Boardman, I. E. S. Edwards, N. G. L. Hammond, and E. T. Sollberger, Vol. 3, 372–441. Cambridge University Press.

Hawkins, J. D. 2000. *Corpus of the Hieroglyphic Luwian Inscriptions*. Vol. 1. Berlin, New York: Inscriptions of The Iron Age, De Gruyter.

Hermann, G. 1989. "The Nimrud Ivories, 1: The Flame and Frond School." *Iraq* 51:85–109.
Herrmann, V. 2017. "Appropriation and Emulation in the Earliest Sculptures from Zincirli (Iron Age Sam'al)." *American Journal of Archaeology* 121 (2): 237–274.
Kelling, G., S. Kadir, S. Kapur, E. Akça, Z. Yeğingil, and M. Eren. 2020. "Provenance of the Materials Used to Make Some Late Hittite Monuments at the Karatepe-Aslantaş and Domuztepe sites, Cilicia (southern Turkey)." In *Archaeological and Anthropological Sciences*, Vol. 12, 1–10. Springer-Verlag GmbH.
Kohlmeyer, K. and A. Kai-Browne 2020. *The Temple of the Weather God of Aleppo*, edited by J. Gonnella, Y. Kanjou, W. Khyatta, K. Kohlmeyer, and H. Zeineddin. Münster: Münster Rhema.
Krienitz, M.-S., K. M. Haase, K. Mezger, V. Eckardt, and M. A. Shaikh-Mashail. 2006. "Magma Genesis and Crustal Contamination of Continental Intraplate Lavas in Northwestern Syria." *Contributions to Mineralogy and Petrology* 151 (6): 698–716. https://doi.org/10.1007/s00410-006-0088-1.
Lease, N. 2000. "Charactérisation Pétrologique et Étude Géologique de la Provenance d'Artefacts en Basalte du Troisième Millénaire av. J.-C. du Nord-Est de la Syrie, Unpublished Ph.D. thesis, Canada: University of Laval.
Ma, G. S. K., J. G. Malpas, K. Suzuki, C.-H. Lo, K.-L. Wang, Y. Iizuka, and C. Xenophontos. 2013. "Evolution and Origin of the Miocene Intraplate Basalts on the Aleppo Plateau, NW Syria." *Chemical Geology* 335:149–171.
Manuelli, F., and F. Di Filippo. 2021. "Hic Sunt Leones. Iconographic Analysis and Computational Modelling for the Study of the Iron Age Free-Standing Lions of the Elbistan Plain (South-Eastern Anatolia), in ASIANA, Asia Anteriore Antica." *Journal of Ancient Near Eastern Cultures* 3: 43–72. December, Firenze University Press.
Manuelli, F., and H. Pittman. 2018. "A Flame and Frond Ivory Plaque from the Neo-Hittite Excavations at Arslantepe/Melid." Regionalism and Communities in Iron Age Anatolia, in ORIGINI XLI, 139–169.
Mazzoni, S. 1984. "Sikizlar: Una Cava d'Età Siro-Ittita." In Studi Micenei ed Egeo-Anatolici , Fascicolo XXIV, In *Memoria di Piero Meriggi (1899-1982)*, 233–243. Roma: Incunabola Graeca, Edizioni dell'Ateneo.
Mazzoni, S. 1986. "A Sculptures Quarry at Sikizlar." *Annales Archéologiques Arabes et Syriennes*. XXXVI–VII.
Mazzoni, S. 1997. "L'Arte Siro-Ittita nel Suo Contesto Archeologico." *Contributi e Materiali di Archeologia Orientale VII*. Studi in Memoria di Henri Frankfort (1897 1954), (a cura di) MATTHIAE P. Roma, Università degli Studi di Roma "La Sapienza".
Mazzoni, S. 1998. "La Siria nell'Età del Ferro. Un Modello di Sviluppo." *ISIMU. Revista Sobre Oriente Próximo Y Egypto En La Antigüedad* 1:13–24.
Mazzoni, S. 2008. "Karatepe-Aslantaş: Azatiwataya. Die Bildwerke." *Aja Online Publications*, Book Review.
Mazzoni, S. 2009. "Ivories and Art Traditions in the Hama Region." *Syrian and Phoenician Ivories of the Early First Millennium BCE: Chronology, Regional Styles and Iconographic Repertories, Patterns of Inter Regional Distributions*, edited by ETS, 9-11 Dicembre 2004, Pisa.
Mazzoni, S. 2013. "Arts and Cross-Cultural Communications in The Early First Millennium: The Syro-Anatolian Contact." *Across the Border: Late Bronze-Iron Age Relations between Syria and Anatolia. Proceedings of a Symposium held at the Research Center of Anatolian Studies*, Koc University, Istanbul, 465–492. Leuven: Koc University.
Novák, M. 2016. "Assyrians and Arameans, Models of Cohabitation and Acculturation at Guzana (Tell Halaf)." In *Assyria to Iberia, Art and Culture in the Iron Age, the Met, Symposia, 23*, edited by J. Aruz and M. Seymour. New Haven and London: Yale University Press.
Novitskii, A. G., and M. V. Efremov. 2013. "Technological Aspects of the Suitability of Rocks from Different Deposits for the Production of Continuous Basalt Fiber." *Glass and Ceramics* 69 (11): 409–412. https://doi.org/10.1007/s10717-013-9491-z.
Orthmann, W. 1971. *Untersuchungen zur Spathetetischen Kunst*. Bonn: Rudolf Habelt Verlag.
Orthmann, W., W. Orthmann, P. Matthiae, and M. Al-Maqdissi, eds. 2013. "Stone Sculpture of the Iron Age in Northern Syria." *Archéologie et Histoire de la Syrie I, La Syrie de l'époque néolithique à l'âge du fer*, 525–542. Wiesbaden: Harrasowitz Verlag.
Osborne, J. F. 2021. *Syro-Anatolinan City States, an Iron Age Culture*. Oxford: Oxford University Press.
Pucci, M. 2008. *Functional Analysis of Space in Syro-Hittite Architecture*, edited by Hadrian Books LTD. BAR International Series. Oxford, England: Archaeopress, Publishers of British Archaeological Reports.
Pucci, M. 2024. "National Museum of Aleppo." In *Cultural Heritage and Development in Fragile Contexts, Research for Development*, edited by M. Loda and P. Abenante, 185. https://doi.org/10.1007/978-3-031-54816-1_12.
Riis, P. J., and M. L. Buhul. 1990. *Hama, Fouilles et Recherches 1931–1938, Les Objets de la Période Dite Syro-Hittite (Âge du Fer)*. NSK XII, København: Nationalmuseet Antiksamlingen.
Rockwell, P. 1993. *The Art of Stoneworking*. Cambridge, New York: Cambridge University Press.

Rukieh, M., V. G. Trifonov, A. E. Dodonov, H. Minini, O. Ammar, T. P. Ivanova, T. Zaza, A. Yusef, M. Al-Shara, and Y. Jobaili. 2005. "Neotectonic Map of Syria and Some Aspects of Late Cenozoic Evolution of the Northwestern Boundary Zone of the Arabian Plate." *Journal of Geodynamics* 40 (2–3): 235–256. https://doi.org/10.1016/j.jog.2005.07.016.

Sharkov, E. V. 1998. "New Data on the Geochronology of Upper Cenozoic Plateau Basalts from the Northeastern Periphery of the Red Sea Rift Area (Northern Syria)." *Doklady Earth Sciences* 358 (1): 19–22.

Sharkov, E. V., I. V. Chernyshev, E. V. Devyatkin, A. E. Dodonov, V. V. Ivanenko, M. I. Karpenko, Yu G., et al. 1994. "Geochronology of Late Cenozoic Basalts in Western Syria." *Petrology* 2 (4): 385–394.

Sharkov, E. V., G. A. Snyder, L. A. Taylor, E. E. Laz'ko, E. Jerde, and S. Hanna. 1996. "Geochemical Peculiarities of the Asthenosphere Beneath the Arabian Plate: Evidence from Mantle Xenoliths of the Quaternary Tell-Danun Volcano (Syrian-Jordan Plateau, Southern Syria)." *Geochemistry International* 34 (9): 737–752.

Thureau-Dangin, F. 1931. *Arslan Tash*, edited by F. Thureau-Dangin, A. Barrois, M. Dunand, and G. Dossin. Paris: Librairie Orientaliste Paul Geuthner.

Trifonov, V. G., A. E. Dodonov, E. V. Sharkov, D. I. Golovin, I. V. Chernyshev, V. A. Lebedev, T. P. Ivanova, et al. 2010. "New Data on the Late Cenozoic Basaltic Volcanism in Syria, Applied to Its Origin." *Journal of Volcanology and Geothermal Research* 199 (2011) (3–4): 177–192. https://doi.org/10.1016/j.jvolgeores.2010.01.013.

Von Oppenheim, M. F. 1931. *Der Tell Halaf, eine neue Kultur im ältesten Mesopotamien*. Leipzig: F. A. Brockhaus.

Von Oppenheim, M. F. 1955. *Tell Halaf. Dritter Band: Die Bildwerke*. Berlin: Walter de Gruyter & Co.

Winter, J. I. 1979. "On the Problems of Karatepe, the Reliefs and Their Context." *Anatolian Studies 29* 29:115–151. https://doi.org/10.2307/3642735.

Winter, J. I. 1982. "Art as Evidence for Interactions: Relations Between Assyrian Empire and North Syria." *Mesopotamien und Seine Nachbarn—XXV Recontre Assyriologique Internationale*. Berlin. 2–7 July 1978, edited by Hans J. Nissen and Johannes Renger. Berlin: Reimer.