DEWA 2023: From Mine to Object. Dialogues between Eastern and Western Archaeometallurgy (3rd-1st millennium BC)
actes de la séance conjointe de la Société préhistorique française
et de l'Association pour la promotion des recherches sur l'âge du Bronze
Musée d'archéologie nationale - Domaine national de Saint-Germain-en-Laye, 22-24 novembre 2023
Textes publiés sous la direction de Z. Hashemi, M. Nordez, M. Sauvage et C. Mordant
Paris, Société préhistorique française, 2026
(Séances de la Société préhistorique française, 26), p. 315-340
www.prehistoire.org
ISSN : 2263-3847 – ISBN : 978-2-9588382-5-6

Gold from the desert: Exploring the possibility of precious metal artefact production at Iron Age Saruq al-Hadid (Dubai, UAE)

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Abstract: Saruq al-Hadid (Dubai, UAE) is one of the most significant but enigmatic archaeological sites in southeastern Arabia and is characterised by a great quantity and diversity of deposited artefacts. Particularly noteworthy are copper-base, iron, and precious metal objects, often found alongside related production debris. The site was occupied from at least the 3rd millennium BCE through to the Iron Age, with periodic reuse in the late pre-Islamic and early Islamic periods. However, most artefacts can be attributed to the Iron Age, reflecting the site's significance and integration within extensive economic and cultural networks at that time. These materials are buried within sand dunes up to 6 m deep and spread across an area of about 1 km^2. This makes it challenging, from an archaeological perspective, to establish direct associations between finished artefacts and production debris. Consequently, analytical studies were employed to explore the potential existence of on-site workshops, and the relation between finished and semi-finished artefacts and working debris, in addition to studies on composition and working techniques and the provenance of raw materials. This paper focuses on precious metal artefacts – made of gold, silver and electrum – and the potential existence of on-site workshops for their production. We discuss a variety of production techniques and possible cultural preferences regarding style and colour. The range of artefacts raises the question of Saruq al-Hadid's role and importance within local and long-distance networks of cultural contact and exchange in the Iron Age.

Keywords: exchange networks, gold, granulation, Iron Age, precious metal production, southeastern Arabia, working techniques.

Résumé : Saruq al-Hadid (Dubaï, Émirats arabes unis) est l'un des sites archéologiques les plus importants, mais aussi les plus énigmatiques du sud-est de la péninsule Arabique. Il se distingue notamment par la grande quantité et la diversité des artefacts qui y ont été découverts. Parmi ceux-ci, les objets en cuivre, en fer et en métaux précieux sont particulièrement remarquables, souvent retrouvés avec des résidus liés à leur production.
Le site fut occupé dès le III^e millénaire avant notre ère et jusqu'à l'âge du Fer, avec des réoccupations périodiques à la fin de la période préislamique et au début de la période islamique. Toutefois, la majorité des artefacts datent de l'âge du Fer, témoignant de l'importance du site et de son intégration dans de vastes réseaux économiques et culturels à cette époque.
Ces matériaux sont enfouis sous des dunes de sable pouvant atteindre six mètres de profondeur et répartis sur une superficie d'environ un kilomètre carré. Cela complique, d'un point de vue archéologique, l'établissement de liens directs entre les objets finis et les déchets de production. Ainsi, des études analytiques ont été menées afin d'examiner la possible existence d'ateliers sur le site, ainsi que les relations entre artefacts finis, semi-finis et déchets de travail. Ces recherches portent également sur la composition, les techniques de fabrication et la provenance des matières premières.
Cet article se concentre sur les artefacts en métaux précieux – or, argent et électrum – et sur la possible existence d'ateliers locaux dédiés à leur production. Il aborde différentes techniques de fabrication et les préférences culturelles potentielles en matière de style et de couleur. La diversité des artefacts soulève enfin la question du rôle et de l'importance de Saruq al-Hadid dans les réseaux de contact et d'échanges culturels, tant locaux que longue distance, à l'âge du Fer..

Mots clés : âge du Fer, granulation, métallurgie, orfèvrerie, techniques, péninsule Arabique, réseaux d'échanges.

The fascination with precious metal artefacts and the skilled techniques associated with their production has a long tradition, as attested by the interest of ancient historians, such as Herodotus, Pliny the Elder, Gregorius Agricola or Vanoccio Biringuccio, in collecting and reporting on production techniques and recipes (e.g. Carroll, 1974 or Moorey, 1994). This fascination continues today, with an expanding corpus of research on ancient gold enhancing our understanding of the subject. The archaeological exploration of ancient production processes and associated precious metal workshops, however, remains incomplete and ongoing, in part because precious metal artefacts are more often restricted for analysis than other archaeological materials.

In this context, the large corpus of precious metals from Saruq al-Hadid (Dubai, UAE) is an important source of information, offering the potential to expand our knowledge of ancient precious metal production and use. Saruq al-Hadid is well known for its rich and varied material assemblage, comprising, for example, copper-base and ferrous artefacts, copper-base production debris, pottery often decorated with snake imagery, decorative shells, soft stone vessels, semi-precious stones in the form of beads or seals, and wooden artefacts (Karacic et al., 2017; Weeks et al., 2017; Boraik Radwan, 2018; Roberts et al., 2019; Stepanov et al., 2019; Weeks, 2023).

A distinct characteristic of the site is its location within the northern extension of the Rub' al-Khali desert, in a still active dune field (figs. 1 and 2). The site was

Fig. 1 – Location of the sites discussed in this article (©David-Cuny).

intermittently occupied from the Neolithic period, with more persistent if seasonal occupation from the Bronze Age, but its largest corpus of finds belongs to the early Iron Age (Iron II period) deposits dating to c. 1000-800 BCE (fig. 3). Subsequent phases of occupation can be identified from the late pre-Islamic period into the early Islamic period in the 11th century AD (Weeks et al., 2019a; Weeks et al., 2023; Franke, in press). Within the ongoing discussion of the nature of human occupation of the site, Weeks et al. (2018) proposed a temporary (likely seasonal) but persistent use of the location. This comprises in particular the stratigraphic units of Horizon II dating to the Iron II period, from which also the majority of precious metal finds derive (table 1).

At this time, socio-economic and ritual aspects shaped the site's material culture; persistent temporary (seasonal) gatherings of groups that can be documented at Saruq al-Hadid represent an important mobile aspect of the Iron Age settlement landscape in southeastern Arabia, otherwise known largely from sedentary sites.

At Saruq al-Hadid, gold and silver-base finished artefacts are present in various shapes and kinds ranging from jewellery to decorative and ritualised artefacts. Most precious metal finds are varieties of beads or small ringlets in addition to plaques and singularities, such as finger rings or miniature artefacts (Boraik Radwan, 2018, GR 5547; Valente et al., 2020, fig. 13). The contemporary appearance of working remnants—in the form of foils, sheets, ribbons and wires, as well as semi-finished or broken precious items—indicates the possibility of gold and silver working at the site. Moreover, the presence of both finished and semi-finished precious metal artefacts raises the question of whether, and to what extent, these material groups might reflect a *chaîne opératoire* for the production of precious metal artefacts on site during the early Iron Age. This question arises as there is little to no direct evidence, in the form of pyrotechnological installations or tools, for spatially delimited precious metal working areas at Saruq al-Hadid.

Furthermore, particular types of gold beads seem to dominate the archaeological record and raise questions regarding the possibility that Saruq al-Hadid may have been not only a production centre connected to the wider region but also a centre that influenced stylistic norms of gold jewellery production and use during the Iron Age. The production of artefacts in other materials is attested at Saruq al-Hadid. For example, production and use of stone tools is evident for the Early and Middle Bronze Ages (Moore et al., 2022; Al-Kassem et al., 2024), while copper smelting and working residues are a significant part of the Iron Age material record of the site (Weeks et al., 2023). Later occupation layers from the pre-Islamic and early Islamic eras exhibit events of scavenging and the recycling of not only copper but also iron (Franke, 2017a; Stepanov et al., 2019; Valente et al., 2020; Franke, in press). Residues from the carving of shell and animal bone are also known from prehistoric contexts at the site, and woodworking might also have been undertaken there (Weeks et al., 2017, fig. 7, 10; Weeks et al., 2019b). The combined evidence indicates an environment that—despite its location in the desert fringes—was an important place not only for communal gathering but also for craft activities.

Such remains, furthermore, highlight the importance of Saruq al-Hadid within Iron Age exchange networks in southeast Arabia and beyond. The precious metal artefacts from Saruq al-Hadid are not singular to the site, and parallels are known from the wider Near East. It is, however, striking that no other sites in southeastern Arabia exhibit comparable amounts of finished precious metal artefacts or working residues. This raises the possibility that Saruq al-Hadid may have functioned as a (or even *the*) primary location for the production and distribution of such artefacts.

Previous research has shown that Saruq al-Hadid is part not only of regional exchange networks but also of long-distance exchange systems. Wood specimens from the site, for example, have been identified as potential imports from the Levant or Iran (Newton, 2016), while iron sword fragments and bi-metallic daggers connect the site by their style, type and geochemical composition to northern Iran (Stepanov et al., 2019; Weeks and Petrie, in press). Copper-base braziers display imagery that is unprecedented in the region and links the site to northern Mesopotamia (Potts, 2009), while depictions carved on marine shells resemble Assyrian iconography (Weeks et al., 2019b) and (imitations of) scarabs connect the site, possibly indirectly, to Egypt and the Levant (Boraik Radwan, 2018, p. 148–149). This evidence clearly shows that Saruq al-Hadid was deeply enmeshed in expansive Iron Age trade networks that facilitated the exchange of materials, technology, imagery and ideas. In this paper, we explore whether Saruq al-Hadid was a production centre for precious metal artefacts during the early Iron Age. We focus on three major questions:

1) Can waste and production materials from the site be linked with finished artefacts found there?

2) To what extent can we establish a *chaîne opératoire* for the production of gold and silver-base artefacts on site? And, if production is indicated;

3) Were gold and silver-base artefacts produced exclusively for the site itself, or were those products part of the wider exchange system of Iron Age southeastern Arabia?

These questions are explored through macroscopic and microscopic observations as well as geochemical analysis of artefacts and production residues, alongside consideration of their archaeological contexts and dating. We focus primarily on finds excavated during three field seasons of the Saruq al-Hadid Archaeological Research Project (SHARP) at the site from 2014 to 2017 (Weeks et al., 2017; Weeks et al., 2018). In addition, we incorporate finds excavated by the Polish Mission (Wygnańska et al., 2022) and already published data in particular from the Sanisera Archaeology Institute team (Soriano et al., 2018), alongside finds from excavations by the Dubai Municipality and other teams published in the Saruq al-Hadid Archaeological Museum catalogue (Boraik Radwan, 2018).

Fig. 2 – Different kinds of beads found in their original arrangement in the central sector at Saruq al-Hadid (©Dubai Culture & Arts Authority).

ON STRATIGRAPHY

The stratigraphic relationships of precious metal artefacts from Saruq al-Hadid are difficult to understand due to the site's complex taphonomy (fig. 3). The majority of gold-base artefacts (n = 65) derive from relatively secure Iron II period contexts within Horizon II and a significant but lower number (n = 43) were excavated within mixed early Iron Age contexts of Horizons I-II (table 1). This describes an intermediate phase between the upper strongly mixed layers in Horizon I (spanning the early Iron Age to the early Islamic period) and the Iron II period deposits of Horizon II.[1] A small number of gold-base artefacts (n = 10) came from Iron I layers within 'concentrated activity areas' of Horizon III (c. 1300-1000 BCE). A single silver-base artefact was recovered from the Wadi Suq to Late Bronze Age layers of Horizon IV (c. 1750-1300 BCE), and no gold-base artefacts were excavated within the earliest layer, Horizon V, dating to the early Wadi Suq period (c. 2000-1750 BCE).[2] The precious metal finds from Horizons IV and III are typologically similar to artefacts from the later Iron Age Horizons, and may be intrusive within these early strata, reflecting the taphonomy of the site and the effect of moving sand dunes. A further five gold-base artefacts were found within the surface layers of Horizon I; and 19 artefacts were not assigned to contexts. The concentration of precious metal finds within Horizon II suggests most silver and gold-base artefacts from Saruq al-Hadid were deposited during the Iron II period, specifically from c. 1000-800 BCE based on a substantial series of radiocarbon determinations (Weeks et al., 2019a; Alkhalid et al., 2024; here: table 1).

ON THE KINDS OF ARTEFACTS

The assemblage of precious metal artefacts from Saruq al-Hadid comprises a large variety of kinds, styles and types of artefacts, and represents one of the largest corpora of precious metals in ancient Arabia. During three SHARP excavation seasons alone, 143 items (table 1) came to light, of which 62 are finished artefacts and 81 are different kinds of working remnants and misfit. The Sanisera Archaeology Institute Mission excavated more than 448 individual items during four long seasons (Soriano et al., 2018, p. 1) and the excavations of the Polish Centre of Mediterranean Archaeology (2017–2018) and Polish Archaeoconsultant company (2019–2020) excavated 59 precious metal artefacts (table 1). These numbers might easily be doubled, as they do not include multiple gold finds from earlier excavations by the Jordanian Mission and Dubai Municipality (Al-Khraysheh and An-Nashef, 2007, p. 81–89; Nashef, 2010; Herrmann et al., 2012, fig. 6c-e) and unpublished artefacts excavated by further teams from, for example, Germany (Dr. Thomas Urban and Partner, Brandenburg; Tübingen University) and Spain (Seville University).

The majority of finished artefacts can be categorised as jewellery and within this category, beads are the most common artefact type. Rings (open and closed) are much less frequent. They may have been finger, toe, ear or nose rings but may also have been used in the decoration of hair or fabrics. Bracelets, on the other hand - which are common among copper-base artefacts at Saruq al-Hadid —are not known among the precious metal finds from the site.

Many beads comprise a combination of individual spheres that are shaped into small ringlets with an average size of about 4–10 mm in diameter; individual granules are on average about 0.8 mm in diameter with few smaller and larger exceptions (Weeks et al., 2017, fig. 22; Al-Khraysheh and An-Nashef, 2007, p. 86–88; here: fig. 4, nos. 11–16). Very rare exceptions are ringlets with only five to six spheres, but which are about 3 to 10 mm in diameter. These beads can be elaborated by the addition of extra rows of spheres, either horizontally or vertically. Beads that are built from horizontally-added rows consist of two rows only (fig. 4, nos. 11 and 14), whereas beads built from vertically-added (stacked) spheres are typically arranged into tubular compositions that are two to 12 rows or more long (fig. 4, nos. 12, 15 and 19). A small number of artefacts combine spheres with sheet metal or filigree to create complex compositions. Prominent examples are beads

1. For a detailed discussion of the stratigraphy at Saruq al-Hadid see Weeks et al., 2019a and, more recently, Alkhalid et al., 2024.
2. In total, three silver-base beads were registered during SHARP excavations, one of which derived from the intermediate phase Horizons I-II, a second one was found within deposits of Horizon IV and a third artefact was unstratified.

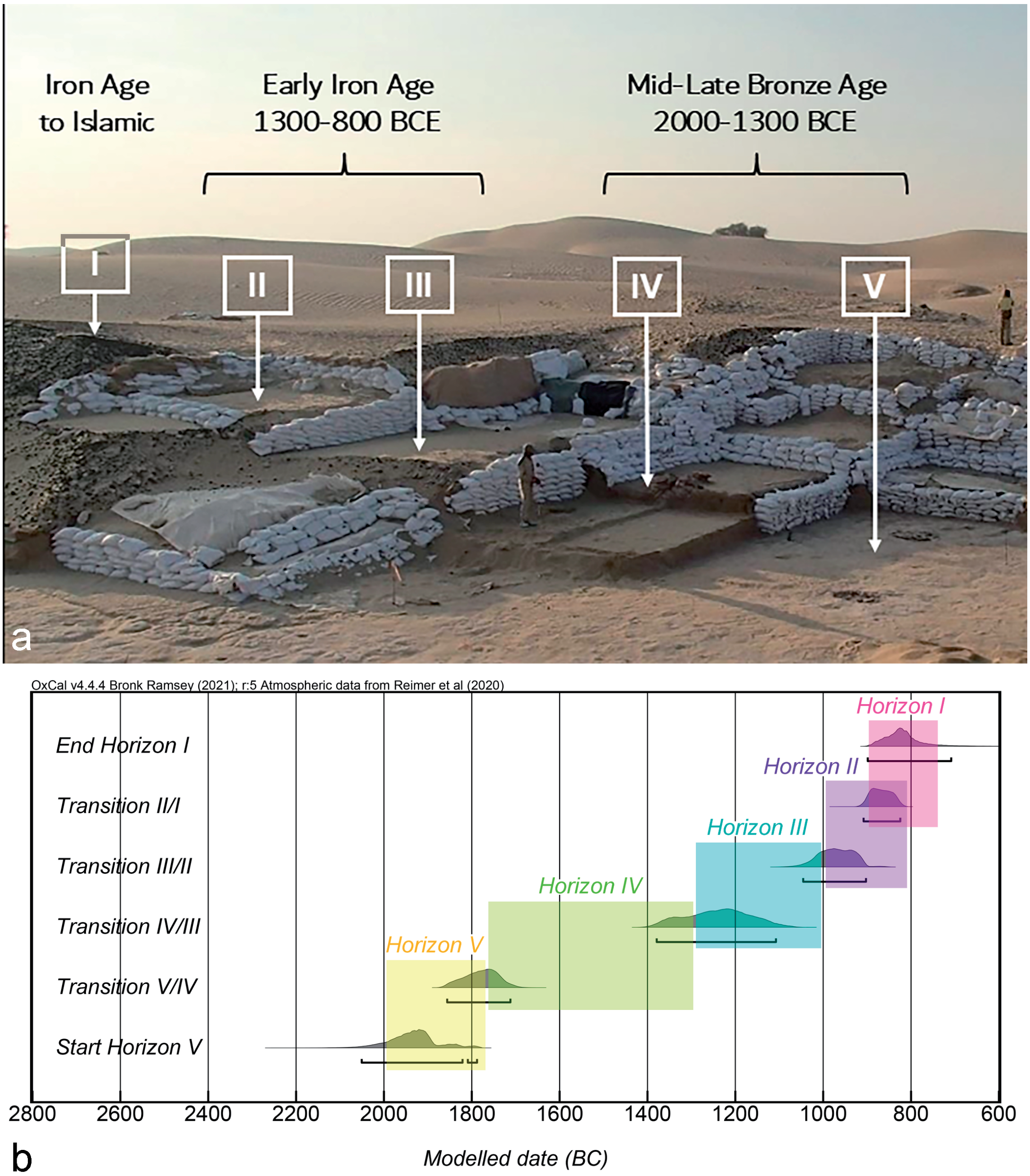

Fig. 3 – Chronological boundaries of the archaeological horizons at Saruq al-Hadid, based on modelled radiocarbon determinations and typological analyses of ceramics (Weeks et al., 2019a).

Horizon	**Period**	**Description**	**No. gold and silver-base finds**	
			SHARP	Polish Mission
I		Surface	5	0
Between [I-II]	EIA+	[slump]	43	8
II	Early Iron Age	Dispersed varied activities	65	51
III	IA I	Concentrated activities	10	0
IV	Wadi Suq - LBA	Midden deposit	1 (Ag)	0
V	Wadi Suq	Diffuse midden, structures	0	0
Other	[unassigned]		19 (2 × Ag)	0
Total			**143**	**59**

Table 1 – Number of gold and silver-base artifacts in the respective horizons excavated at Saruq al-Hadid. Note that the majority of finds derived from IA II contexts.

Fig. 4 – The assemblage of precious-metal artefacts from Saruq al-Hadid comprises a great variety of finished artefacts, as well as working remnants and misfits (©SHARP/David-Cuny).

with a conical sheet metal body that was capped with one to three rows of spheres at their lower and upper ends (fig. 4, no. 18). In addition to beads, finger rings and pendant-like artefacts were also produced in intricate arrangements combining sheet metal, spheres and filigree (Boraik Radwan, 2018, p. 107, 116–117).

The second most common group of beads on the site includes a wide range of spherical, cylindrical or barrel shaped beads (fig. 4, nos. 1-6). While the latter comprise the largest group within sheet-beads, a typological differentiation between various kinds of spherical sheet-beads is not always decisive (Weeks et al., 2017, fig. 22; Al-Khraysheh and An-Nashef, 2007, p. 84); variations may have been common and 'perfection' not a necessity. Barrel beads are in most cases between 2 and 5 mm in length, with an average diameter of c. 3-5 mm but can be exceptionally larger or smaller; decorations, such as indents, are rare (here: fig. 4, no.3; Boraik Radwan, 2018, GR1868, bottom left).

A rather extraordinary type is described by the term 'horn-shaped artefact', several design variations of which are found at the site (fig. 4, no. 23 and fig. 5). Typically, these are bi-metallic, comparatively dense and massive items, consisting of a (potentially cast) silver core covered with a gold-base foil (Al-Khraysheh and An-Nashef, 2007, p. 85; Boraik Radwan, 2018, p. 108). Variations are commonly seen in their horn-like extensions, which can either be straight, or bent inwards or outwards, and also within their broadly cylindrical cores that are worked into different shapes and sizes. A shallow depression can frequently be found in the top of the core element between the horn-shaped appendages and opposite a central seam-like extension (variant 1); but the exact extension and shape of these details vary among individual artefacts. Only a few examples do not exhibit a seam-like extension (variant 2). On average, these items are about 15–30 mm wide and about 20–30 mm long, and weigh about 30 to 40 g, placing them among the heaviest precious metal artefacts from the site.

The function of the horn-shaped artefacts is still uncertain, but they are often described as hair accessories, or nose or earrings (compare, e.g. Boraik Radwan, 2018, fig. 23 and Soriano et al., 2018, p. 3), although no functional details conclusively indicate how these artefacts may have been worn. However, it is possible that they had a purely symbolic function and were experienced in this form as finished and complete. Rare jewellery items are so-called cage-beads (fig. 4, no. 20), a term that describes an intricate filigree arrangement of (nearly) completely fused but originally twisted wires that either leave an open space in their centre—which is why they are associated with cages—or spiral around a core (Weeks et al., 2017, fig. 22, SF29674; Boraik Radwan, 2018, p. 109). Several artefacts display filigree work or show designs with spheres that appear to have been prepared for mounting semi-precious stones. These include (finger) ring fragments worked in filigree, a carnelian pendant mounted on a metal sheet and adorned with spheres, and tassel-shaped objects crafted from twisted strips (or wires), topped with spheres and two wire-like extensions (Soriano et al., 2018, fig. 10; Boraik Radwan, 2018, p. 107 and 116–117). Twisted strips are also used in the production of elongated 'tubular' beads that are capped with spheres at their top and bottom (Boraik Radwan, 2018, p. 110). None of the latter items were discovered in SHARP excavations, but they are known from other areas of the site.

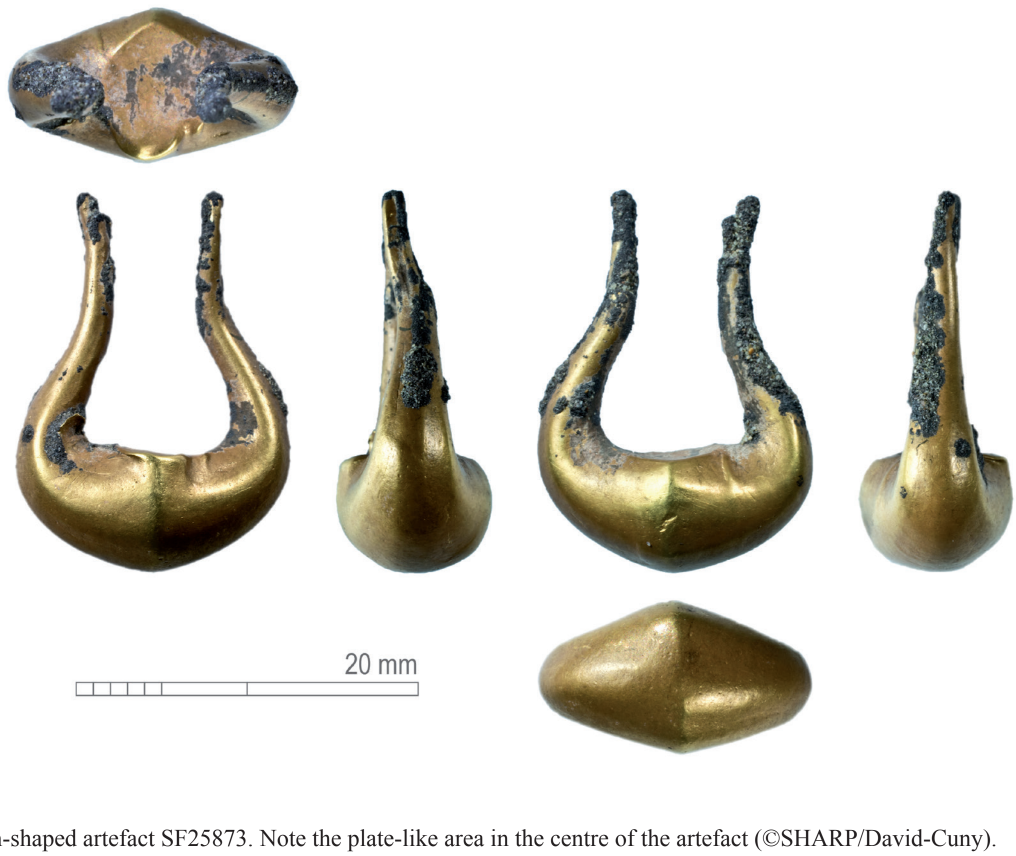

Fig. 5 – Horn-shaped artefact SF25873. Note the plate-like area in the centre of the artefact (©SHARP/David-Cuny).

Decorative and non-jewellery items include plaques, which comprise a minority of precious metal items on the site. Some of these metal sheets are blank, but the majority are decorated with depictions of geometrical patterns or zoomorphic figures commonly worked in *repoussé* (fig. 4, nos. 24 and 25). In most cases the plaques show piercings at their edges, indicating that they may originally have been intended to be attached to garments or wooden items (fig. 4, nos. 10, 24, 25). A particularly well-crafted example depicts a hare (fig. 4, no. 24). Noteworthy are the edges of the sheet metal that are so tightly cut off at the section displaying the hare's ear, an imperfection that contrasts with the otherwise delicate depiction of the animal. Here, the cut is—in contrast to all other three corners —rounded, and it is possible that it stems from a secondary treatment related to the reuse or recycling of the sheet.

A small minority of gold-base items can be related to the group of symbolic, ceremonial or potentially ritual (miniature) artefacts. Despite their absence within SHARP excavations, they are an important group of gold-base artefacts that are strongly interwoven with the symbolic and ritual nature of the site (Weeks et al., 2023). Their presence in areas other than the SHARP excavations may be an indication of their spatial importance within the site as a whole. Among those are a miniature bow with a quiver (Valente et al., 2020, fig. 13), and miniature snake 'figurines' or figurative animal depictions (Boraik Radwan, 2018, p. 113 and 115). All of these items have copper-base counterparts, and their rare occurrence in precious metals highlights the wider significance of these symbols for the site and its participating communities.

Only a few artefacts are best described as misfits, failures or unfinished artefacts. Evident examples are a bead worked from gold-base sheet metal and a gold-base wire-shaped ringlet with a ribbon fused onto it. The latter artefact seems to be a misfit during working and may have been kept as spare material (fig. 4, no. 21). The sheet bead shows its originally inward-folded (upper and lower) edges bent upwards and seems to have been—possibly intentionally—unfolded (fig. 6). This effect classifies the bead as a working remnant rather than damaged during burial conditions or failure. A particularly important example is a small ring-shaped item with indents on its outer surface (fig. 7, no. 1). It is a perfect facsimile of two finished artefacts from the site that show granulated spheres that were brazed into such indents within a ring-base (fig. 7, no. 2).

A particular group among the working remnants are partly fused, cut, split, twisted or knotted wires, strips and ribbons that reflect working techniques evidenced in finished artefacts from the site (fig. 8). These kinds of

Fig. 6 – The upper and lower rims of sheet bead SF26345 seem to have been intentionally unfolded possibly to reuse the material. Note the original edges that were roughly cut (©SHARP/David-Cuny).

Fig. 7 – SF33355 (1) is a perfect facsimile of finished artefacts from the site; the indents were possibly intended to be filled with granules, as seen in the finished specimen SF21804 (2) (©SHARP/David-Cuny).

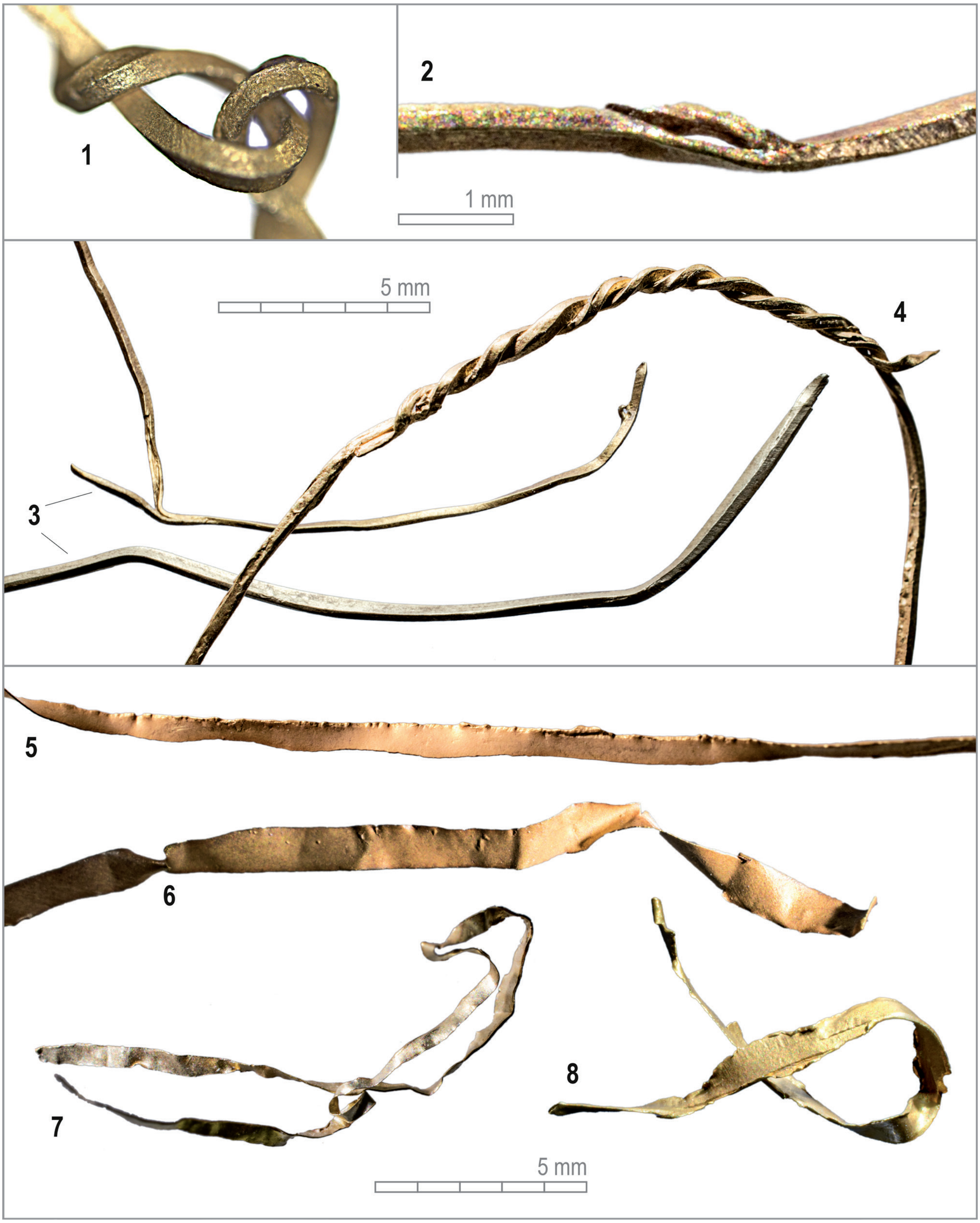

Fig. 8 – Golden wires and ribbons from Saruq al-Hadid often show signs of processing such as twisting, splitting, cutting or knotting. Note the incised marks along the cutting edges of nos. 5 and 8 (©SHARP/David-Cuny).

pre-worked items are often found in bundles that mark them as potential spare working material (fig. 4, nos. 7 and 8). Only a few of them were discovered, but they are part of a larger corpus of bundled or unbundled semi-finished strips, ribbons, wires or sheet fragments (see also Al-Khraysheh and An-Nashef, 2007, p. 83). Ribbons often display indented linear marks along their cut edges (fig. 8, nos. 5 and 8), indicating that they were cut from larger sheet metal units for further processing. More importantly, these marks show that ribbons were not ran-

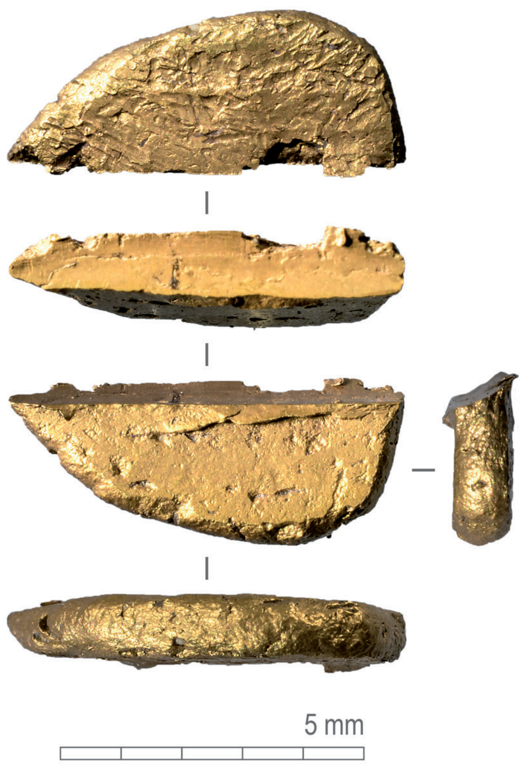

Fig. 9 – Half of an ingot (SF25478) from Saruq al-Hadid (©SHARP/David-Cuny).

domly cut off but that their final width was intentionally planned and, therefore, marked before cutting.

Only three semi-finished artefacts in the form of unworked raw material are known from the site. These comprise one potential (half) ingot fragment (SF25478) in the form of a small disk (Franke, 2017a, p. 617-618; here: fig. 9); one amorphous piece of (casting) debris; and one similarly irregularly shaped piece that is described as ingot fragment (Soriano et al., 2018, fig. 11). Despite the significant typological variability within the precious metal assemblage from Saruq al-Hadid, recurring styles and techniques raise the possibility of specific local trends in gold-base jewellery design at the site. In particular, beads built from (rows of) spheres are very prominent in the corpus, and working remnants and misfits indicate their likely production on site.

ON PRODUCTION TECHNIQUES

There is little to no primary evidence that supports the identification of working areas for the production of precious metal artefacts at Saruq al-Hadid. This is not necessarily surprising, as ancient gold working is typically not associated with large pyrotechnological installations or workshops, nor with specific sets of tools that are diagnostic of this craft. For example, ethnographical research has shown that the sophisticated and specialised gold workers of the Asante people (Ghana) employed an anvil, bellows made of goat skin, some hammers, a pair of pliers and two to three files, in addition to a brass blowpipe and an olive oil lamp for soldering (Wilson, 2002, p. 16). Based on the lack of direct evidence from Saruq al-Hadid in the form of pyrometallurgical installations (e.g. furnaces, forges), associated residues (e.g. crucibles), or tools, we need to identify secondary markers to verify or reject the hypothesis that precious metals were worked at the site, while recognising the difficulties created by the site's complex taphonomy.

To our knowledge, Saruq al-Hadid is the only late prehistoric site on the Arabian Peninsula that evidences the co-occurrence of substantial numbers of finished and semi-finished precious metal artefacts. This co-occurrence strongly suggests a direct link between these two artefact classes, supporting the contention that the working of precious metals was a component of the activities at Saruq al-Hadid. In this section we will explore different steps in precious metal artefact production and discuss to what degree these activities could have been undertaken at the site.

To identify whether working remnants were the basis of precious metal artefacts from Saruq al-Hadid, ten 'finished' and 22 'semi-finished' artefacts were selected for geochemical and microscopic analysis. In addition, micro-photography on site by one of the authors (HD-C) supported many fundamental observations and conclusions. Due to a particular interest in the identification of working techniques for beads composed of individual spheres, sheet beads were not a focus for analysis; an exception here is SF26831, which was worked from a metal sheet at its centre and capped by three rows of spheres on each end (fig. 4, no. 18). The selected semi-finished artefacts were fragments of wires, sheets and ribbons. Complete artefacts were only available for non-invasive and semi-quantitative (SEM-EDS) analysis; working remnants were quantitatively analysed with LA-ICP-MS.[3] Thus, the analytical nature of the data sets differs significantly (quantitative versus qualitative) and their comparison can be challenging. Nevertheless, in this study these analyses allowed the reliable detection and differentiation of major compositional trends.

Precious metal working processes are associated with some specific tools, including pliers, files or hammers as mentioned above (also Moorey, 1994, p. 226). Such tools are present among the wide range of copper-base finds from Saruq al-Hadid but could also have been produced from a variety of (in)organic materials, including wood, bone, or stone. Their presence on site, however, does not necessarily directly relate them to the activities of metal craftspeople. We have to consider that ancient craftspeople—as today—highly valued their tools and discarded them probably only when broken beyond repair. Last but not least, most production processes included the

3. Elemental LA-ICP-MS in combination with XRF analysis for major elements were performed at the Goethe University Frankfurt a.M., Germany under the supervision of Sabine Klein. Semi-quantitative analysis was performed with a JEOL-6010 Scanning Electron Microscope at the University of New England, Australia by Kristina A Franke.

influence of heat (e.g. for annealing), and excavations at Saruq al-Hadid have produced many hearths, of varying dimensions, with associated charcoal remains, but none of them could be directly linked to the working with precious metals..

Beating

The production process of gold-base sheets and foils is known as beating, whereby a thin ingot is flattened into sheet metal (Maryon, 1949, p. 103; Darque-Ceretti and Aucouturier, 2013, p. 648–649). Evelyn Darque-Ceretti and Marc Aucouturier (2013, p. 654) mention the use of ingots with a thickness of about 5 mm in this process. Two such potential ingot fragments are known from Saruq al-Hadid. One is the semi-circular gold-base artefact SF25478, c. 7 mm wide and c. 2 mm thick (fig. 9). Soriano et al. (2018, p. 7) report a similar fragment, of more irregular shape, that also seems to have been cut (into half) and which is c. 10 mm wide and 4 mm thick. The beating process is already attested from the 3rd millennium BCE in ancient southwest Asia but is rather complex and requires technological know-how (Moorey, 1994, p. 226; Darque-Ceretti and Aucouturier, 2013, p. 653–654).

The tools required for this process, however, are simple and only an anvil and a (roundish) stone/pebble are needed. To produce thinner foils and leaves, the material can be beaten between thin organic materials—e.g. animal intestines (Giumlia-Mair, 2020, p. 5). While many different kinds of cobbles or pounding stones were excavated within the Iron Age layers at Saruq al-Hadid, a clearly identifiable anvil stone has not yet come to light. The evident halving of the ingots may be related to the ritualisation of production processes and is also observed with other kinds of finds at the site, although this requires further exploration. It is noteworthy that the beating process is facilitated by the purity of the material, but near-pure gold is hardly evident at Saruq al-Hadid (see below section On Taste and Particular Choices) even though refining of gold has been known since the 2nd millennium BCE (Asderaki and Rehren, 2008, p. 511).

Cutting

Once the gold-base sheet metal had been beaten into shape, the material could be cut into, for example, ribbons for further processing. Sheet and foil fragments are relatively rare on site and most preserved examples are relatively small, not exceeding 10 mm². Therefore, the best evidence for the process of cutting derives from microscopy and micro-photography of ribbons and plaques. These studies show that most edges are irregular, i.e. zig-zagging, indicating the use of sharp or pointed tools, such as awls, knives or chisels (fig. 8, nos. 5–8). Noteworthy are additional incised lines that are preserved along some of these cutting edges that indicate that cuts were not random; rather, sections of sheet metal were divided and marked before the final cutting itself (fig. 8, nos. 5 and 8).

Wire production

Prehistoric wires were regularly produced by either hammering metal into shape, creating a square cross-section (fig. 8, nos. 1–4), or by strip or block twisting, creating a circular cross-section (Carroll, 1972; Oddy, 1977; Northover, 1995; Armbruster, 2000, p. 102, 105–107; here: fig. 4, nos. 20 and 21).[4] Strip-twisting can either be applied by rolling a thin, narrow metal sheet between two hard surfaces or by drawing the material through a hole in a so-called drawplate or drawing-die (Caroll, 1972; Oddy, 1977, p. 84–85); twisting a square wire is called block-twisting and can also be produced by twisting square rods with the help of a pair of pliers at each end (Oddy, 1977, p. 83). All techniques leave different kinds of working traces behind, such as indents and impressions through hammering, larger grooves on rolled strip- or block-twisted wires, and narrow, elongated grooves when the material is drawn strip-twisted (Williams, 1924, pl. XIX and XX; Carroll, 1972, fig. 8 and 10; Oddy, 1977, fig. 6). With the latter technique, horizontal lines are often visible along the produced wire, caused by the material being repeatedly drawn through a hole in the drawplate (Carroll, 1972, p. 322).[5]

All of these processes were applied under the influence of heat, causing a partial fusion of the grooves and making the detection of the working technique more difficult. Hammering and strip-twisting are both evident at Saruq al-Hadid. Simple ring-shaped items, including the previously mentioned incised core of a semi-finished bead (fig. 4, no. 22 and fig. 7, no. 1; for working fragments see also fig. 8, nos. 1–4), are examples of wires with square cross-section, while wires used in cage beads are round in cross-section and show elongated, narrow grooves, and were probably drawn strip-twisted (fig. 4, no. 20 and 21). Rolled strip-twisted wires were applied in the decoration of the tassel-shaped gold-base artefact (Boraik Radwan, 2018, p. 107) but may have also been applied with the decoration of the rim of a small copper bowl (Boraik Radwan, 2018, p. 77). Two prepared wire fragments were excavated in the Polish sector, one of which was produced by strip twisting and shows large, loose grooves that give the impression that the fragment could have been twisted further. The second fragment shows thin elongated and narrow grooves that may stem from draw strip-twisting and resemble the wires used in cage beads. Clear evidence of the production of a wire by twisting two individual strips

4. Wires with a round cross-section can also be produced by smoothing off the edges of wires with square cross-sections but only with loss of material (Armbruster, 2000, p. 104).
5. The date of the invention of the technique for producing wires by drawing a solid rod is still under debate, but recent findings suggest that this may have already taken place in Europe during the Bronze Age. Evidence for this is provided by a single potential drawing plate found at Isleham in Great Britain. However, Northover (1995) suggested that this technique was short-lived and had fallen into oblivion. Compare for a controversial discussion, for example, Northover, 1995; Armbruster, 2000, p. 107; and Özșen, 2019.

can be seen in a small section of a wire with a rectangular cross-section from the SHARP excavations (fig. 8, no. 4).

Deformation

Deformation techniques applied at Saruq al-Hadid are diverse and range from 'simple' hammering into shape to intricate filigree work. Plaques from Saruq al-Hadid also show the application of incised patterns and *repoussé* that may have been embossed or punched. The singularity of the motifs found at Saruq al-Hadid may imply the individual crafting without embossing but rather with punching, although their total number is too low to be conclusive. A simple form of *repoussé* was also applied on sheet beads in the shape of, for example, a dotted pattern, but only few examples exist (fig. 4, no. 3). Plaques have also been perforated—probably with awls—from outside-in as well as from inside-out to provide for their attachment to a second material (fig. 4, compare nos. 24 and 25). Deformation also includes the production of spherical, cylindrical or barrel-shaped beads from sheets or ribbons (fig. 4, nos. 1 and 3). Here, we often find that the upper and lower edges of the beads are roughly cut and folded inwards (compare fig. 6). In some cases, folding had not been applied, but it remains uncertain whether those artefacts were finished or intended for further processing. Some sheet beads show such intricate shapes that additional shaping tools (i.e. stems) may have been used in their production. Also, it is feasible that ribbons were coiled in preparation for cutting individual beads. Here, a ribbon (or wire) is wound around a cylindrical core to create a spiral from which individual loop sections can then be cut; the latter can be further developed into beads (e.g. Leusch et al., 2014, p. 173–174). This technique is suggested to be used for mass production and potential candidates are small cylindrical beads from Saruq al-Hadid, but the evidence from the site is not explicit and a large number of sheet beads are barrel shaped or spherical (compare fig. 4, nos. 1–3).

Deliberate deformation is also applied on granulated spheres from Saruq al-Hadid, a technique that seems contradictory at first, since one of the major advantages of granulation is to produce perfectly round spheres without additional tools (e.g. moulds). However, the deformation of the originally round spheres is one of the strongest characteristic features of granulated beads at the site (fig. 4, nos. 11 and 14; fig. 7). While flat surfaces on the upper, lower or outer sides may also be caused during production or use, diagonally shaped inner edges or diamond-shaped granules are indeed deliberate designs, a conclusion that is supported by the frequent appearance of this type among gold-base beads from Saruq al-Hadid. However, spheres with flattened top and bottom surfaces may also have been deliberately shaped to facilitate the stacking of several ringlets into multi-row compositions.

Gilding

In order to produce larger golden artefacts with a limited amount of gold, gilding techniques were developed from the 3rd millennium BCE onwards, but their identification and differentiation is not always possible without invasive analysis (Oddy, 1981). During foil or leaf gilding, a gold-base foil (or leaf)[6] is mechanically applied to a second material, followed by repeatedly pressing and burnishing (Oddy, 1981, p. 74–77; Darque-Ceretti and Aucouturier, 2013, p. 649; Giumlia-Mair, 2020, p. 5); the mechanical application of foils (instead of leaves) onto a second material is also called plating. When metal is plated or mechanically gilded, adhesion is low and can more easily cause corrosion of the subjacent material (Hauptmann, 2020, p. 330). Egyptian sources report on the use of organic adhesives to improve the technique's quality (Oddy, 1981, p. 76; Giumlia-Mair, 2020, p. 3–5). In contrast, diffusion gilding causes the fusion of two materials, whereby a leaf (or foil) is directly fused with a metal core under the influence of moderate heat and repetitive pressing and punching (Schlosser et al., 2012; Hauptmann, 2020, p. 330–331). Depletion gilding is evident from, for example, Ur in 3rd millennium BCE Mesopotamia and exploits the higher affinity of copper for oxidation compared to gold and silver (La Niece, 1995; Hauptmann and Klein, 2016, p. 87–88). Under the influence of heat and oxygen, the copper content is oxidised and, consequently, the amount of gold (and silver) on the surface of the artefact enriches; the oxidised copper on the artefact's surface has to be removed mechanically (Hauptmann and Klein, 2016, p. 87; Hauptmann, 2020, p. 331–332). Depletion gilding requires higher quantities of copper in the gold, which are not evident at Saruq al-Hadid.

At Saruq al-Hadid, foil gilding was applied in the production of horn-shaped artefacts, but due to the lack of invasive analysis it is difficult to clearly distinguish the exact technique that was used (fig. 5). However, microscopic analysis showed folds within the gold layers of some of these artefacts that suggest foil gilding rather than fusion gilding. These folds occur alongside burnishing lines that are very fine, regular and parallel (which distinguishes them from use ware) and that indicate further flattening of the applied gold layer. Some artefacts also show partially detached foil as result of the corrosion process of their silver-base cores. The use of foil gilding at Saruq al-Hadid is further supported by the discovery of two gold-base sheets in the shape of horn-shaped artefacts but without a silver-base core (Boraik Radwan, 2018, p. 108). Both finds still bear impressions and creases that imply their previous application on a solid core of unknown material; in addition, one find exhibits the (insufficiently burnished?) overlapping ends of the gold-base foil at its bottom. It is therefore possible that the original core was removed—maybe as part of recycling activities at a later stage at Saruq al-Hadid (on recycling see: Franke, 2017a; Stepanov et al., 2019; Valente et al., 2020; Weeks et al., 2023; Franke, in press.; for the artefact see: Boraik Radwan, 2018, fig. 23). It is noteworthy that both empty gold-

6. The difference between foil and leaf gold-base metals lays in their thickness (Giumlia-Mair, 2020, p. 2); foil can support its own weight (thickness > 10 µm), while leaf cannot support its own weight (thickness < 2-10 µm).

base foil artefacts do not show any traces of the central seam-like extension that is characteristic of variant 1. Also, horn-shaped artefacts from Saruq al-Hadid often show corroded silver on their surfaces, which supports the evidence of plating rather than diffusion gilding (Al-Khraysheh and An-Nashef, 2007, fig. 12; here: fig. 5).

The use of materials other than silver, such as organic substances or pastes, as core material for this type of artefact is not known from Saruq al-Hadid, whereas there is ample evidence of well-preserved wooden and bone artefacts, and also vitreous paste beads from the site (Franke, 2017b; Weeks et al., 2017, p. 39–42).

It is still possible that both gilding techniques were applied on site. The major advantage of diffusion gilding - in contrast to foil or leaf gilding - is that it enables post-gilding deformation. This could explain variations in shape, in particular of the horn-shaped extensions, observed within the Saruq al-Hadid corpus. Soriano et al. (2018, p. 7 and fig. 9), for example, discovered traces on artefacts from Saruq al-Hadid indicating hammering that may derive from punching during diffusion gilding or from post-gilding deformation. However, different shapes could also have been obtained by using differently cast cores (see below). It is possible that both kinds of technologies were applied in the production of horn-shaped artefacts but at different times, which we cannot distinguish stratigraphically.

Granulation

Granulation is primarily applied to gold-base metals but occasionally also used with silver-base material at Saruq al-Hadid (fig. 10). This technique is a relatively ‘simple’ process, in which small pieces of metal are dropped into a hot source— either ash or liquids, such as water or oil—to form metal droplets (Carroll, 1974). These

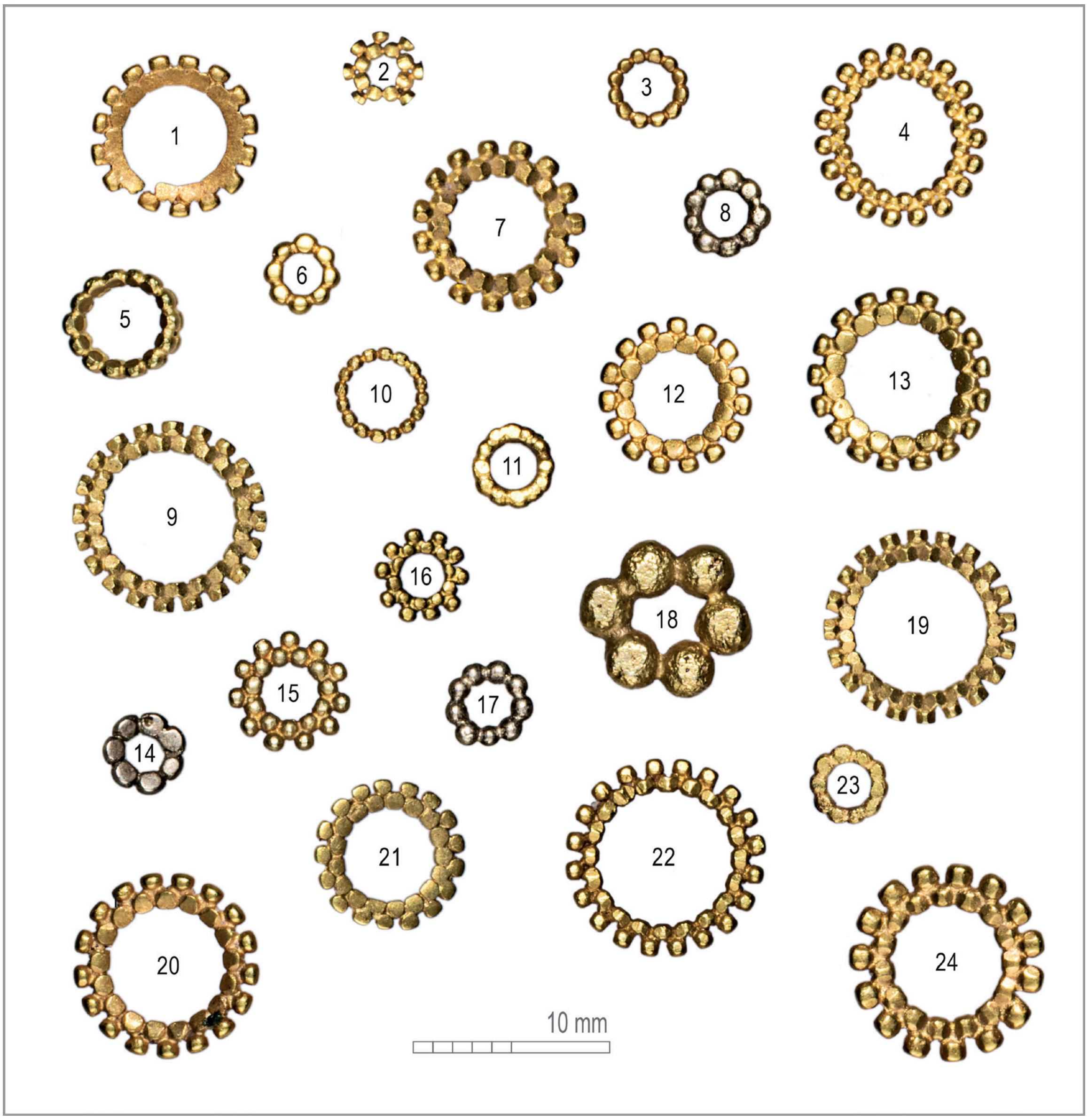

Fig. 10 – Different types of beads made from multiple spheres. Note the intentional deformation of the spheres observed in most of these beads at Saruq al-Hadid and the wide range of represented colours (©SHARP/David-Cuny).

droplets may be of different sizes and are, in most cases, hand sorted after production to facilitate the use of either similarly-sized granules or a deliberate combination of differently-sized granules (e.g. Loepp and Maass, 2017). Although Saruq al-Hadid has produced many hearths and ash-pits that could theoretically have been used to produce granules in ash, no individual gold or silver-base granules have been found associated with such installations. Thus, assumptions about the application of ash for granule production remain hypothetical; the use of liquids for granulation would also have been possible at the site.

The fusion of individual spheres into an artefact, or onto a second material, may employ different techniques: i) soldering (or brazing); ii) flux fusion (also called copper compound); and iii) direct fusion (or sintering or fritting). Of these techniques, only direct fusion has not been identified in relation to the fusion of granulated beads from Saruq al-Hadid. Soldering is based on differences in melting points arising from the proportions of silver and/or copper within the metal; a solder with a lower melting point than the primary metal enables fusion without remelting (and consequently reshaping) individual granules during the process.

At Saruq al-Hadid, analysed solders most often showed increased silver rather than increased copper levels in bonding areas between individual granules. Such joints are relatively wide and unique in their microstructure and are recognised by an amorphous and grainy texture that is accompanied by a seam-like structure (fig. 11b-d). The detection of a single spot of a different composition and surface texture on the surface of a sphere in bead SF25386 indicates the use of a solder with increased silver contents (fig. 12b); the c. 13 wt% Ag measured on the spilled solder strongly contrasts with the c. 2 wt% Ag measured on the top of the granule itself. Additionally, optical microscopy and micro-photography confirmed lighter or more reddish colourations in fusion gaps than in granules, indicating the addition of silver or copper to the metal that caused this change in colour (fig. 11b). Flux fusion, where a copper powder is used for soldering, was much less commonly applied at Saruq al-Hadid. Indicators comprise strongly increased copper contents and a dendritic structure in bonding areas (Born et al., 2009, p. 26); and out of nine analysed beads within the SHARP study, only one evidenced this technique (fig. 13).

Granulation is one of the most frequently applied working techniques at Saruq al-Hadid and is nearly exclusively found in bead (ringlet) production. Exceptions are the singular tassel-shaped artefact, a ring bezel with a semi-precious stone inlay and a braided ring, all of which are dec-

Fig. 11 – Bead SF289789 (a) was produced using a solder with increased silver content. Note the characteristic microstructure in the bonding area (b–d) (a ©SHARP/David-Cuny, b-c: optical microscopy ©SHARP/Franke; d: BSE image ©SHARP/Franke).

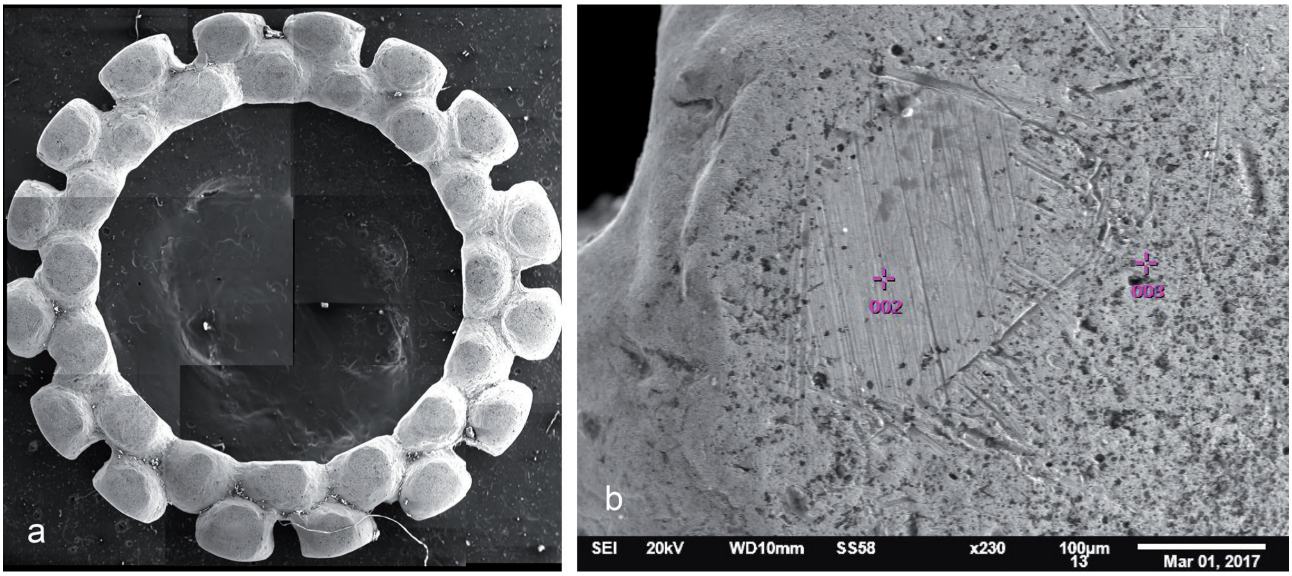

Fig. 12 – On the surface of one granule in bead SF25386 (a), a splatter of solder with elevated silver levels was detected (b) (BSE images ©SHARP/Franke). Note the indents between the individual spheres visible on the left side of the bead (a).

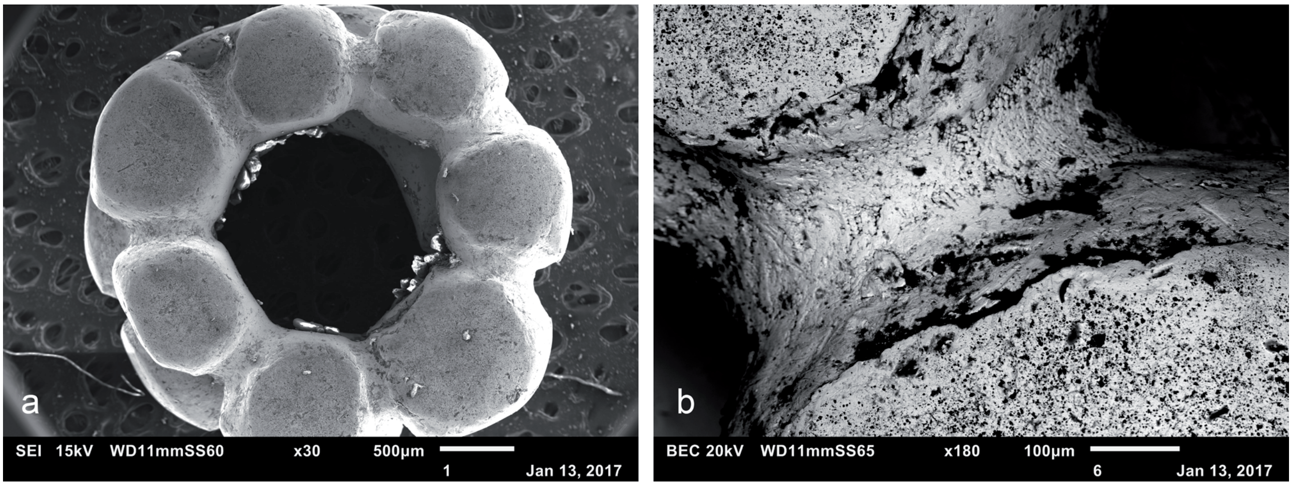

Fig. 13 – Bead SF25385 (a) was produced using a copper powder. Note the characteristic microstructure in the bonding area (b) (BSE images ©SHARP/ Franke).

orated with spheres that imply granulation by the shape of their bonding areas and their style of application (Boraik Radwan, 2018, p. 107 and 116–117). Granulated beads range from simple circular arrangements of individual spheres to multi-row beads, with vertically and horizontally joined granules. While additional horizontal spheres are joined individually into the gaps between the spheres of the inner ringlet, vertically combined examples most often consist of individual granulated ringlets that are joined to create tubular beads with two to ten rows or more.

Casting and 'fake granulation'

The casting of artefacts is well evidenced for copper-base items at Saruq al-Hadid, and some of the precious metals were also identified as casts. A small number of spherical beads show distinguishing features that identify them as casts: i) The metal is significantly thicker than that used in sheet beads; ii) their inner surfaces show a rough and irregular texture; and iii) a single example shows an overhanging rim with a rough texture (fig. 14, nos. 1 and 2). All these features indicate that these beads were produced via lost-wax casting. This technique is known in many variations and a full discussion of its complexity exceeds the scope of this paper (e.g. Hunt, 1980 or Davey, 2009). However, lost-wax casting generally uses the effect of a shapable and meltable material (such as wax) that is encased in a second material (e.g. clay, sand), and that is melted and replaced by hot metal that is poured into the resulting cavity. Lost-wax casting has the particular advantage of producing round shapes and intricate designs that cannot easily be achieved with bivalve mould casting (Davey, 2009). Some of these beads also show complex shapes that are more easily achieved with casting than by shaping from sheet metal (Leuch et al., 2014, p. 175; here: fig. 14, no. 2). It has been suggested that very small

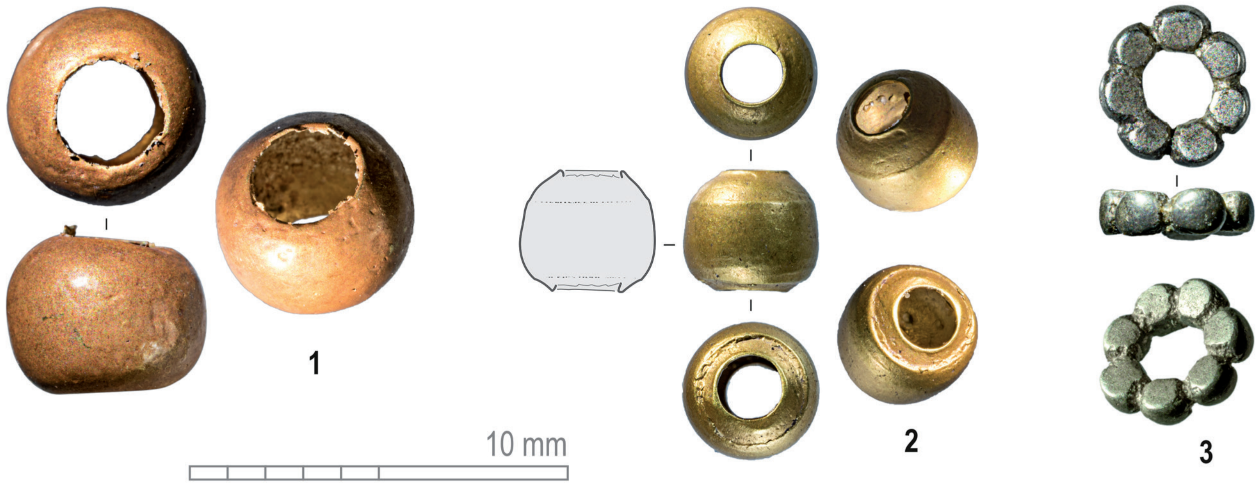

Fig. 14 – Some beads at Saruq al-Hadid were also cast. Note the rough inner surfaces of beads SF34250 (1) and SF20035 (2), the texture of the outer rim in bead SF20035 (2t) and the rounded but irregular edges of the individual spheres in bead SF28245 in addition to casting cavities (3) (©SHARP/David-Cuny).

lost wax castings were manufactured with the help of a so-called casting tree, on which several items could be cast at once (Armbruster and Meyer, 2024, p. 21–22). This process is further simplified when using a mould to produce wax moulding blanks. Some beads from Saruq al-Hadid appear to be identical and may have been produced in such a process (fig. 10, nos. 9 and 19).

In addition, a bead composed of individual spheres appeared to be cast rather than granulated (fig. 14, no. 3). This kind of bead comprises a particular type that was labelled by Soriano et al. (2018, fig. 1) as 'flower-shaped bead'. They are either designed from a single row (fig. 14, no. 3) or double vertical rows and consist of up to seven individual spheres. Indicative markers for lost-wax casting can be found, for example, in the round upper edges, areas showing casting porosity and the rather porous surface texture. In addition, Soriano et al. (2018, p. 5–6) identified several other beads as cast artefacts that also resemble markers of granulation.

Although not of precious metal, further examples of the use of the casting technique include nine lead beads and one metallic antimony bead found at Saruq al-Hadid (fig. 15). These beads were designed to look as though they were created by fusing individual spheres, but clear casting seams on their outer edges show that they were cast in a bivalve mould. Moreover, the number of top spheres differs from the number of bottom spheres in individual artefacts, indicating the use of top and bottom mould pairs with different numbers of depressions (fig. 15, nos. 2–5). In their uncorroded metallic state these beads would have been silver in colour, and they may have been intended as potential 'replacements' for granulated precious metal beads.

Overall, the techniques applied to the working of precious metals at Saruq al-Hadid are manifold. They range from beating, to the production of semi-finished working materials, to the shaping of a variety of different kinds of artefact classes and types. The contemporary evidence of ingot fragments, working remnants and finished artefacts, however, supports the existence on site of a *chaîne opératoire* including the above-described working techniques. Whether individual workshops were responsible for individual steps or whether one (or several) worshop(s) supported the entire working chain is uncertain at this stage.

ON TASTE AND PARTICULAR CHOICES

In the analysis of gold-base artefacts, silver and copper contents are significant markers in the identification not only of particular working properties (e.g. melting point, hardness) but also of particular colours and, to a lesser degree, in the distinction between natural compositions and deliberate alloys.

In the previous section, we explored the working of precious metals at Saruq al-Hadid, and that finished artefacts and working remnants likely belong to a set of artefacts that reflect workshop activities at the site. Elemental analyses allow us to discuss aspects of the working of precious metals and, more importantly, possible cultural preferences in metal colours in general and in relation to particular artefact groups that may have guided technological practices.

The geochemical compositions of 44 artefacts from Saruq al-Hadid—including working remnants (sheets, ribbons and wires) and finished artefacts (beads composed from or with the addition of spheres), together with the bonding areas between individual spheres—are plotted on the ternary Au-Ag-Cu diagram (fig. 16). Here, it is possible to assess the extent to which they exhibit different colours and to explore the nature of compositional clusters for categories of precious metal artefacts from Saruq al-Hadid.

Finished artefacts (beads) only display two compositional ranges: i) those with high gold levels (HGL) of c. 80–98 wt% Au (n = 6); and ii) those with low gold levels (LGL) of c. 23 and c. 34 wt% Au (n = 2). Within

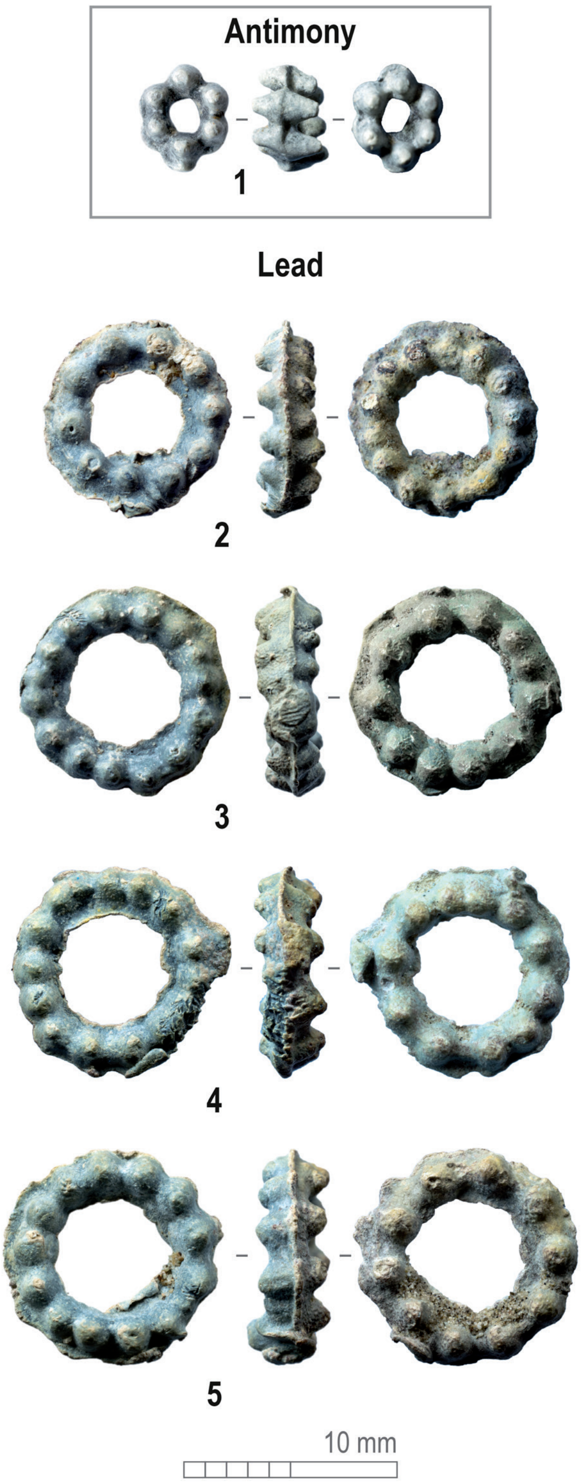

Fig. 15 – Selection of cast beads. The slightly larger pieces were made of lead (2-5), while a single smaller artefact was made of antimony (1). Note the difference in the number of ‚spheres' between top and bottom sides of beads 2-5 (©SHARP/David-Cuny).

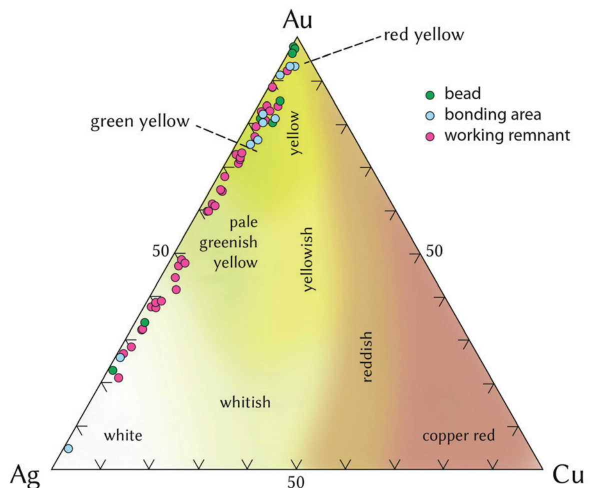

Fig. 16 – Ternary diagram with gold (Au), silver (Ag) and copper (Cu) showing the different geochemical compositions and colours of the analysed beads, as well as the bonding areas between individual spheres (qualitative; SEM-EDS) and working remnants (quantitative; LA-ICP-MS). Note the analytical gap between 50 and 60 wt% Au. While working remnants are distributed across almost the entire compositional range of gold-silver alloys, the analysed finished artefacts plot only within certain compositions (©SHARP/Franke).

the HGL group we can further distinguish between those artefacts produced of nearly pure gold (96-98 wt% Au; HGL1; n = 3) and those with lower gold levels of c. 80-85 wt% Au (HGL2; n = 3).

The colour of beads with HGL1 values is broadly yellow, with a reddish touch, while those within group HGL2 display a slight shift from yellow towards greenish yellow (fig. 16). Beads with LGL are within the range of whitish gold and appear silver in colour, based on their high silver content (compare also fig. 10). Copper levels are on average low (Cu ≤ 5 wt%) and do not significantly alter the artefacts' colour towards red. However, two artefacts with HGL2 levels exhibit relatively high amounts of copper of c. 4 and 5 wt% Cu, which shifts their colour back from greenish yellow to rather yellow (fig. 16). Nearly all beads fall into the same compositional range within which working remnants (i.e. ribbons and wires) plot. However, no working remnants plot together with nearly pure gold artefacts (HGL1). Bonding areas analysed between individual spheres, of which most have been identified as solders, similarly plot within the range of working remnants but—reflecting their nature as solders and in comparison, to gold-base artefacts—have higher silver and, in exceptional cases, also higher copper levels.

Working remnants display nearly the entire range of gold levels within the diagram and their colour also significantly shifts from yellow towards green-yellow in contrast to the analysed artefacts described above. Here, we have to add the group of medium gold levels (MGL) that splits into MGL1 with c. 60-70 wt% Au and MGL2 with c. 40-50 wt% Au. No samples fall into the range of 50-60 wt% Au and the diagram shows a significant gap between two major groups with either gold levels ≥ 60 wt% Au or ≤ 50 wt% Au (fig. 16). The same is true for gold levels above 92 wt% Au and below 20 wt% Au; no working remnants and only one solder of nearly pure silver lies within the latter range.

Working remnants show a wide variety in gold levels, but they also seem to cluster at particular levels more than at others (fig. 16). The wide range of compositions within this artefact group could hint towards either the use of different precious metal sources with varying silver and gold contents, or the mixing of gold-base and silver-base metals to (roughly) achieve certain colours. The small clusters (as well as the larger two gaps) within this wide range, on the other hand, indicate the production of particular compositions or recipes and may hint towards individual batches that may have derived from the same workshops. Furthermore, we would like to argue that the sample set of 37 specimens (out of a total of 83 excavated working remnants) is representative and that the identified compositional clusters—defined as much by gaps as by compositional similarity—represent true groups.

The study by Soriano et al. (2018) supports this result, although it is important to note that their study is based on different kinds of finished artefacts including only one wire-like fragment—in contrast to the present study that focuses on beads composed of spheres in combination with wire, ribbon and sheet fragments. However, the differences in the kinds of artefacts analysed by each study are complementary. The results from Soriano et al. (2018) show two major similar clusters within the range of HGL samples, while the groups MGL and LGL are represented by only two artefacts, respectively. Six out of 14 analysed artefacts fall into the range of HGL; four consisting of nearly pure gold (HGL1) and two plotting within or close to the HGL2 group. Here, we would need to extend our HGL2 group to about 71–87 wt% Au, which represents finished artefacts with two different colours of yellow and green yellow (fig. 16). The same is true for artefacts produced from nearly pure gold and the range of HGL1 samples must be increased by 2 wt% to about 94–98 wt% Au. This result is significant and indicates that those artefacts were not primarily produced in yellow or white gold but also in a visibly greener and redder yellow gold. It is noteworthy that each of these groups includes two artefacts worked from gold-base sheet metal (i.e. barrel bead and an embossed sheet) respectively, which describe an artefact group that was not geochemically analysed within the SHARP analytical programme. All further artefacts are beads that consist of spheres; these are all primarily described as produced by lost-wax casting (Soriano et al., 2018, p. 5).

Furthermore, the study by Soriano et al. (2018) also exhibits a gap between c. 50-60 wt% Au and no artefacts produced from nearly pure silver. No results are evident for the MGL1 range—with a pale greenish colour—where only working remnants plot within the SHARP study. Importantly, this range describes the hardest gold-silver alloy, and the ideal combination for increased hardness lies at about 65 wt% Au and 35 wt% Ag, with a 1:1 atomic ratio of both metals. In addition, this kind of material offers ideal properties as a solder, featuring a substantial decrease in melting point compared to (nearly) pure gold. This, combined with a relatively broad melting range between solid and liquid, allows for precise control during soldering, where the goal is to induce a surface texture change without completely dissolving the material.

Since no analysed solders were detected at this compositional range, it is reasonable to assume that this kind of composition (in wires or ribbons) was not used in this state but was mixed with another composition to be used for soldering. Here, it seems feasible that this composition was mixed with the metal that was originally used to produce the individual granules that were to be soldered into ringlets. One reason may have been to equal out the apparently strong colour differences. Its colour, however, made it well distinguishable from precious metals used in the production of (granulated) beads, which supports this hypothesis. Noteworthy are also two artefacts with about 50 wt% Au (MGL2; Soriano et al., 2018, table 2 and fig. 5); they are both wire-like artefacts, but neither (granulated) beads nor sheet beads are present in this group. Their colour ranges at a level where pale green-yellow shifts towards whitish and only working remnants represent this group in the SHARP study (fig. 16). These artefacts are also harder than nearly pure silver or silver coloured LGL artefacts but of a similar silvery colour. Moreover, this alloy also offers a second advantage: while (nearly) pure silver is strongly affected by corrosion and patination, silver with higher gold content is more resistant to both surface discolouration and corrosion. The result that nearly all artefacts within MGL are represented by wire-like finds supports the idea that these different MGL compositions were primarily produced to make artefacts that required a particular strength (e.g. simple rings) but in two different colours of pale green-yellow and white—gold and silver—and with the advantage of being less affected by corrosion or discolouration. The lack of artefacts within group MGL1, however, may be due to the low frequency of these kinds of artefacts in the combined studies.

Significantly, we can note that silver-coloured artefacts held considerable value at Saruq al-Hadid. This is evidenced by the working remnants of group MGL2 but also by working remnants and two finished silver-base artefacts in group LGL. These findings underscore the appreciation for this kind of silvery colour, that is indistinguishable to the naked eye from nearly pure silver despite its compositional difference.

In addition, the original colour of nine cast lead beads and the single cast antimony bead, that all resemble granulation in their style, was certainly whitish silvery (fig. 15). These finds further highlight the significance of this colour group and raise the question of favourable cultural attitudes to such 'pale' metal. Silver granulation is far more complex and also far less common than gold granulation. Bead SF30731 may serve as a prime example of potential pitfalls encountered in silver granulation, especially when employing increased silver contents in soldering, a technique frequently applied at the site (fig. 17). A single example reported by Soriano et al. (2018, sample 1405_54) may have been produced from a silver-base material but may have been soldered with a copper powder. While its overall shape is well preserved, its joints (and one individual sphere) were highly affected by corrosion. A third silver-base artefact, SF28245, appears to be cast and resembles a shape that is also known from gold-base artefacts from the site (fig. 14, no. 3). These examples may indicate that smiths at Saruq al-Hadid were not as well trained in silver granulation as

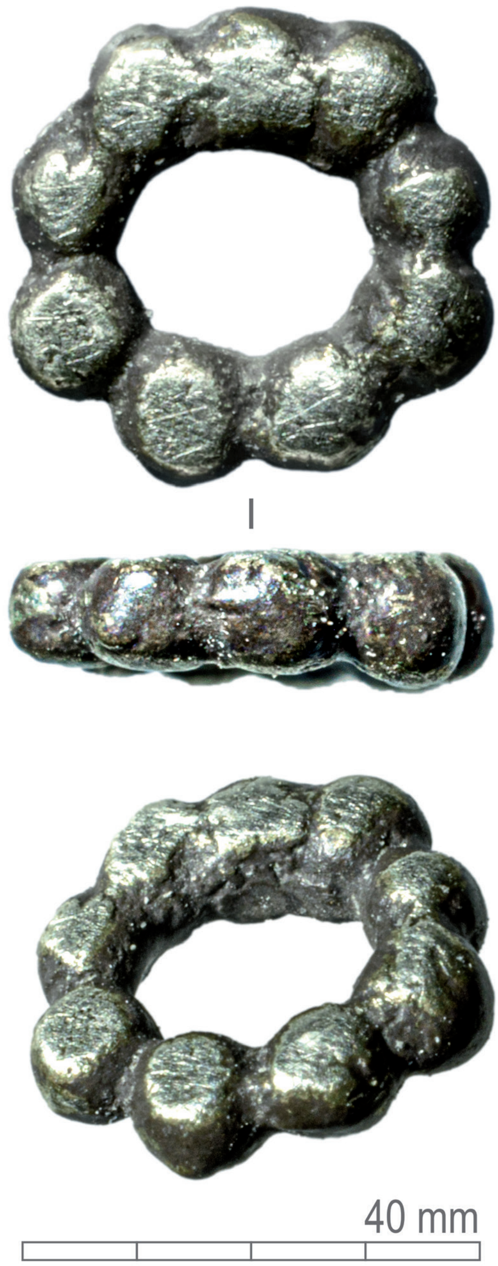

Fig. 17 – Bead SF30731 was produced from nearly pure silver and soldered with a high-silver agent. In contrast to gold-base granulated beads, the individual spheres deformed during soldering (©SHARP/David-Cuny).

in gold granulation but still aimed to fulfil the demand for artefacts of this colour.

The addition of gold to silver, however, is deliberate and was most likely undertaken to protect the metal from corrosion. All analysed artefacts from Saruq al-Hadid (besides the above-mentioned bead 1405_54, Soriano et al., 2018) are well preserved. This was not the case with the silver-base cores of the horn-shaped artefacts, which regularly show corrosion where the gilding failed to protect the metal (fig. 5). This indicates that the cores of these artefacts were made of purer silver. This may also highlight the precious character of gold. No amount of this material seems to have been wasted when not necessary for visual or technological reasons. Limited access to silver—and for the smiths limited exposure to the materiality of silver—may well have influenced the limited number of silver-base artefacts on the site, while at the same time increasing the interest in this particular colour. The evidence of the metallic lead and antimony beads further supports the idea that a certain level of demand for this colour existed at Saruq al-Hadid during the early Iron Age. In particular, lead (and maybe also antimony) may have been more easily accessible and thus somewhat cheaper alternatives to silver at particular times.

Moreover, a chronological factor for the preference for particular colours or styles during the early Iron Age cannot be ruled out at this stage. It is possible that particular colour choices, such as silver, were only temporary trends across the several centuries of Iron Age activities at the site.

In regard to copper contents in gold-base artefacts from Saruq al-Hadid, it is noteworthy that natural amounts of copper in gold are normally low and typically do not exceed 1–2 wt% Cu (Hauptmann, 2020, p. 320). This fits with the copper levels found in finished artefacts as well as those of many analysed working remnants (fig. 16). However, higher copper levels (but still hardly exceeding 5 wt% Cu) are also present, primarily being detected in working remnants and less frequently in bonding areas between granules in finished beads. It is noteworthy that the three artefacts of nearly pure gold, which do not plot with any working remnants, show the lowest copper levels within our study (fig. 16). The same is true for nearly pure gold artefacts studied by Soriano et al. (2018); almost all exhibit copper levels are below 1 wt%. Hence, the addition of copper to gold-base metal seems to fulfil primarily technological needs to support soldering. Higher copper contents that shift the colour from yellow to red are not evident at Saruq al-Hadid, and this metal appears to have played no major role in precious metal production at the site despite (or maybe even because of) its abundance of copper artefacts. The gap between the two major colour clusters of variations in yellow (60–98 wt% Au) and white (20–40 wt% Au) may reflect the use of different base materials for these alloys. However, none of the silver-base cores of the horn-shaped artefacts was available for analysis, so we cannot compare this composition to our silver-base LGL and MGL2 samples.

This discussion is further complicated by the wide range of gold-silver alloys within natural deposits (e.g. Rehren et al., 1996; Hauptmann, 2020). The present study, however, shows that analysed gold-base artefacts in the form of working remnants are present within the entire range of potential compositions of gold and silver but also cluster at certain levels. The combined evidence of these two observations supports the idea that the composition of the majority of gold-base artefacts results from deliberate alloying. Also, certain compositions represent both, particular colours and technological advantages. Hence, the deliberate mixing of gold and silver-base metals seems probable even if different kinds of natural alloys may have been the base for these artefacts. Adding gold to silver-base alloy protects and hardens the metal, while adding silver to a gold-base alloy improves the metal's hardness and lowers the melting point for brazing. The alloy that is represented by the compositional gap between 50–60 wt% Au, on the other hand, does not present any discernible advantages in comparison to either lower or higher gold levels: it neither provides a new colour (since it is pale greenish-yellow) nor does it offer better working conditions within the already employed colour range of pale and greenish-yellow. In other words, this compositional range may simply have not offered any advantages that would have promoted its deliberate production.

ON DELIBERATE CHOICES IN STYLE

The distinctive collection of precious metal artefacts from Saruq al-Hadid shows some diversity, not only in the kinds of artefacts produced but more importantly also in their techniques of production. A notable characteristic of the corpus is the high proportion of jewellery and in particular beads, in contrast to, e.g. (finger) rings or pendants that are unique finds. Most common are 'simple' beads worked from sheet metal (or cast, in exceptional cases) and beads that are composed of multiple spheres. Non-invasive analyses indicate that most of the latter were produced by different kinds of granulation processes. In contrast to Soriano et al. (2018), our study shows that cast artefacts are the exception.

In fact, despite arguing that most of the analysed beads in their study are produced by lost-wax casting, Soriano et al. (2018) stated that the interpretation of some specimens remains uncertain. Indeed, some of the published examples show the distinct features of soldering seams and amorphous texture, and significant compositional differences between individual spheres and bonding areas that may indicate granulation rather than casting (Soriano et al., 2018, fig. 4 and 6b, table 3). Here, the cast examples worked from lead and antimony that resemble granulation are again important and emphasise the interest in this particular style independent from the applied working technique (fig. 15).

The combined number of analysed finished beads is admittedly limited compared to the large quantity of this kind of artefact found at Saruq al-Hadid, and both studies demonstrate that a distinction between granulation and (lost-wax) casting remains challenging despite considerable effort. This is even more difficult with on-site methods, such as field microscopy and micro-photography. While both studies clearly show that casting was part of the production process of beads that include multiple spheres, we would argue that granulation rather than casting was the dominant working technique at Saruq al-Hadid. However, it is striking that particular artefact types were produced using granulation as well as by casting.

The different working techniques encountered for similar designs at Saruq al-Hadid may represent finer chronological units than we can currently present for the early Iron Age beads and their appearance over more than 300 years. Consequently, a chronological component and a shift towards one or the other working technique cannot be ruled out within the rather large time span of their appearance. This may certainly also apply to the different results on gold artefacts from Saruq al-Hadid. Our present understanding of site stratigraphy and taphonomy precludes the development of a more refined chronology for the precious metal artefacts form the early Iron Age; moreover, the lack of discrete working areas at Saruq al-Hadid further limits the potential to explore spatio-temporal differences in technological choices. The existence of the same type of beads but produced with different methods highlights that style overruled production technique (whether contemporary or within a chronological shift). Small bead ringlets designed from individual spheres were clearly favoured at the site regardless of the manufacturing method used to produce them, a fact that is further emphasised by the cast lead and antimony ringlets.

Here, a third characteristic within the corpus of precious metals is noteworthy: many beads show intentional deformation (fig. 10). Although granulation offers the advantage of creating near-perfect globular spheres, this effect was seldom used at Saruq al-Hadid. Most beads designed from spheres exhibit flat edges on their inner and outer but also on their top and bottom sides. Importantly, flat edges are not limited to cast beads—which would be far less astonishing, but they are also evident with granulated beads.

In some cases, flattening seems to have been part of the production process and does not necessarily solely indicate a design preference. This may be particularly true for beads with flattened inner surfaces, and it is possible that such beads were worked around (e.g. wooden) cylinders or cones to facilitate the brazing process. However, since it is also possible to preserve a perfectly spherical appearance without any such appliances, the deformation must have been part of the final desired design, whether it was due to working techniques or to later shaping. A similar idea may apply to spheres that are flattened on their top and bottom surfaces, as seen in most ringlets. We have already discussed that tubular beads with multiple vertical rows are produced from stacked individual ringlets and the flattening of these surfaces certainly facilitated this kind of production. In some cases, flat outer surfaces may also be caused by use or depositional damage but, again, the flattening most often appears regular and exact, suggesting intention rather than randomness. The most obvious deliberate manipulation is represented by diagonal and diamond-shaped patterns with spheres (fig. 10, e.g. nos. 7, 9, 19, 24). This very particular design seems to be commonly applied on beads from Saruq al-Hadid and is regularly found with granulated (fig. 12a) but also with cast ringlets (Soriano et al., 2018, fig. 2). The co-occurrence of this design on granulated and cast beads further emphasises that working techniques were subordinated to design preferences.

The granulation technique was apparently not chosen to attain a perfect spherical design. Also, a diamond-shaped effect would potentially have been more easily achieved via casting. Hence, the application of the granulation technique for this design may have been based on a 'custom' (shaped by culture, geography, and time) associated with the site rather than with specific technological considerations. As stated earlier, granulation does not require a complex set of tools and preparation. More importantly, no final adjustments, such as filing off potential casting rims, is necessary, offering the benefit of less loss of precious metal during processing. In this, lost-wax casting is certainly also more efficient than mould casting but still less efficient than granulation (compare fig. 15). Consequently, it may have been more useful to produce 5 mm beads by granulation and then deform these accordingly under the influence of heat than cast such items which needed final adjustments. Hence, the deformation of granulated spheres may be an advantageous technique reflecting 'cultural customs' that integrated practicality.

DISCUSSION AND CONCLUSIONS

In the previous sections we discussed the corpus of finished and semi-finished precious metal artefacts from Saruq al-Hadid. The diversity and volume of this assemblage are unparalleled within late prehistoric Arabia. When considering the ultimate purpose of the deposited precious metal artefacts, the materials more strongly correlate with work sequences of craftsmen than with consumption patterns of non-specialists. This is particularly evident when comparing the Saruq al-Hadid assemblage to finds from the wider region. Here, an (unprovenanced) collection from Yemen is particularly important. In 1973, Geoffrey Turner published a small part of the Muncherjee Collection, held in the Aden Museum, which included a wide variety of gold-base jewellery (Turner, 1973, p. 172). He suggested a Qatabanian (southern Yemen) origin and dated the artefacts from the 8th/7th to the 6th/5th centuries BCE (fig. 1). These dates are somewhat later than the finds from Saruq al-Hadid but are based on "..no stratigraphic dating evidence and very little comparative material ..." (Turner, 1973, p. 127).

In this collection, we find some of the unique singularities evident at Saruq al-Hadid, such as the bezel of a ring mounted with a semi-precious stone that is designed with granulation on its fitting (Turner, 1973, pl. L, no. 6; Boraik Radwan, 2018, p. 117) but also the wide range of ringlets and beads designed from individual spheres that are evident at Saruq al-Hadid (figs. 4 and 10). More importantly, these ringlets and beads are in many cases part of more complex designs (i.e. earrings, pendants) and are decorative key elements (Turner, 1973, pl. XLIX, H, J, K; pl. L, nos. 4, 5; pl. LI, nos. 12, 13, 15). Here we find single row ringlets worked around a ring-shaped inner wire (Turner, 1973, pl. XLIX, J, right, bottom), beads built from two vertically aligned ringlets (Turner, 1973, pl. XLIX, K, right, bottom), as well as tubular beads composed of a central sheet metal and capped with a single row or two rows of ringlets (Turner, 1973, pl. LI, nos. 12, 13 and 15). The publication also shows the same kind of ringlets and beads listed above as singular items (Turner, 1973, pl. LII, nos. 22 and 23; pl. LIII, nos. 34, 35, 37, 38; pl. LIV, no. 42) in addition to tubes built up from wires and capped by spheres (Turner, 1973, pl. LII, no. 24). Noteworthy are two beads composed of only five and six but very globular spheres that find their comparison in several gold and silver-base finds from Saruq al-Hadid (Turner, 1973, pl. LIII, nos. 34–35; here fig. 4, no. 13; fig. 10, no. 18). Some items are similar in style and arrangement but show significant variations in comparison to the finds from Saruq al-Hadid. Among them are tubular beads composed of stacked ringlets (Al-Khraysheh and An-Nashef, 2007, fig. 15; Boraik Radwan, 2018, p. 110; here: fig. 4, no. 19) but that never exceed 10 rows within the collection from Yemen (Turner, 1973, pl. LIII, no. 36), or spheres arranged around an inner ring-shaped wire but with two horizontally aligned rows (Turner, 1973, pl. LIV, no. 40), which are only evident with a single row at Saruq al-Hadid (fig. 7, no. 2). Tubular sheet beads are similarly capped with a single row of spheres/ringlets (Turner, 1973, pl. LIV, nos. 42 and 43) but are shorter than at Saruq al-Hadid (Boraik Radwan, 2018, p. 110). Earrings with "two adjacent conical bell-shaped beads" (Turner, 1973, p. 130 and pl. XLIX, G) are comparable in their general arrangement to the tassel-shaped items from Saruq al-Hadid but are missing the wire-like ('horn-shaped') extensions (Boraik Radwan, 2018, p. 107). While the artefacts from Yemen have a clearly defined function as components of earrings, the finds from Saruq al-Hadid show no functional attribute.

Also, several types commonly attested at Saruq al-Hadid are not evident within the collection from Yemen, such as the very characteristic cage beads or horn-shaped artefacts (Al-Khraysheh and An-Nashef, 2007, fig. 12; Boraik Radwan, 2018, p. 108 and GR 1868, bottom left; Soriano et al., 2018, fig. 2, bottom centre; here fig. 4. nos. 20 and 23). Also, the (cast) so-called flower-shaped bead (Soriano et al., 2018, fig. 1, middle row left, centre; here fig. 14, no. 3) is not represented in Turner's collection. Similarly, no spherical sheet (or cast) beads are present despite a single example of a spherical bead composed of two half elements (Turner, 1973, pl. LII, no. 18) that does not find any comparisons within the Saruq al-Hadid assemblage. Since Turner (1973) only published drawings but no photos, it is difficult to estimate the extent to which flattened granule surfaces are not depicted or were not evident.

In some cases, flat surfaces seem to have been illustrated, but the drawings are often inconsistent in their side and front views and no distinct conclusions can be drawn from them. In this, it remains uncertain whether the precious metal finds from Yemen were potentially produced within Saruq al-Hadid workshops and the differences highlighted between the two collections suggest otherwise. However, the spectrum presented by Turner (1973) clearly shows the widespread connectivity of a particular style in gold-artefact production. More importantly, it supports the hypothesis that gold (and silver-base) beads and ringlets were not merely produced at Saruq al-Hadid, but possibly traded as single items, with the intention to be integrated into more complex and intricate jewellery artefacts at their destination.

Another important collection of comparable gold-base jewellery derives from the southern Levant, with well exemplified finds from Tell Tawilan and Tell Fara/Beth Pelet (fig. 1). At Tell Tawilan, a gold hoard was excavated during the 1980s that comprised gold-base jewellery, in particular earrings (Ogden, 1995).

Ogden (1995, p. 75) dated the hoard to the 10th/9th century BCE in comparison to finds from Tell Fara/Beth Pelet. Several artefacts are described as tassel earrings of different styles and with varying details. Noteworthy are some similar attributes in comparison to the finds from Saruq al-Hadid. The upper bell-shaped part is in some cases similarly composed of block-twisted wires with the functional wire extensions attached. The lower part that displays the 'tassels' is in most cases composed differently. However, one specimen exhibits the larger globules that cap each individual 'tassel' and that are characteristic for the Saruq al-Hadid artefacts. Two of these items also show a granulated decoration that bonds the upper (bell-shaped) part with the (functional) wire extension on their tops. The hoard also included an earring with three attached granulated beads that are composed of three vertically stacked rows of granules (Ogden, 1995, fig. 8.18 and 8.19; Verduci, 2014, fig. 4:2). The beads from Tell Tawilan are possibly slightly larger in diameter (c. 7 mm in comparison to Saruq al-Hadid c. 4–6 mm) than the beads composed of a single and two rows from Saruq al-Hadid. Ogden (1995, p. 72) proposed that these granulated ringlets were added later—perhaps for safekeeping during deposition—and were originally not intended as part of the design. In contrast to the finds from Yemen, this seems plausible and the attached ringlets fit less clearly into the overall composition; a matching second earring did not show such ringlets (Ogden, 1995, fig. 8.17 and 8.18). The best match with Saruq al-Hadid's gold-base jewellery, however, is a singular granulated bead that is composed of two horizontally aligned rows (Ogden, 1995, fig. 8.33). The important detail lies in the diamond-shaped spheres and the overall composition, which strongly resemble finds from Saruq al-Hadid. The bead from Tawilan is, with a diameter of c. 15 mm, slightly larger than average granulated beads from both sites but matches the rare, larger ringlets of this particular type with a diameter of about 10 mm at Saruq al-Hadid (Ogden, 1995, p. 74; here: fig. 4, no. 11, fig. 8a, and fig. 10, no. 24). Geochemical analysis (Ogden, 1995, table 8.2.) indicated (in particular with loop earrings) some higher copper levels than seen in the gold and silver-base finds from Saruq al-Hadid. Two analyses of the above-described granulated bead, however, gave about 3 wt% Cu, well within the range of copper levels seen at Saruq al-Hadid.

The tassel earrings from Tell Fara/Beth Pelet derive from IA II burials and are similar in their general appearance but seem to have been worked differently than the finds from Saruq al-Hadid (compare Petrie, 1930, p. 11, pl. XXXIII, nos. 381 and 384, and pl. XXXVII, bottom right with Boraik Radwan, 2018, p. 107). However, several tubular beads—also found in IA II burials and in an arrangement with carnelian beads—are built from four and five vertically added rows of spheres and closely resemble a shorter version of the tubular beads from Saruq al-Hadid (Petrie, 1930, p. 11 and pl. XXXVII, bottom right; compare here: fig. 2 and fig. 4, no. 19). In addition, several silver-base ringlets composed of small and also larger spheres are comparable to the beads from Saruq al-Hadid and are displayed as spacer beads (Petrie, 1930, p. 11 and pl. XXXVII, bottom right; here fig. 10, nos. 10 and 18).

The small number of plaques left behind from Saruq al-Hadid may similarly support the result that precious metal artefacts at Saruq al-Hadid were intended to be part of more complex items and were not necessarily worked to their final form at the site. A common characteristic of these sheet metals is their roughly cut edges. These contrast with their piercings, which were probably intended for the subsequent application of the plaques. Their semi-finished character may support the idea that these sheets were intended to be traded as they were meant to be fixed to a second material (e.g. wood, bone, fabric) at their destination only.

Two comparable Levantine finds derive from more recent works in Jerusalem/Israel and were found as part of the Temple Mount Project (TMP) in 2020[7] and the Pilgrimage Road Project (PRP) in 2024 (fig. 1).[8] The bead from the PRP consists of two rows, each with 7 spheres with flattened surfaces and is a very good match to beads from Saruq al-Hadid (FN no. 9). However, it was discovered in the debris of a Roman structure and is thus considerably younger.[9] The bead from the TMP dates to the IA II and consists of four vertical and two horizontal rows which have not been found as such at Saruq al-Hadid, but which are comparable to single ringlets with two horizontal rows of eight spheres each from the site (fig. 10, nos. 2, 15 and 16). The flat surfaces and indents visible between individual spheres of the TMP bead, however, are two important details that are shared with the single ringlet beads from Saruq al-Hadid (for indents see fig. 12a).

Short tubular beads composed of four rows and of eight rows but capped with larger spheres at both ends are also known from the queens' tombs at Nimrud (Hussein,

7. *Temple Mount Project: Salvaging Heritage from Archaeological Crime Debris*. https://www.jpost.com/israel-news/sifting-the-past-605135; accessed 10/2025; *Find and Finder of the Month: A Rare Gold Bead from the First Temple Period found by Binyamin Milt*. https://tmsifting.org/en/2020/11/26/find-and-finder-of-the-month-a-rare-gold-bead-from-the-first-temple-period/ accessed 10/2025.
8. *The Pilgrimage Road*. https://cityofdavid.org.il/en/the-pilgrimage-road/; accessed 10/2025.
9. *Rare Gold Bead from the City of David more than 1,600 Years Old Discovered in Jerusalem*. https://cityofdavid.org.il/en/rare-gold-bead-from-the-city-of-david-more-than-1600-years-old-discovered-in-jerusalem-eng/; accessed 10/2025.

2016, pl. 53a). These can be compared to the larger examples from Saruq al-Hadid (Boraik Radwan, 2018, p. 110; here fig. 4, no. 19).

There is also a strong degree of similarity between artefacts from Saruq al-Hadid and an unprovenanced collection of gold beads from Iran, and dated to about 1000 BCE (fig. 1). The Iranian collection includes granulated tubular beads but—more importantly—a flower-shaped bead and a double ringlet, both with deformed granules that are regularly detected with beads from Saruq al-Hadid (Dubin 2009, p. 52, fig. 40). Unlike the beads from Saruq al-Hadid, however, the spheres here are arranged around a disc-like centre. This detail is uncommon with Saruq al-Hadid beads, which exhibit only small flattened inner circles (fig. 10, no. 1). A cage bead from Marlik—but of a rather different arrangement than evident at Saruq al-Hadid (Negahban, 1996, pl. 56)—and a horn-shaped (hollow?) gold-base foil artefact from Lorestan (Louvre Collections, AO 14012)[(10)], which is comparable to variant 2 at Saruq al-Hadid, add to the range of comparable artefacts from Iran (fig. 1).

Finally, cage beads found in Georgia that are on display in the Georgian National Museum, Tbilisi, are a relatively close match in their overall composition to finds from Saruq al-Hadid (compare also Dibba below; here: fig. 1 and fig. 4, no. 20). A tubular bead composed of five (stacked) vertical rows from Armenia may be a further link to the Caucasus when comparing the individual rows of this bead to single ringlets or double row beads with flattened surfaces on their top and bottom from Saruq al-Hadid (Jakubiak et al., 2017, fig. 9; here: fig. 4, nos. 12 and 13 and fig. 13a).

There are also local comparanda to the Saruq al-Hadid assemblage within southeastern Arabia, including some of the bead types less commonly encountered in the wider region. From Daba al-Bayah (Oman), for example, derives a broadly similar cage bead (Frenez et al., 2020, fig. 9b); and at Bat (Oman) a spherical sheet bead was excavated (Weisgerber, 2007, p. 9 bottom figure; here: fig. 1). At Bat, granulated beads were also discovered. One of these consists of differently sized spheres, a composition that is not evident at Saruq al-Hadid (Loepp and Maass, 2017, fig. 1). A second artefact comprises a single ringlet with two horizontal rows possibly made of copper and is in its material comparable to a single find from Saruq al-Hadid. A third bead from Bat consists of several vertical rows that are flattened on the inside, a detail that compares to multi-row beads from Saruq al-Hadid (Weisgerber, 2007, p. 9 bottom figure; compare here: fig. 4, no. 19). The latter two beads are not published as individual finds and it is difficult to discern the precise details of their shape from the published report and images (Weisgerber, 2007).

Comparable beads composed of spheres were also recovered from Rumeilah in Al Ain (UAE), of which one shows deformed surfaces (Boucharlat and Lombard, 1985, pl. 73, no. 10; here: fig. 1). The publication does not list any information on the bead's size, but the find may rather compare to the rare but evident beads with larger spheres of more than 3 mm in diameter. In addition, several comparable copper-base artefacts (e.g. arrowheads, a dagger and bracelets) demonstrate that the site is broadly contemporary with Saruq al-Hadid (Boucharlat and Lombard, 1985, pl. 62 and 63). Horn-shaped artefacts have been excavated in early Iron Age burials at Jebel al-Buhais in Sharjah (UAE; here: fig. 1), but they do not show a seam-like extension in the core's centre and, therefore, rather resemble the less common variant 2 from Saruq al-Hadid (Jasim, 2023, fig. 351).

Additionally, the Jebel al-Buhais Iron Age burials exhibit further important parallels, with many containing copper-base artefacts such as arrowheads and daggers that resemble the copper-base inventory from Saruq al-Hadid. Gold-base jewellery is, on the other hand, rare at Jebel al-Buhais (Jasim, 2023).

The same is possibly true for the horn-shaped artefacts from Bida Bint Saud in Abu Dhabi (UAE) that are on display in the Al Ain Museum (UAE) and they are comparable to the horn-shaped variant 2 from Saruq al-Hadid.

The copper industry at Saruq al-Hadid seems to have been deeply interwoven with the local economy, as seen at contemporary sites such as Bithnah, Masafi or Adam in burials and ritualised contexts (Benoist et al., 2015; Gernez and Jean, 2021; Jean et al., 2021; here: fig. 1). This similarly applies to the production and deposition of precious metals in Saruq al-Hadid but with many fewer comparable finds. Beyond that, there appears to be a strong connection to long-distance trade, reflected in very similar ideas about precious jewellery and its styles, even more so than in copper-base and ferrous artefacts from Saruq al-Hadid, which also display strong connections to wider West Asian styles. There are more examples and comparable finds that indicate the role of Saruq al-Hadid as a trading hub and highlight its connections to the nearby and the wider regions. These require a detailed discussion that extends beyond the remit of this paper and will be presented in a future publication. The discussion above, however, demonstrates the importance of Saruq al-Hadid and its gold (and silver-base) jewellery production for the early Iron Age exchange systems. Despite the lack of actual workshops, the material left behind displays the entire *chaîne opératoire* from beating ingots into sheet metal to cutting strips, to hammering and twisting wires in shape, and producing gold and silver-base artefacts. The lack of workshops and tools is not very surprising, and fits well with the currently understood pattern of persistent but temporary/seasonal use of the site, where craftspeople would arrive and leave with their tool sets. Ethnographical examples support the reconstructed temporary and transient character of craft activities at Saruq al-Hadid; precious metal smiths in particular are known to have operated without fixed workshops and, even if sedentary, to produce a very limited repertoire of tools and equipment (e.g. Armbruster, 1995, p. 130; Wilson, 2002).

The number of precious metal finds deposited at Saruq al-Hadid is exceptional and presently without comparison in ancient Arabia. It is not only the sheer number of arte-

10. Louvre collections. https://collections.louvre.fr/en/ark:/53355/cl010130418; accessed 10/225.

facts, reaching into the thousands but also the ratio in which the two categories of finished and semi-finished precious metal finds appear at the site. The quantity of semi-finished artefacts from excavations by SHARP and the Polish Mission is at least equal to and potentially 1.3 times greater than the quantity of excavated finished artefacts, depending on the classification of semi-finished and misfits pieces. This ratio highlights the significance of working remnants at Saruq al-Hadid. Working remnants were not randomly left behind; rather, they demonstrate that precious metals were an important component of cultural practices at the site and contributed to its significance within early Iron Age exchange networks. Individual finds demonstrate a direct connection between the two artefact groups of finished and semi-finished items. The most significant examples include pre-shaped and prepared strips, ribbons, and wires that have already been cut, twisted, fused, or split.

An additional single but significant example is the ring-shaped item with indents on its outer surface (fig. 7a). This find seems to be a semi-product for a ringlet with granules attached to its indentations (fig. 7b). Only a few complete artefacts are known from the site, but they directly relate working remnants with finished artefacts supporting the production of precious metal artefacts on site. The presence of such a quantity of valuable finished and semi-finished materials left behind at Saruq al-Hadid poses a puzzle. The question of whether it was removed from circulation solely or partly for ritual reasons remains unresolved; it certainly must have held significant economic value not only for the site but for wider regional exchange systems.

Acknowledgements: This work was undertaken in collaboration with the Dubai Municipality under contract no. 639/1/1413904. We acknowledge their direct and in-kind support, and the additional support received from our host institutions. We acknowledge the support provided in the elemental analysis undertaken by Sabine Klein and her team at the Goethe University Frankfurt a. M., Germany. We acknowledge the very helpful comments of both reviewers Marilou Nordez and Martin Sauvage.

BIBLIOGRAPHICAL REFERENCES

Al-Kassem A., Groucutt H. S., Reize F., Alsuwaidi M. A., Al Ali B. M. A., Boraik Radwan Karim M. (2024) – Neolithic Arrowheads and Bronze Age Industry at Saruq al Hadid, UAE, *Journal of Archaeological Science: Reports*, 57, p. 1–15.

Alkhalid M., Alkassem A., D'auria A., Naime Y., Reize F., Alsuwaidi M., Boraik M., Ali B. A. (2024) – Archaeological Excavations at Sarūq al-Ḥadīd 2022-2023 Season: Stratigraphy and New Absolute Chronological Sequence of Area G, *Arabian Archaeology and Epigraphy*, 35, p. 71–102.

Al-Khraysheh F., An-Nashef K. (2007) – *Dubai: Civilization and Progress throughout Three Thousand Years. Five Seasons of Joint Archaeological Excavations between the Emirate of Dubai and the Hashemite Kingdom of Jordan at Sārūq al-Ḥadīd*, Dubai, Department of Tourism and Commerce Marketing, Government of Dubai, 240 p.

Armbruster B. (1995) – Traditionelles Goldschmiedehandwerk in Westafrika und bronzezeitliche Metallverarbeitung in Europa. Technologien im ethnoarchäologischen Vergleich, *Beiträge zur allgemeinen und vergleichenden, Archäologie* 15, p. 111–201.

Armbruster B. (2000) – *Goldschmiedekunst und Bronzetechnik, Studien zum Metallhandwerk der Atlantischen Bronzezeit auf der Iberischen Halbinsel*, Montagnac, Monique Mergoil (Monographies Instrumentum, 15), 232 p.

Armbruster B., Meyer C. (2024) – Gold Artifacts from the Early Scythian Princely Tomb Arzhan 2, Tuva-Aesthetics, Function, and Technology, *Arts*, 13, 2, 46 p., https://www.mdpi.com/2076-0752/13/2/46.

Asderaki E., Rehren T. (2008) – Complex Beauty: The Manufacture of Hellenistic Wreaths, in Y. Facorellis, N. Zacharias and K. Polikreti (eds.), *Proceedings of the Fourth Symposium of the Hellenic Society for Archaeometry*, Oxford, BAR (BAR International Series, 1746), p. 507–514.

Benoist A., Le Carlier de Veslud C., Goy J., Degli Esposti M., Armbruster B., Attalaelmanan G. (2015) – Snake, Copper and Water in South-Eastern Arabian Religion during the Iron Age: the Bithnah and Masāfi Evidence, in C. Robin, J. Schiettecatte and G. Charloux (eds.), *Pre-Islamic South Arabia and its Neighbors: New Developments of Research,* proceedings of the 17[es] Rencontres sabéennes (Paris, 6-8 June 2013), Oxford, BAR (BAR International Series, 2740; British Foundation for the Study of Arabia Monographs), p. 21–36.

Boraik Radwan M. (2018) – *Saruq al-Hadid Museum Archaeology Catalogue*, Dubai, Dubai Municipality, 159 p.

Born H., Schosser S., Schwab R. (2009) – Granuliertes Gold aus Troia in Berlin: erste technologische Untersuchungen eines anatolischen oder mesopotamischen Handwerks, *Restaurierung und Archäologie: Konservierung, Restaurierung, Technologie, Archäometri*e, 2, p. 1–19.

Boucharlat R., Lombard P. (1985) – The Oasis of Al Ain in the Iron Age: Excavations at Rumeilah (1981-1983), Survey at Hili 14, *Archaeology in the United Emirates*, 4, p. 44–73.

Carroll D. L. (1972) – Wire Drawing in Antiquity, *American Journal of Archaeology*, 76, 3, p. 321–323.

Carroll D. L. (1974) – A Classification for Granulation in Ancient Metalwork, *American Journal of Archaeology*, 78, 1, p. 33–39.

Darque-Ceretti E., Aucouturier M. (2013) – Gilding for Matter Decoration and Sublimation. A Brief History of the Artisanal Technical Know-how, in A. E. G. Candeias and I. C. A. Sandu (eds.), *1st International Conference on Innovation in Art Research and Technology (INART 2013)*, procceidings of the conference (Evora, 10–13 July 2013), *International Journal of Conservation Science*, 4 (Special Issue), p. 647–660.

Davey C. J. (2009) – The Early History of Lost-Wax Casting, in J. Mei and T. Rehren (eds.), *Metallurgy and Civilisation: Eurasia and Beyond*, London, Archetype Publications, p. 147–154.

Dubin L. S. (2009) – *The Worldwide History of Beads*, London, Thames and Hudson (rev. edition), 396 p.

Franke K. A (2017a) – Chapter 11. Precious Metal Artefacts (Gold, Silver, Lead, Antimony), in L. Weeks (ed.) *Saruq al-Hadid Archaeological Research Project (SHARP). Interim Report III*, unpublished, p.551–637.

Franke K. A (2017b) – Chapter 13.2. Beads and Vitreous Materials, in L. Weeks (ed.) *Saruq al-Hadid Archaeological Research Project (SHARP). Interim Report III*, unpublished, p. 657–670.

Franke K. A (2026) – On the Edge of Crises, a View from Archaeometry, in S. Pollock, R. Bernbeck, G. Eberhardt, and M. Kehl (eds.), *Unforeseeable Futures. Confronting Crises in the Archaeology of Highland Societies*, Leiden, Sidestone Press (The Iranian Highlands 5), p. 165–184.)

Frenez D., Genchi, F., David-Cuny, H., Al-Bakri, S. (2020) – The Early Iron Age Collective Tomb LCG-1 at Dibbā al-Bayah, Oman: Long-Distance Exchange and Cross-Cultural Interaction, *Antiquity*, 95, 379, p. 104–124.

Gernez G., Jean M. (2021) – Excavations of an Iron Age Site near Adam in Central Oman, in M. Luciani (ed.), *The Archaeology of the Arabian Peninsula*, 2. *Connecting the Evidence,* proceedings of the international workshop held at the 10th International Congress on the Archaeology of the Ancient Near East (Vienna, 2016), Vienna, Österreichische Akademie der Wissenschaften, p.149–161

Giumlia-Mair A. (2020) – Plating and Surface Treatments on Ancient Metalwork, *Advances in Archaeomaterials*, 1, 1, p. 1–26.

Hauptmann A. (2020) – *Archaeometallurgy - Materials Science Aspects*, Cham, Springer, 595 p.

Hauptmann A., Klein S. (2016) – Golden Artifacts from the Royal Tombs of Ur, *Metalla*, 22, 1, p. 84–88.

Herrmann J. T., Casana J., Qandil H. S. (2012) – A Sequence of Inland Desert Settlement in the Oman Peninsula: 2008-2009 Excavations at Saruq al-Hadid, Dubai, UAE, *Arabian Archaeology and Epigraphy*, 23, p. 50–69.

Hunt L. B. (1980) – The Long History of Lost Wax Casting: over Five Thousand Years of Art and Craftsmanship, *Gold Bulletin*, 13, 2, p. 63–79.

Hussein M. M. (2016) – *Nimrud: The Queens' Tombs*, Baghdad, Iraqi State Board of Antiquities and Heritage, and Chicago, the Oriental Institute of the University of Chicago, 432 p.

Jakubiak K., Iskra M., Piliposyan A., Zaqyan A. (2017) – Preliminary Report on the 2016 Season in Metsamor (Armenia), *Polish Academy in the Mediterranean*, 26, 1, p. 557–569.

Jasim S. A. (2023) – *The Necropolis of Jebel al Buhais. Prehistoric Discoveries in the Emirate of Sharjah, UAE.*, Sharjah, Sharjah Archaeology Authority, 3rd ed., 334 p.

Jean M., Pellegrino M. P., Bigot L., Pinot J., Castéja V. de, Gernez G. (2021) – The Archaeological Site of Mudhmar East (Adam, Ad-Dakhiliyah, Oman): Results from the 2019 Excavations, *The Journal of Oman Studies*, 22, p. 158–185.

Karacic S., Boraik M., Qandil H., David-Cuny H. (2017) – Snake Decorations on the Iron Age Pottery from Sarūq al-Ḥadīd: a Possible Ritual Centre?, *Proceedings of the Seminar for Arabian Studies,* 47, p. 139–150.

La Niece S. (1995) – Depletion Gilding from Third Millennium BC Ur, *Iraq*, 57, p. 41–47.

Leusch V., Pernicka E., Armbruster B. (2014) – Chalcolithic Gold from Varna: Provenance, Circulation, Processing, and Function, in H. Meller, R. Risch and E. Pernicka (eds.), *Metals of Power – Early Gold and Silver*, Proceedings of the 6th Mitteldeutscher Archäologentag (Halle/Saale, 2013), Halle/Saale, Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt (Tagungen des Landesmuseums für Vorgeschichte Halle, 11, 1), p. 165–182.

Loepp D., Maass A. (2017) – Experimental Replication of a Granulated Gold Bead from an Ancient Tomb at Bat, Oman, *Metalla*, 23, 1, p. 29–38.

Maryon H. (1949) – Metal Working in the Ancient World, *American Journal of Archaeology*, 53, p. 93–125.

Moore M. W., Weeks L., Cable C., Al-Ali Y., Boraik M., Zein H. (2022) – Bronze Age Stone Flaking at Saruq al-Hadid, Dubai, Southeastern Arabia, *PLoS ONE*, 17, 7, 46 p.

Moorey P. R. S. (1994) – 5.2. Precious Metals, in P. R. S. Moorey, *Ancient Mesopotamian Materials and Industries: the Archaeological Evidence*, Oxford, Clarendon Press, p. 217–240.

Nashef K. (2010) – Sārūq Al-Ḥadīd. An Industrial Complex of the Iron Age II Period, in A. Avanzini (ed.), *Eastern Arabia during the First Millennium BC*, proceedings of the international conference (Pisa, 2008) Rome, L'Erma di Bretschneider (Arabia Antica, 6), p. 213–226.

Negahban E. O. (1996) – *Marlik: the Complete Excavation Report,* Philadelphia, University Museum, University of Pennsylvania. (University Museum Monograph, 87), 408 p.

Newton C. (2016) – Chapter 05. Archaeobotany, in L. Weeks (ed.), *Saruq al-Hadid Archaeological Research Project (SHARP). Interim Report III*, unpublished, p. 97–146.

Northover P. (1995) – Late Bronze Age Drawplates in the Isleham Hoard, in B. Schmid-Sikimić and P. Della Casa (eds.), *Trans Europam: Beiträge zur Bronze- und Eisenzeit zwischen Atlantik und Altai: Festschrift für Margarita Primas*, Bonn, Dr. Rudolph Habelt, p. 15–22.

Oddy A. (1977) – The Production of Gold Wire in Antiquity: Hand-making Methods before the Introduction of the Draw-Plate, *Gold Bulletin*, 10, 3 p. 79–87.

Oddy A. (1981) – Gilding through the Ages, *Gold Bulletin*, 14, 2, p. 75–79.

ÖYŞEN I. (2019) – Drahtziehen in der Bronzezeit? Zu den drei Ziehbronzen aus dem Hort von Isleham, Cambridgeshire, in P. Baas (ed.), *Proceedings of the XXth International Congress on Ancient Bronzes: Resource, Reconstruction, Representation, Rol*e, Oxford: BAR Publishing (BAR International Series, 2958), p.101–106.

Ogden J. M. (1995) – Chapter 8. The Gold Jewellery, in C.-M. Bennett and P. A. Bienkowski (eds.), *Excavations at Tawilan in Southern Jordan*, Oxford, British Institute at Amman for Archaeology and History, Oxford University Press (British Academy Monographs in Archaeology, 8), p. 123.

Petrie F. (1930) – *Beth-Pelet I (Tell Fara)*, Vienna, Adolf Holzhausen's Successors and London, British School of Archaeology in Egypt, 26 p.

Potts D. T. (2009) – Urartian and Assyrian Echoes at Saruq al-Hadid (Emirate of Dubai), *Liwa*, 2, p. 39.

Rehren T., Hess K., Philip G. (1996) – Auriferous Silver in Western Asia: Ore or Alloy?, *Journal of the Historical Metallurgy Society*, 30, 1, p. 1–10.

Roberts J., Weeks L., Fillios M., Cable C., Carter M., Al Aali Y. Y., Radwan M. B., Zein H. (2019) – The Exploitation of Marine Resources at Saruq al-Hadid: Insights into the Movement of People and Resources in Bronze and Iron Age South-eastern Arabia, *Arabian Archaeology and Epigraphy*, 30, 2, p. 179–198.

Schlosser S., Reinecke A., Schwab R., Pernicka E., Sonetra S., Laychour V. (2012) – Early Cambodian Gold and Silver from Prohear: Composition, Trace Elements and Gilding, *Journal of Archaeological Science*, 39, 9, p. 2877–2887.

Soriano I., Perea A., Escanilla N., Contreras Rodrigo F., Al Ali Y. Y. A., Boraik Radwan Karim M., Zein H. (2018) – Goldwork Technology at the Arabian Peninsula. First Data from Saruq al Hadid Iron Age Site (Dubai, United Arab Emirates), *Journal of Archaeological Science: Reports*, 22, p. 1–10.

Stepanov I., Weeks L., Franke K., Rodemann T., Salvemini F., Cable C., Al Ali Y., Radwan M. B., Zein H., Grave P. (2019) – Scrapping Ritual: Iron Age Metal Recycling at the Site of Saruq al-Hadid (UAE), *Journal of Archaeological Science*, 101, p. 72–88.

Turner G. (1973) – South Arabian Gold Jewellery, *Iraq*, 35, 2, p.127–139.

Valente T., Contreras F., Mahmud A., Boraik Radwan Karim M., Al Mansoori M. S, Zein H. (2020) – Five Seasons of Excavations in Areas 2a and G of Saruq al Hadid (Dubai, UAE): Iron Age II Evidences of Copper Production, Workshop Area and Ceremonial Activities, *Isimu*, 23, p. 169–195.

Verduci J. (2014) – Personal Display in the Southern Levant and the Question of Philistine Cultural Origins, *Polish Archaeology in the Mediterranean*, 2, 23, p. 247–268.

Weeks L. (2023) – Sarūq al-Ḥadīd, in *Thematic Dictionary of Ancient Arabia*. Online edition 2023, doi: https://doi.org/10.60667/tdaa-0111.

Weeks L., Cable C., Franke K., Newton C., Karacic S., Roberts J., Stepanov I., David-Cuny H., Price D., Bukhash R. M., Radwan M. B., Zein H. (2017) – Recent Archaeological Research at Saruq al-Hadid, Dubai, UAE, *Arabian Archaeology and Epigraphy*, 28, 1, p. 31–60.

Weeks L., Cable C. M., Franke K. A., Karacic S., Newton C., Roberts J., Stepanov I., Mcrae I. K., Moore M. W., David-Cuny H., Al Aali Y. Y., Boraik M., Zein H. M. (2018) – Saruq al-Hadid: a Persistent Temporary Place in Late Prehistoric Arabia, *World Archaeology*, 51, 1, p. 157–182.

Weeks L., Cable C. M., Karacic S., Franke K. A., Price, D. M., Newton C., Roberts J., Al Ali Y. Y., Boraik, M., Zein H. (2019a) – Dating Persistent Short-Term Human Activity in a Complex Depositional Environment: Late Prehistoric Occupation at Saruq-al-Hadid, Dubai, *Radiocarbon*, 1, 35, 35 p., doi:10.1017/RDC.

Weeks L., David-Cuny H., Avanzini A., Lischi S., Genchi F., Caputo F., Al Ali Y. Y., Boraik M. (2019b) – Worked and Decorated Shell Discs from Southern Arabia and the Wider Near East, *Arabian Archaeology and Epigraphy*, 30, 2, p. 213–238.

Weeks L., Petrie C. A. (in press) – Iran and Arabia in the Iron Age: New Discoveries, in B. Mutin and N. Eskandari (eds.), *The Archaeology of the Southeastern Iranian Plateau Between the Neolithic and Achaemenid Periods*, Turnhout, Brepols (ARWA collection / ARATTA), accepted July 2022.

Weeks L., Valente T., Franke K. A., Contreras F., Boraik Radwan M., Zein H. (2023) – *Iron Age Copper Production and the 'Ritual Economy' of Saruq al-Hadid (Dubai, UAE)*, proceedings of Abu Dhabi's Archaeology Conference (Abu Dhabi, 2022), Oxford, Archaeopress, p. 239–269.

Weisgerber G. (2007) – *Deutsches Bergbau-Museum Bochum: Bat World Heritage Monument. Spring Season 2007 Report*, http://www.deutschoman.de/dogaktivitaeten/forschung/grabungenbat; accessed 06/2017.

Williams C. R. L. (1924) – *Catalogue of Egyptian Antiquities, Numbers 1-160: Gold and Silver Jewelry and Related Objects*, New York, The New York Historical Society, 281 p.

Wilson D. (2002) – Asante Indigenous Goldsmithing: The Impact of Contemporary Culture on Akan Jewelry, *African Diaspora*, *ISPs*., 45 p.

Wygnańska Z., Bagi O., Rądkowska J., Zych I., Rempel S., Juchniewicz K., Boraik Radwan M. (2022) – Reconstructing a Changing Landscape of Human Activities in the Iron Age II at Saruq al-Hadid (Dubai), *Proceedings of the Seminar for Arabian Studies*, 51, p. 449–464.

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