# Hasanlu and the Emergence of Iron in Early 1st Millennium BC Western Iran

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## Introduction

While the origins of iron metallurgy remain subject to much debate, current arguments would suggest that its development and initial sporadic usage occurred in Anatolia and Transcaucasia (*e.g.*, Colchis) during the 2nd millennium BC, although that has never been proven (Pleiner 2000; Pigott 1989, 69). What is clear is that by the closing centuries of this millennium, the transition to iron was underway in the eastern Mediterranean (*i.e.*, from Greece and Anatolia south into the Levant).[1] Iron was rapidly becoming the metal of choice for tools and weapons, but the popularity of bronze by no means waned and certain tools and weapons continued to be made with this alloy of copper and tin. However, tin-bronze was gradually being pigeonholed as a decorative material appropriate only for personal ornaments and items worked, for example, in *repoussé*.

In the period prior to iron's wide-spread appearance (*c.* mid-late 2nd millennium BC), the archaeological record of north-western Iran yields evidence of a dramatic cultural shift that classically has been attributed to the invasion of Indo-Iranian-speaking tribes (Young 1967, 24; Burney & Lang 1972, 117; Ghirshman 1979). However, this shift did not occur overnight, but rather indicates an extended phase of cultural transition that lasted over several centuries. Bronze Age metalworkers in Iran may well have had a rudimentary knowledge of metallic iron as a possible by-product of copper/bronze smelting[2]. Even if true, they apparently had little need or inclination to pursue iron-making during the Iron I period (*c.* 1450/1350-1100 BC). During this time, the bronze-making skills of the indigenous population seem to have served all stylistic and functional needs of the population.

During the early Iron Age of western Iran, tin-bronze was certainly the copper alloy of choice for ornaments as well as tools and weapons (*e.g.*, Moorey 1982, 94-95; see also Moorey 1994, 263-265). Some arsenical copper continued to be produced and was excavated at sites in Dailaman (*e.g.*, Egami *et al.* 1965; 1966) and in Gilan at Marlik (Negahban 1996). It is possible that tin-bronze was somewhat harder to come by in these regions, although it is important to note that few of the 'utilitarian' artefacts from other sites in the region have been analysed, thus adding the caveat that perhaps this discrepancy is a product of different types of assemblages being analysed. Interestingly, only modest amounts of iron were found at Marlik and other sites in Gilan (Pigott 1980, 424-425, 429). Despite the proximity of Iran to the supposed core area of iron's early development, widespread and continuous use of the metal did not occur until the 10th/9th centuries BC (Iron II period) of north-western Iran at sites such as Hasanlu, Dinkha, and Haftavan and at a significant distance to the southeast at Sialk in central Iran (*Ibid.*).

Before looking at the evidence for early iron in western Iran, it is important to address why iron may have been adopted in this region in the first place.

Iron is the fourth most common element in the earth's crust and its ore minerals are as close to being ubiquitous in Southwest Asia as such minerals can be. It is widely available, for example, on the Anatolian and Iranian Plateaux (Fig. 1). As a result, the production of iron had certain economic advantages over bronze-making, which, for example, was dependent upon the long-distance trade in tin metal and/or ores. It should be noted, however, that iron's ubiquity was offset by the time and manpower needed to smelt and forge it (Smith 1971, 51). While true steel (*i.e.*, iron with a high and uniformly-distributed carbon content) has mechanical properties superior to those of a cold-worked 10% tin-bronze, published analyses of ancient Near Eastern iron artefacts show that they were made most often made of a low-carbon, heterogeneously-carburised wrought iron that was on par with the best tin-bronzes of the early Iron Age (Fig. 2). In other words, there is little current evidence to suggest that iron was a technological innovation initially adopted as a result of its superior mechanical properties.

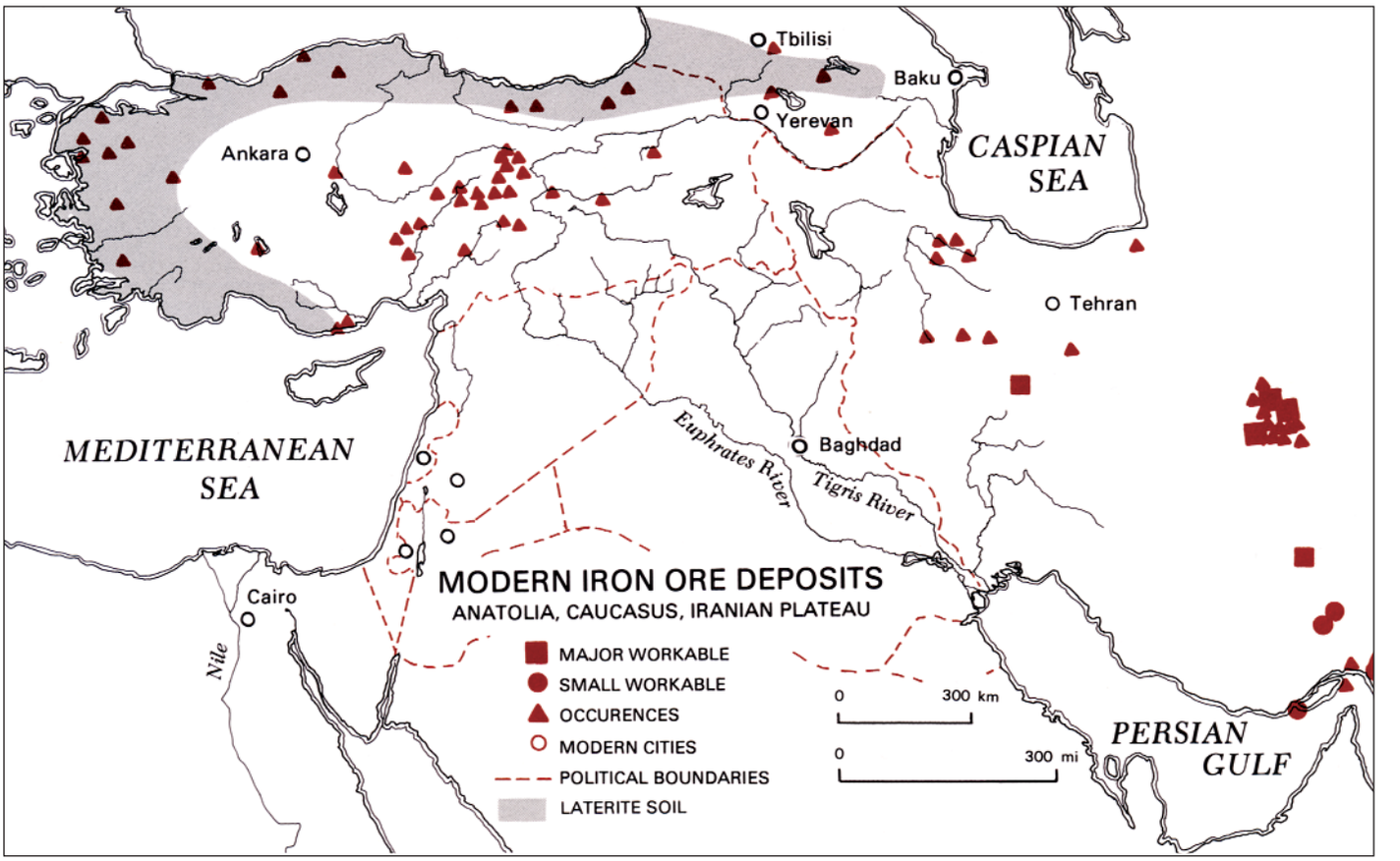


*Fig. 1: Locations of modern iron ore deposits in Anatolia, Iran and the Caucasus; (Pigott 1989, 69, Fig. 4).*

Therefore, we seek answers elsewhere as to why iron was accepted relatively rapidly in western Iran. The impetus for acceptance in this region may have come from its iron-using neighbours to the west, most notably the Assyrian Empire. It is in the Iron II Period, when the Assyrians began to mount significant military campaigns into western Iran, that iron first occurs *en masse* in the area. We know from Assyrian texts that iron was held in high esteem among its elites, both military and royal (Pleiner & Bjorkman 1974, 286-288)[3]. Peoples in western Iran undoubtedly had the opportunity to visit Assyria and witness first-hand its grandeur and/or felt Assyria's power as its armies regularly intruded deeply into their homelands. The desire to emulate Assyrian might and strength, symbolised in Assyria by the iron dagger (Pleiner & Bjorkman 1974), may have facilitated the acceptance of a new technology that would not have been difficult to master by people steeped in millennia-old traditions of metalworking. Indeed, iron seems to have been worked first as a decorative material by Iranian bronze-workers, who then moved on to producing a whole repertoire of tools, weapons, and decorative artefacts utilising the unique properties of the new metal (Pigott 1980; 1981). Although local innovation is theoretically possible, it is hard to imagine that the synchronic arrival of iron with the coming of the Assyrians was merely a coincidence.

## North-western Iran: Iron at Hasanlu Tappeh

The Iron Age citadel of Hasanlu, likely destroyed by the Urartians[4] around 800 BC, provides one of the points of reference for understanding iron in elite settlement contexts in western Iran (*e.g.*, Dyson & Voigt 1989). The site and the role that iron played there can be seen as a microcosm of what was transpiring in similar contexts across much of the Ancient Near East.

Almost 2000 iron artefacts were excavated from the late 9th century BC destruction level of the Hasanlu Period IVB citadel. Of these, some 65% were weaponry. It is important to note that a similar amount of tin-bronze, which was most frequently used for equestrian trappings, architectural decoration, personal ornaments, and certain weapons and armor, was also excavated at the site (de Schauensee 1988). The metallographic analyses of several of the iron artefacts from the destruction level indicate that the metal is best termed a low-carbon, heterogeneously-carburiszed wrought steel (Pigott 1981, 229-267; see also Knox 1963) (Fig. 3). In this

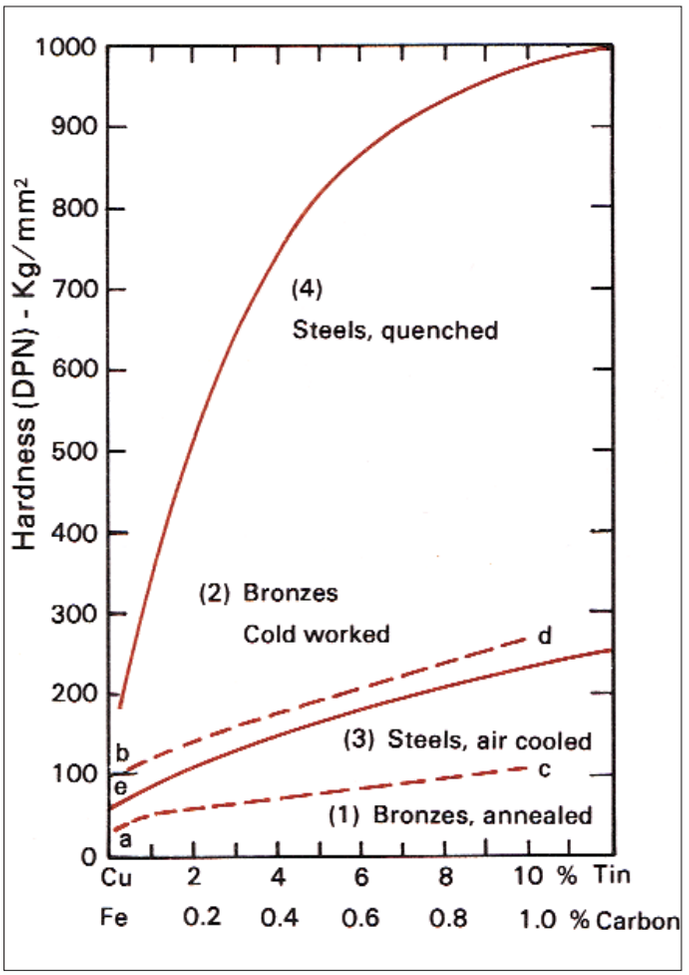


*Fig. 2: Graph comparing the hardness of different forms of iron and copper. Pure copper that has been annealed has the lowest efficiency (point a); it increases in hardness with the addition of tin (up to 10 percent, point c), and with cold-working (point d). Pure iron (point e) is hardened by the addition of carbon, thereby making it into steel. "If steels are heated and allowed to cool naturally, the range of their hardness (curve 3) is slightly below that of worked bronzes, but they become spectacularly superior if quenched (curve 4). The curves are approximate and the hardness varies considerably with impurity content, details of casting technique, prior annealing, and other factors. The brittleness of an alloy generally increases with its hardness." (Pigott 1989, 68, Fig. 2).*

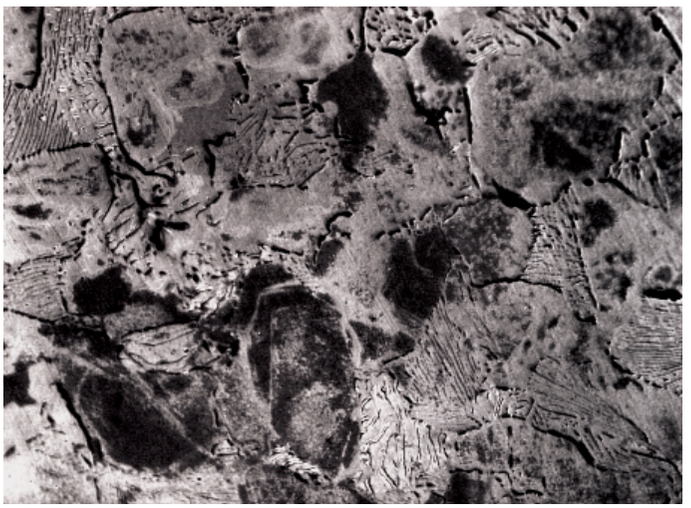

*Fig. 3: Photomicrograph of iron sword UM 65-31-220, showing pseudomorphic pearlite colonies (note their lamellar structure) preserved in the oxidized matrix of the sword. The light coloured, elongate lamellae are probably uncorroded carbides. This artefact had evidence of evenly distributed carburization ( in the form of pearlite colonies) in the central portion of the blade, as well as at the blade's edge. Thus it would qualify as a "mild" steel and most probably was an effective weapon of war. Along one edge of the blade distorted structures in the oxide suggest some evidence of cold-working deformation of the metal. Grain size, when apparent, is seen to be coarse, and there is some indication of the artefact having been cooled fairly slowly (Pigott 1989, 76, Fig. 15).*

period, iron was one of a variety of materials being experimented with for decorative effect, and it often occurs as part of bimetallic artefacts such as spears with iron sockets and tin-bronze blades, iron daggers with tin-bronze cast-on hilts, and *repoussé* tin-bronze belt plaques with iron rivets. Certain iron artefacts, such as *repoussé* iron plaques, were obviously worked as if they were made of tin-bronze. By the Iron III period (*c.* 800-550 BC), however, bimetallism had waned and the two metals were increasingly differentiated in use: tin-bronze for decorative items and iron for tools and weapons.

Hasanlu was a major regional settlement of considerable size and significance during the Iron Age until its destruction in the late 9th century BC. It was located along a major route through north-western Iran between Assyria and points further east. In this strategic location, the site likely controlled local as well as long-distance travel and trade and may have acted as a regional processing, production, and/or distribution centre for all kinds of materials, both imported and locally procured. Furthermore, by controlling the hinterland around it and the long-distance resources, Hasanlu would have had ready access to the fuel, ores, and labour necessary for the production of iron on a substantial scale.

However, if iron was being produced on a large scale at Hasanlu, one would expect substantial residues of production including slag and furnace remains. At Hasanlu, as with most sites in the Ancient Near East, the remains of iron production proved to be elusive. No direct evidence of iron smelting or smithing was found other than some large boulders of the iron ore magnetite, which were built into walls and used as floor paving in Citadel buildings. It is possible that the industrial process of smelting was conducted away from the Citadel, but some level of iron working had to have been taking place at the site for three reasons. First, there is the large quantity of militarily-oriented iron artefacts found at the site that would have required the services of blacksmiths to repair, resharpen, and reforge. Second, there are a few iron artefact types unique to Hasanlu, including equestrian shoulder 'rondels' (plaques) in *repoussé*

*Fig. 4: Iron artefacts unique to Hasanlu include two types of hoarse gear: sidebar cheek pieces with three holes (a) and decorative plaques (b). The plaque or rondel is decorated with a winged horse in relief, made by hammering on the reverse side of the plaque. (a: UM 73-5-369, L. 5,8 cm; b: HAS 60-876, Diam. 19,5 cm) (Pigott 1989, 71, Figs. 6a, b).*

and iron sidebar cheekpieces with three holes for attachment to bridles (Fig. 4), which were probably produced locally. Both of these equestrian artefacts are north-western Iranian in style and are not known on Assyrian reliefs (Dyson & Muscarella 1989). Finally, the standardised size and shape of a certain type of iron knife is also suggestive of local smithing practices. Only the repetitious efforts of a skilled blacksmith familiar with the properties of iron could result in the consistency of form found in this class of small, tanged iron knives with a single cutting edge and an upturned point (Fig. 5). Some 86 such knives were excavated at Hasanlu (Pigott 1980, 426, Tab. 12.3) and more examples were found in contemporary individual burials at nearby Dinkha Tappeh (Muscarella 1974).

## The Role of Assyrian Influence in Western Iran

The most important question that remains unanswered concerns the actual source of the iron metal being forged into tools and weapons at sites like Hasanlu and elsewhere in western Iran. If iron ores were not being mined and smelted by western Iranian peoples from *c.* 1000 BC onwards, then the most likely source for the raw metal was the Assyrian Empire which exercised a profound influence in the region over several centuries. At Hasanlu, for example, there are various possible sources for the iron found in Period IVB contexts, including the possibility of an Assyrian garrison occupying the Citadel before the Urartians invaded. The iron artefacts, much of them weaponry and/or related to the military could have been imported from Assyria in finished form. Or, perhaps as iron bloom were imported and subsequently forged to desired shapes by blacksmiths accompanying the troops. Local bronze-workers may have been enlisted as well, thus explaining the iron artefacts worked like tin-bronze. One also cannot discount a trade in iron coming from Assyria in return for produce, timber and horses from the fertile valleys of western Iran. Some iron might even have been given by local Iranian polities as a sign of allegiance to Assyria.

*Fig. 5: Small iron knives with a single cutting edge and upturned point were apparently mass-produced at Hasanlu. (HAS 74-286, L. 10,8 cm) (Pigott 1989, 74, Fig. 12).*

Nor can one ignore the possibility that iron was taken as booty or tribute by the Citadel elite who sent raiding parties to loot regional settlements of their stores of iron. Overall, it is clear that the influence of Assyria was pervasive in the region and local smiths may have depended upon Assyrian blacksmiths to teach them about the unique characteristics of the metal iron and how to work it under the smith's hammer.

Therefore, the cultural changes occurring at Hasanlu from the mid-2nd millennium BC onwards – including the emergence of a highly-stratified society with a powerful military presence – would have fostered in many ways an atmosphere of both local creativity but also emulation of all things Assyrian (see Winter 1977, 379). In Assyria, iron was a metal of special status associated with the military elite and imbued with religious significance. For the local western Iranian elite, owning items in iron (either Assyrian in origin or local imitations) would have conferred a certain status on them, thereby enhancing their prestige and political power (ibid., 381). In this light, it is not so surprising that the emergence of the widespread use of this relatively new material at Hasanlu and across western Iran generally occurred in a period of emerging affluence, social stratification, and military might and in a context of artistic and technological innovation.

## Central Western Iran: Luristan

This brief overview of iron in the Iron Age of western Iran would not be complete without mention of the finds from the province of Luristan. There is little question that new insights into the role of iron in mortuary contexts will be revealed as scholars begin analy-

sing the newly-published results of the excavations by the Belgian Archaeological Mission in Iran (BAMI) directed by the late Louis Vanden Berghe. Two scholars, Drs. Ernie Haerinck and Bruno Overlaet at the University of Ghent, are undertaking the daunting task of publishing the masses of data from the numerous excavated Iron Age cemeteries that yielded great quantities of iron artefacts (see, for example, Overlaet 2003). Future assessments of the published archaeological data on Luristan iron, combined with analytical initiatives (*e.g.*, metallography, AMS dating, Pb-isotope analysis) that focus on some of the best-preserved iron artefacts, are guaranteed to rewrite our understanding of not only iron's role in the region, but across the entire Ancient Near East.

## The Iron Daggers from Luristan

Of significance to future studies is the well-known and unique class of iron daggers that are thought to hail from the cemeteries of Luristan and are found in museum collections around the world (Fig. 6). These unusual daggers, which bear both zoomorphic and anthropomorphic images on their pommels, have been much discussed in the literature (*e.g.*, France-Lanord 1969, 75-126; Moorey 1991; Muscarella 1989; Pleiner 1969a; b; Rehder 1991; Smith 1971). Among the almost 90 daggers known there are no excavated examples; all were acquired by various museums and collectors in the 1920s, 1930s, or later as Luristan's ancient cemeteries were being heavily looted for their remarkable ornate bronzes. This naturally raises the question of their validity as artefacts as opposed to modern forgeries. For example, among the many unusual characteristics of these daggers is their marked degree of similarity, undoubtedly the result of their having been manufactured in one workshop or by one group of smiths (*e.g.*, Moorey 1991, 2) or perhaps by modern metalworkers copying ancient prototypes. Furthermore, most of the daggers are well-preserved for iron of such antiquity, although this could be a product of their deposition in the protective environment of tombs and the low temperature working of the iron (*i.e.*, being air cooled below 750oC), which makes the metal more corrosion-resistant (Smith 1971, 51) as well as soft and ductile (Rehder 1991, 16, 19; Pigott 1999, 93-94).

Fortunately, two of the daggers (from the Royal Ontario Museum and Massachusetts Institute of Technology) have been radiocarbon dated by accelerator mass spectrometry (AMS) to the period 1094+60 years BC (Rehder 1991, 14; Moorey 1991). Not only was it a relief to discover that at least two of the daggers were authentic, but it came as a surprise because they were previously thought to date to the Iron III period (*c.* 800-550 BC) (Moorey 1971, 128). Of course, these two radiocarbon dates merely reflect when the iron was smelted, so the daggers could have been made from recycled metal at a later date (see below). If it is found that other daggers date to a similar time period, it would place this class of daggers among the very earliest iron artefacts in western Iran. Moreover, they would join an exclusive group of pre-1000 BC iron artefacts known from across the Ancient Near East (see Waldbaum 1999).

### Their Manufacture

The way in which the daggers were manufactured is also intriguing (see, *e.g.*, Smith 1971). Rehder (1991) has suggested that the iron was smelted by metalworkers who understood forge-welding, but that the daggers were later manufactured by smiths who did not have this knowledge (Moorey 1991, 6-7). In iron smelting, if the furnace producing the iron yielded a single large bloom then the forging of the single bloom to extrude slag and coalesce the metal would not necessarily teach the smiths the benefits of forge wel-

*Fig. 6: Iron sword from Luristan, unknown provenance. (Tehran, National Museum Inv.-No. 988, L. 54 cm); Photo: DBM, M. Schicht.*

ding. However, Rehder suggests that the producers of the daggers' iron were smelting small 'mini' blooms that had to be forge-welded together into large pieces of iron stock. Quite possibly, from wherever these blooms were being made, they were traded away to smiths in places such as Luristan, who then used the stock to assemble the daggers. However, the daggers were not shaped by forge-welding multiple pieces of iron together. Rather, they were crimped and riveted together from 8-15 individual parts, possibly by bronzesmiths who "were improvising brilliantly in ignorance of iron's special qualities" (Moorey 1991, 6-7; see also Maxwell-Hyslop & Hodges 1966, 169; Rehder 1991; Smith 1971, 52). Thus, if we accept Rehder's suggestion, the possibility exists that the blooms were being manufactured in one place (perhaps from workshops in neighbouring Assyria[5]) and then traded to smiths in Luristan – a model for early iron production that could be extended to all of western Iran.

## Concluding Remarks

Iconographic arguments proposed by Roger Moorey (1991, 7-8) suggest that dagger imagery could have been linked to an underworld deity such as Nergal, who is in turn associated with both Assyro-Babylonian, Hittite, and Hurrian cult as well as the sword. This underworld association would be appropriate for a weapon that was perhaps manufactured exclusively as a mortuary offering (*cf.* Moorey 1991, 8). The daggers' curious unwieldiness fits well with the idea that they were not intended for battle. In addition, the iron used in the blades tends to be a low-carbon heterogeneously-carburised wrought iron that is fairly weak to start with and only becomes weaker with annealing. They were, therefore, soft and ductile daggers (Rehder 1991, 16). Thus, the general sense is that they were being manufactured as prestigious grave goods to be interred with deceased individuals, perhaps those of a certain elite status or rank such as a class of warriors (see Muscarella 1989, 351; Rehder 1991, 18).

Of course, given the acontextual status of the Luristan iron daggers, they will be plagued by controversy until each one has been subjected to radiocarbon analysis. It is extremely difficult to argue with the radiocarbon dates for the smelting of the iron used in the two Luristan daggers, but it remains to be seen what an art historical approach can tell us about the date of their actual manufacture. As a result of our recent MASCA analytical program on the bronzes from Luristan excavated by the Belgian Mission (see Fleming *et al.* in press), a note on the iconography of the daggers can be raised that, in turn, might reflect on their chronology. On a number of the Luristan daggers there is depicted in forged and chiselled metal the image of a bearded human face. A very similar bearded human visage is found on tin-bronze axe-adzes from the excavated Luristan cemetery at Bard-i Bal, which is dated to the Iron III period (*c.* 800-550 BC) by Haerinck and Overlaet (in press). Whether this image is part of a long-lived Luristan iconographic tradition or supportive of the later date for the actual manufacture of the daggers, which both Smith (1971) and Rehder (1991, 16) deemed particularly remarkable examples of the early blacksmith's craft, remains to be seen. Only continued scholarly research into the archaeology and ancient technology of iron metallurgy in western Iran will shed new light on this and a myriad of other intriguing questions.

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## Notes

1 Among the numerous references that can be consulted on the coming of iron in the Ancient Near East, the following are particularly informative: Curtis et al. 1979; Maddin 2003; Moorey 1994, 278-292; Muhly 1982; Pleiner 2000; Pleiner & Bjorkman 1974; Waldbaum 1999; Wertime & Muhly 1980. The discussion in this chapter of the catalogue is based on my previous publications (Pigott 1980; 1981; 1982a; b; 1989; 1999, 6-7, 90-96).

2 The possibility that the initial encounters with metallic iron (other than meteoritic) were the result of iron produced during the smelting of copper ores has been discussed by a number of scholars (*e.g.*, Cooke & Aschenbrenner 1975; Gale et al. 1990; Maddin 2003, 310; Merkel & Barrett 2000; Pigott 1982a, 21; 1999, 6; Smith 1966; Tylecote 1970, 290; Tylecote & Boydell 1978; van der Merwe & Avery 1982; Wertime 1964, 1262; 1973). Despite the fact that iron can be produced during copper smelting, neither archaeology nor the laboratory has been able to provide any well substantiated early examples of such iron.

3 What remains curious about iron in the Assyrian Empire is that despite the enormous amount of iron used by the Assyrians, archaeology has yet to identify significant evidence for the mining and smelting of this important metal. It is difficult to imagine that Assyria acquired all of its iron from outside the empire by means such as conquest, trade, treaties, and tribute.

4 The potential influence and role of Urartian iron and ironworking in western Iran has not been examined in detail nor discussed herein. Those

interested in this topic can consult the following sources: Kellner 1979; McConchie 1998; Merhav 1991.

5 There is strong evidence to suggest that Assyria was an empire conversant with iron technology by the later 2nd millennium BC (Curtis et al. 1979; Pleiner & Bjorkman 1974).

# Bibliography


BURNEY, C. & LANG, D. M.:
1972 The People of the Hills, New York.

COOKE, S. B. & ASCHENBRENNER, S. E.:
1975 The Occurrence of Metallic Iron in Ancient Copper. Journal of Field Archaeology 2, 251-266.

CURTIS, J. (ed.):
1993 Early Mesopotamia and Iran: Contact and Conflict 3500-1600 BC, London.

CURTIS, J. E., STECH WHEELER, T., MUHLY, J. D. & MADDIN, R.:
1979 Neo-Assyrian Iron Working Technology. Proceedings of the American Philosophical Society 123, 369-390.

DE SCHAUENSEE, M.:
1988 Northwest Iran as a Bronzeworking Centre: The View from Hasanlu. In: J. Curtis (ed.), Bronzeworking Centres of Western Asia *c.* 1000-539 BCE, London.

DYSON, R. H., Jr. & MUSCARELLA, O. W.:
1989 Constructing the Chronology and Historical Implications of Hasanlu IV. Iran 27, 1-27.

DYSON, R. H., Jr. & VOIGT, M. M. (eds.):
1989 East of Assyria: The Highland Settlement of Hasanlu. Expedition 31 (2-3).

EGAMI, N., FUKAI, S. & MASUDA, S.:
1965 Dailaman I, the Excavations at Ghalekuti and Lasulkan 1960. The Tokyo University Iraq-Iran Archaeological Expedition Report No. 6, Tokyo.
1966 Dailaman II, the Excavations at Noruzmahale and Khoramrud, Tokyo.

FLEMING, S. J., PIGOTT, V. C., SWANN, C. P. & NASH, S. K.:
in press Bronze in Luristan: Preliminary Analytical Evidence from Copper/Bronze Artifacts Excavated by the Belgian Expedition. To be published in: E. Haerinck & B. Overlaet (eds.), Proceedings of the Conference "The Iron Age in Iran" November 2003, University of Ghent.

FRANCE-LANORD, A.:
1969 La Fer en Iran au premier millenaire avant Jesus Christ. Revue d'histoire des mines and metallurgie I, 75-126.

GALE, N. H., BACHMANN, H.-G., ROTHENBERG, B., STOS-GALE, Z. A. & TYLECOTE, R. F.:
1990 The Adventitious Production of Iron in the Smelting of Copper. In: B. Rothenberg (ed.), The Ancient Metallurgy of Copper, London: Institute for Archaeo-Metallurgical Studies.

GHIRSHMAN, R.:
1979 L'Iran. La Migration des Indo-Aryens et des Iraniens. In: Akten des VII. Internationalen Kongresses fur Iranische Kunst und Archäologie, München, 7.-10. September 1976. Archäologische Mitteilungen aus Iran. Ergänzungsband 6, Berlin.

HAERINCK, E. & OVERLAET, B.:
in press The Chronology of the Pusht-I Kuh, Luristan. Results of the Belgian Archaeological Mission in Iran. Festschrift for Peder Mortensen, Aarhus, 87-103.

KELLNER, H.-J.:
1979 Eisen in Urartu. In: Akten des VII. Internationalen Kongresses fur Iranische Kunst und Archäologie, München, 7.-10. September 1976. Archäologische Mitteilungern aus Iran. Ergänzungsband 6, Berlin, 151-156.

KNOX, R.:
1963 Detection of Iron Carbide Structure in the Oxide Remains of Ancient Steel. Archaeometry 6, 43-45.

MADDIN, R.:
2003 The Beginning of the Use of Iron. In: Th. Stöllner, G. Körlin, G. Steffens & J. Cierny (eds.), Man and Mining – Mensch und Bergbau. Der Anschnitt, Beiheft 16, Bochum, 309-318.

MAXWELL-HYSLOP, K. R. & HODGES, H.:
1966 Three Iron Swords from Luristan. Iraq 28, 164-176.

McCONCHIE, M.:
1998 Iron Technology and Ironmaking Communities in Northeastern Anatolia: First Millennium BCE. Ph.D. Thesis, Dept. of Classical Studies and Archaeology, University of Melbourne, Australia.

MERHAV, R.:
1991 Urartu – A Metalworking Center in the First Millennium BCE, Jerusalem: Israel Museum.

MERKEL, J. & BARRETT, K.:
2000 'The Adventitious Production of Iron in the Smelting of Copper' Revisited: Metallographic Evidence against a Tempting Model. Historical Metallurgy 32(1), 59-66.

MOOREY, P. R. S.:
1971 Catalogue of Ancient Persian Bronzes in the Ashmolean Museum, Oxford.
1982 Archaeology and Pre-Achaemenid Metalworking in Iran: A Fifteen Year Retrospective. Iran 20, 81-101.
1991 The Decorated Ironwork of the Early Iron Age Attributed to Luristan in Western Iran. Iran 29, 1-12.
1994 Ancient Mesopotamian Materials and Industries, Oxford.

MUHLY, J. D.:
1982 How Iron Technology Changed the Ancient World. Biblical Archaeology – A Review 8(6), 40-54.

MUSCARELLA, O. W.:
1974 The Iron Age at Dinkha Tepe, Iran. Metropolitan Museum Journal 8, 47-76.
1989 Multi-Piece Iron Swords from Luristan. In: L. de Meyer & E. Haerinck (eds.), Miscellanea in Honorem Louis Vanden Berghe 1, Ghent, Archaeologia Iranica et Orientalis, 349-366.

NEGAHBAN, E. O.:
1996 Marlik: The Complete Excavation Report. 2 Vols. University Museum Monograph 87, Philadelphia, University of Pennsylvania Museum.

OVERLAET, B.:
2003 The Early Iron Age in the Pusht-i Kuh, Luristan. Acta Iranica 40. Luristan Excavation Documents IV, Leuven.

PIGOTT, V. C.:
1980 The Iron Age in Western Iran. In: T. A. Wertime & J. D. Muhly (eds.), The Coming of the Age of Iron, New Haven, 375-416.
1981 The Adoption of Iron in Western Iran in the Early First Millennium B.C.: An Archaeometallurgical Study. Ph.D. Dissertation, Dept. of Anthropology. University of Pennsylvania, Ann Arbor, University Microfilms International.
1982a The Innovation of Iron. Cultural Dynamics in Technological Change. Expedition (Fall), 20-25.
1982b AHAN. In: E. Yarshater (ed.), Encyclopaedia Iranica Vol. I, Fasc. 6, New York, 624-633.
1989 The Emergence of Iron Use at Hasanlu. Expedition 31(2-3), 67-79.
1999 The Development of Metal Production on the Iranian Plateau: An Archaeometallurgical Perspective. In: V. C. Pigott (ed.), The Archaeometallurgy of the Asian Old World. MASCA Research Papers in Science and Archaeology 16, Philadelphia, The University of Pennsylvania Museum, 73-106.

PLEINER, R.:
1969a The Beginnings of the Iron Age in Ancient Persia. Annals of the Naprstek Museum 6, Prague, Naprstek Museum.
1969b Untersuchung eines Kurzschwertes der Luristanischen Typus. Archäologischer Anzeiger 1, 41-47.
2000 Iron in Archaeology: The European Bloomery Smelters, Praha, Archeologicky Ustav Avcr.

PLEINER, R. & BJORKMAN, J. K.:
1974 The Assyrian Iron Age: the History of Iron in the Assyrian Civilization. Proceedings of the American Philosophical Society 118, 283-313.

REHDER, J. E.:
1991 The Decorated Iron Swords from Luristan: Their Material and Manufacture. Iran 29, 13-20.

SMITH, C. S.:
1966 On the Nature of Iron. In: Made of Iron. Houston, Art Dept., University of St. Thomas, 29-40.
1971 Techniques of the Luristan Smith. In: R. H. Brill (ed.), Science and Archaeology, Cambridge, 32-52.

TYLECOTE, R. F.:
1970 Early Metallurgy in the Near East. Metal and Materials 4, 285-293.

TYLECOTE, R. F. & BOYDELL, P. J.:
1978 Experiments on Copper Smelting, Based on Early Furnaces Found at Timna. In: B. Rothenberg (ed.), Chalcolithic Copper Smelting: Excavations and Experiments. Institute for Archaeo-Metallurgical Studies (IAMS) Monograph 1. London, IAMS, 27-49.

VAN DER MERWE, N. J., & AVERY, D. H.:
1982 Pathways to Steel. American Scientist 70(2), 146-155.

WALDBAUM, J. C.:
1999 The Coming of Iron in the Eastern Mediterranean: Thirty Years of Archaeological and Technological Research. In: V. C. Pigott (ed.), The Archaeometallurgy of the Asian Old World. MASCA Research Papers in Science and Archaeology 16, Philadelphia, The University of Pennsylvania Museum, 27-57.

WERTIME, T. A.:
1964 Man's First Encounters with Metallurgy. Science 146, 1257-1267.
1973 The Beginnings of Metallurgy: A New Look. Science 182, 875-887.

WERTIME, T. A. & MUHLY, J. D. (eds.):
1980 The Coming of the Age of Iron, New Haven.

WINTER, I. J.:
1977 Perspective on the 'Local Style' of Hasanlu IVB: A Study in Receptivity. In: L. D. Levine & T. C. Young, Jr. (eds.), Mountains and Lowlands: Essays in the Archaeology of Greater Mesopotamia. Bibliotheca Mesopotamica 7, Malidu, 371-386.

YOUNG, T. C., JR.:
1967 The Iranian Migration into the Zagros. Iran 3, 11-34.