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Bronze weapons as funerary furniture in tombs of the Talysh area (Azerbaijan and Iran)

and the contribution of their archaeometallurgical analyses

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Abstract: This paper is based on research carried out over five years (2012-2016) under the joint Franco-Azerbaijani archaeological Mission of the Lenkoran River valley, in the Lenkoran basin and along the river's tributaries in the province of Lerik, which dealt with the question of the transition between Bronze and Iron Ages in southern Azerbaijan (and was co-directed by M. Casanova† and A. Alekperov†). It will address the main features of the composition and the distribution of metal artefacts within the burials, with comparisons in the wider context of Talysh (Iran and Azerbaijan) as well as neighbouring regions of the Caucasus. The contribution of technological studies applied to archaeological metallic material (copper alloys) will be discussed based on the results of recent X-radiography and PIXE analyses conducted by the French laboratory C2RMF, on a set of objects, partly previously discovered by J. de Morgan (1889-1901) and partly found during the recent fieldwork.

Keywords: Talish, Azerbaijan, Iran, South Caucasus, Late Bronze Age, Early Iron Age, Copper alloy, Weaponry, Dagger, Archaeometallurgy..

Résumé : Cet article repose sur des recherches menées durant cinq ans (2012-2016) dans le cadre de la Mission archéologique franco-azerbaïdjanaise de la vallée du Lenkoran, dans le bassin du fleuve Lenkoran et le long de ses affluents, dans la province de Lerik. Ces travaux, codirigés par M. Casanova† et A. Alekperov†, portaient sur la question de la transition entre l'âge du Bronze et l'âge du Fer dans le sud de l'Azerbaïdjan. L'étude présentera les principales caractéristiques de la composition et de la répartition des artefacts métalliques découverts en contextes funéraires, avec des comparaisons situées dans le cadre plus large du Talysh (Iran et Azerbaïdjan) ainsi que dans les régions voisines du Caucase. La contribution des études technologiques appliquées au matériel archéologique métallique (alliages cuivreux) sera également examinée, sur la base des résultats récents de radiographie X et d'analyses PIXE réalisées par le laboratoire français du C2RMF sur un ensemble d'objets provenant du Talysh, en partie découverts par J. de Morgan entre 1889 et 1901, et en partie issus des travaux de terrain récents.Mots-clés : Talysh, Azerbaïdjan, Iran, Caucase méridional, âge du Bronze récent, âge du Fer ancien, alliage cuivreux, armement, dague, archéométallurgie.

Mots clés : Talish, Azerbaidjan, Iran, Sud Caucase, Bronze récent, Premier âge du Fer, alliage cuivreux, armes, poignard, archéométallurgie.

Between 1889 and 1891, Jacques de Morgan conducted explorations across the Caucasus, Iran, and Anatolia as part of his scientific mission in Persia. Thus, in 1890, he explored the former Russian Talysh—now the Lenkoran and Lerik districts of the Republic of Azerbaijan—and in 1901 the Persian Talysh—now the Ardabil and Gilan Provinces of Iran. Thirteen sites located in Azerbaijan were explored—Hovil, Amarat, Conu, Tülü Aspa-Hiz, Veri, Razgov, Mistan, Hiveri, Çayrud, Kraveladi, Cucu Tuk, Monidigah, and Mistaïl—as well as ten sites in Iran—Qal'a, Khodja Daoud Köpru, Namin, Tchila-Khane, Lor-Daghi, Chagoula-Derre, Vajalik, Tach-Koprü, Hasan Zamini, and Shir Shir (fig. 1). The sites of Dokalian and Agha Evlar, also explored in 1901 in Iran, are located outside the Talysh region, on the other side of the great Ardabil plain. For this study, the current toponymy of the sites was chosen, as presented in the excavation reports of the Lenkoran Mission, rather than the names used at the time of Morgan's exploration (table 1).

As a result of its extensive excavations, several thousand artefacts were uncovered. Upon his return to France, Morgan donated this remarkable collection to the Musée

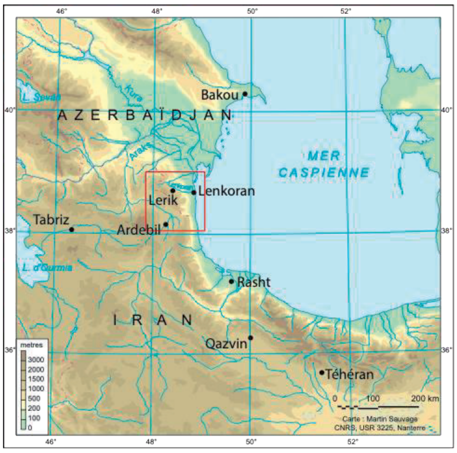

Fig. 1 – Sites from the Late Bronze Age and Early Iron Age in the Talysh area (maps: M. Sauvage/Archaeological Mission in Lenkoran).

After Morgan 1896 and 1905	Current toponymy	International Phonetic Alphabet
Kravéladi	Kraveladi	kʁaveladi
Hôvil	Hovil	ovil
Djüodjikash	Cucu Tuk	dʒu dʒu tuk
Véri	Veri	veʁi
Razgoour	Razgov	ʁazgɔv
Amarat	Amarat	amaʁat
Mistan	Mistan	mistan
Tülü Aspa-Hiz	Tülü Aspa-Hiz	tyly aspa-iz
Djönü	Conu	dʒɔnu
Hivéri	Hiveri	ivɛʁi
Mistaïl	Mistaïl	mistail
Monidighia	Monidigah	monidiga
Tchïrou	Çayrud	tʃajʁud
Qal'a	Qal'a	kala
Khodja Daoud keuprü	Khodja Daoud Köprü	kodʒa daud kopʁy
Nâmin	Namin	namin
Tchila-Khané	Tchila-Khane	tʃila kane
Lor-Daghi	Lor-Daghi	lɔʁ dagi
Chagoula-Dérré	Chagoula-Derre	ʃagula deʁe
Vadjalik	Vajalik	vadʒalik
Tach-koprü	Tach-köprü	taʃ kopʁy
Hassan-Zamini	Hasan Zamini	asan zamini
Chir-Chir	Shir Shir	ʃiʁ ʃiʁ

Table 1 – Comparison between the site names given by Jacques de Morgan and their current toponymy and current pronunciation.

des Antiquités Nationales (MAN) in Saint-Germain-en-Laye. The assemblage includes pottery, ornaments, weapons, and tools, spanning a wide chronological range from the second millennium to the early first millennium BCE (table 2).

The NABIALLA Project, a French-Azerbaijani archaeological collaboration, addresses two complementary research objectives. First, the Morgan Project aims

Chronological framework of the Talysh	
Middle Bonze Age	2100-1600 BCE
Early Bronze Age	1600-1300 BCE
Iron Age I	1300-1100 BCE
Iron Age II	1000-800 BCE
Iron Age III	800-600 BCE

Table 2 – Chronology from the Middle Bronze Age to Iron Age III for the Talysh region.

to re-examine artefacts previously excavated and preserved in public collections, both within Azerbaijan and abroad—particularly those housed at the MAN—in light of recent archaeological findings. Second, the Lenkoran Project involves systematic fieldwork focused on Bronze and Iron Age necropolises in the Lenkoran and Lerik districts of Azerbaijan. Together, these initiatives seek to enhance our understanding of regional funerary practices during these periods.

As part of the Morgan Project, a selection of bronze weaponry was subjected to archaeometallurgical analysis, including PIXE (Particle-Induced X-ray Emission) and X-radiography, in order to better characterize the composition of the metal objects and to determine the manufacturing techniques used in the production of the daggers. This article presents the results of these analyses.

THE SCIENTIFIC BACKGROUND

For the last 20 years, new methods in archaeology have been developed in Azerbaijan and many new discoveries have been made by chance or through the opportunity afforded by archaeological surveys prompted by huge public projects and the Tbilisi-Baku-Ceyhan pipelines constructed through Azerbaijan, Georgia and Turkey during the period 2003-2005 (Schachner, 2002; Sagona, 2004; Smith, 2005; Shanshishvili and Narimanishvili, 2012).

Within this framework, the NABIALLA Project (Necropolises in Azerbaijan during the Bronze and Iron Ages in the Lerik and Lenkoran Areas) was set up within a scientific cooperation agreement signed in 2011 which involved the CNRS (UMR 7041 ArScAn, Nanterre), the Archaeological and Ethnographical Institute of the Azerbaijani Academy of Sciences, the University of Lyon 2, the French Ministry of Culture with its General Directorate for Heritage and the French Museums Service, and the National Museum of Archaeology (MAN, Saint-Germain-en-Laye).

Running for five years (2012–2016) under the supervision of Michèle Casanova, the late Professor of Near Eastern Archaeology (Lyon 2 University) and Abuzar Alakbarov, late researcher at the National Institute for Archaeology and Ethnography of Azerbaijan, the new French-Azerbaijani archaeological joint project dealt with two specific topics. On the one hand (the Lenkoran Axis), it aimed to study the necropolises of the Lenkoran and Lerik areas (Republic of Azerbaijan) during the Bronze and Iron Ages (including fieldwork) and, on the other hand (the Morgan Axis, under the supervision of C. Lorre: Lorre, 1997 and 2008 ; Lorre et al., dir., 2009), it included the new study and re-examination of archaeological material formerly discovered at the end of the 19th century by the archaeologist Jacques de Morgan when he explored the Talysh area (Morgan 1896; 1905). All this archaeological material previously discovered and stored in public collections, either in Azerbaijan or abroad (especially in France), was to be studied in comparison with archaeological remains found more recently (Lorre, 2012; Casanova et al., 2016).

Indeed, the MAN keeps in its Collection for Comparative Archaeology a wide range of Caucasian archaeological artefacts (stone implements, ceramics and metallic weapons, ornaments and figurines) partly originating from the excavations conducted on either side of the Russian-Persian border by the two Morgan brothers, at the end of the 19th century. This collection has been partially published and several past studies go back to a time when current techniques of observation and analysis were not yet in use. Before the NABIALLA Project started and throughout its course, the MAN's collection was checked, sorted and restored. An online photographic catalogue, still partial, exists on the French national database Joconde. Several academic works (from the École du Louvre and University of Paris 1– Panthéon-Sorbonne) have re-examined parts of this material, in particular that from the Lenkoran necropolises of Conu and Aspa Hiz (Haze, 2010; Manceau, 2010), while two PhD theses have also been defended on the technical working issues and prehistoric uses of carnelian in the area concerned (Debrabant, 2016) and on funerary practices and material culture in the Talysh at the end of the Bronze Age and beginning of the Iron Age (Haze, 2018). In the meantime, further research has led to a better understanding of Morgan's personality and his scientific activities (a special exhibition about Morgan took place in 2007–2008 and a special conference in 2008, thanks to cooperation with the University Paris 1 – Panthéon-Sorbonne and the High School for Mining Engineers of Mines-ParisTech).

The Franco-Azerbaijani archaeological Mission of the Lenkoran River valley directed by Michèle Casanova and Abuzar Alakbarov, in the Lenkoran basin and along the river's tributaries in the province of Lerik in southern Azerbaijan (2012–2016) resumed fieldwork with a first attempt at a chronological point of view. The new archaeological discoveries and studies confirm the extensive chronological scope of the Talysh area's occupancy from the Middle Bronze Age to the Iron Age, with rich and valuable funerary material which may express a flourishing and even powerful state of civilisation. 14C dating was carried out on tomb 1144 from the Monidigah site in Lenkoran. It provided chronological ranges for three people buried in the tomb: between 1055 and 899 BC; between 978 and 827 BC; and between 1209 and 1016 BC. Although the ranges are fairly wide, these results indicate that these people were buried in the Early Iron Age, between EIA I and EIA II (Haze, 2018, p. 161).

The first stages of the NABIALLA Project have led us in particular to update the state of knowledge concerning funeral practices of the Bronze/Iron transition in this region. Prospecting for sites such as Mistail, Conu, Amarat and particularly excavating sites such as Kraveladi, Cucu Tuk and Monidigah allowed us to complete observations made by Morgan in his time and brought back original elements on burial practices in this area, in comparison with more recent works on the neighbouring Iranian territory (Begemann et al., 2008; Oudbashi et al., 2012; Piller, 2013).

TYPES AND CONTEXTS OF WEAPONS

Weapons were found in large quantities in the graves of the Talysh. Among the 1,666 objects from the Talysh tombs—combining those held in the collections of the MAN and those unearthed during excavations by the Franco-Azerbaijani Archaeological Mission in Lenkoran—341 are weapons. These include bladed weapons, projectile weapons, polearms, and close-combat weapons (fig. 2). These include draft weapons, throwing weapons, pole weapons or fist weapons. The amount of the different categories of armament reflects well the discoveries described by Jacques de Morgan in his publications. Spearheads and arrowheads are much more numerous. They are followed by the daggers, which include particular pieces with molded handle allowing many chronological comparisons. Knives, swords and axes occur in small quantities, and pikes and armour plates are almost absent.

The catalogue of forms is wide enough for each category of weapons. Materials are also quite heterogeneous. Copper alloys are the most widely used for making weapons, accounting for almost three quarters of the corpus. Iron is used too, mainly for spearheads, and there are also weapons made of stone and some bimetallic ones, copper alloy and iron. The materials used for the weapons' manufacture also provide good chronological indications. Nevertheless, it is necessary to be cautious as copper alloy weapons were still manufactured during the Iron Age. It is therefore normal to find a large majority of copper alloy artefacts. Among these artefacts, certain types of weapons were most commonly uncovered in Talysh tombs:

– *Arrowheads:* 106 arrowheads were discovered in Talysh, with a wide variety of shapes and materials. Almost all the arrowheads are made of copper alloy, but a small number from the Conu settlement are made of stone and obsidian. From a typological point of view, they are composed of two parts, a tang or socket and an ogival, triangular or biconvex point, simple or with barbs. The origin of obsidian arrowheads can be traced back to Armenia, where this type, which represents a masterpiece of obsidian cutting, is characteristic of the Karmir-Berd culture (third and last phase of the Middle Bronze Age in Armenia: 27th–16th centuries BC; Santrot, dir., 1996, p. 60). A batch of this type of arrowhead was also found in a tomb in the Horom necropolis in the Shirak region of Armenia. They are of a later date and this tomb dates their use to the Early Iron Age: 12th–9th centuries BC (Fichet de Clairfontaine, dir., 2007, p. 166–168).

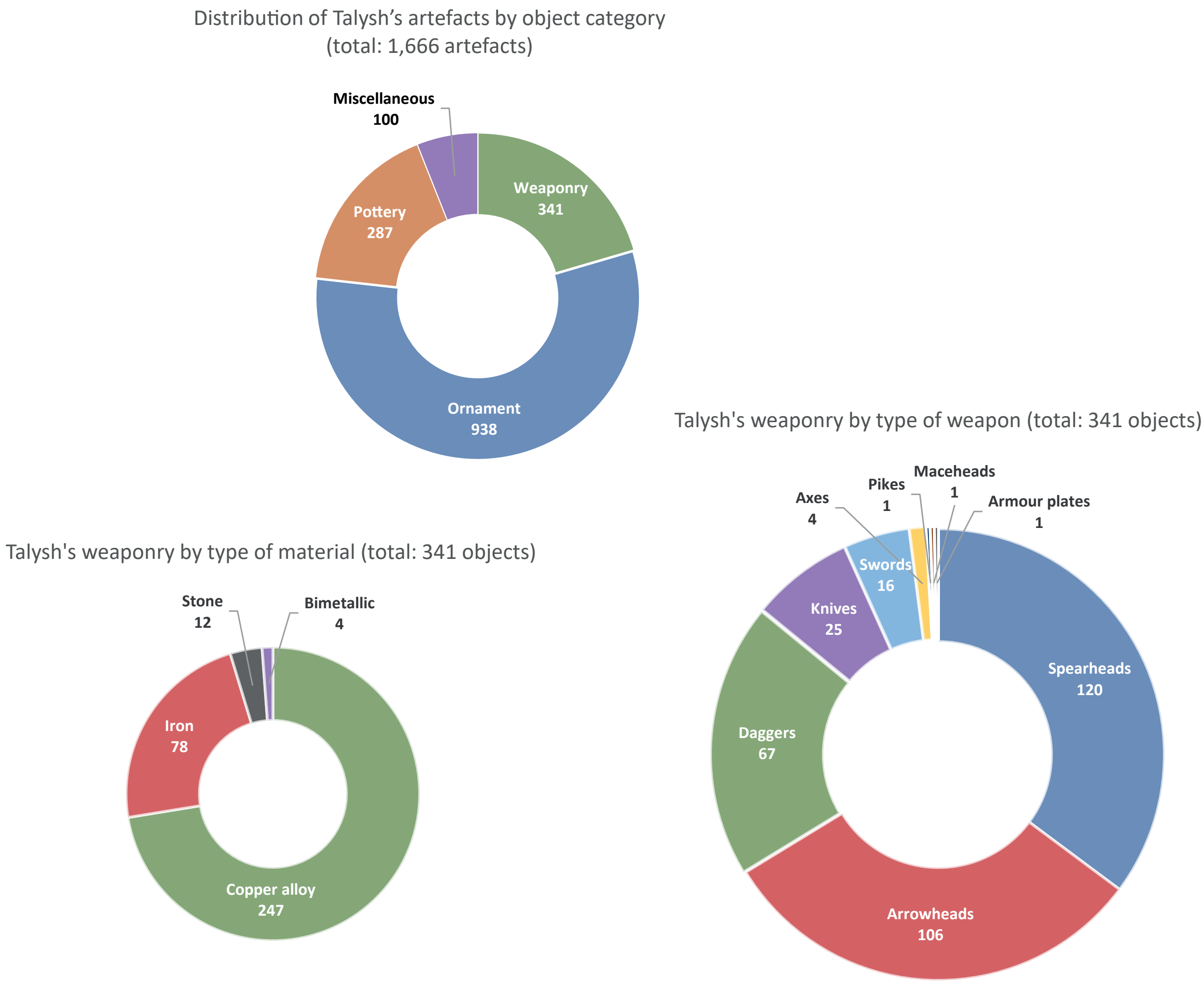

Fig. 2 – Distribution of artefacts discovered in the Talysh graves (1,666 objects, including 341 weapons).

– *Spearheads:* 116 are in MAN's collections and four were discovered during recent excavations in Lenkoran. The corpus of spears is fairly homogeneous, with very little variability in shape. Almost all the pieces are fitted with a socket: 115 specimens have been discovered in the Talysh graves and show little variability in size or blade shape. There is great parity in materials, with 58 spearheads made of iron and 62 of copper alloy. The most common form, with a biconvex blade (fig. 3, 4-6), is widespread in the Caucasus, where it is characteristic of the Early Iron Age from the 12th to the 9th century BC (Fichet de Clairfontaine, 2007, p. 171). Iron spearheads first appeared in Transcaucasia at the end of the second millennium BC. Examples, dated to Period II of the Final Bronze Age in Transcaucasia (12th–9th centuries BC) are known from Armenia, Georgia and Azerbaijan, from where they spread to northern and north-western Iran around the Caspian Sea and to the Koban Culture in the Caucasus (Curtis and Kruszynski, 2002, p. 65).

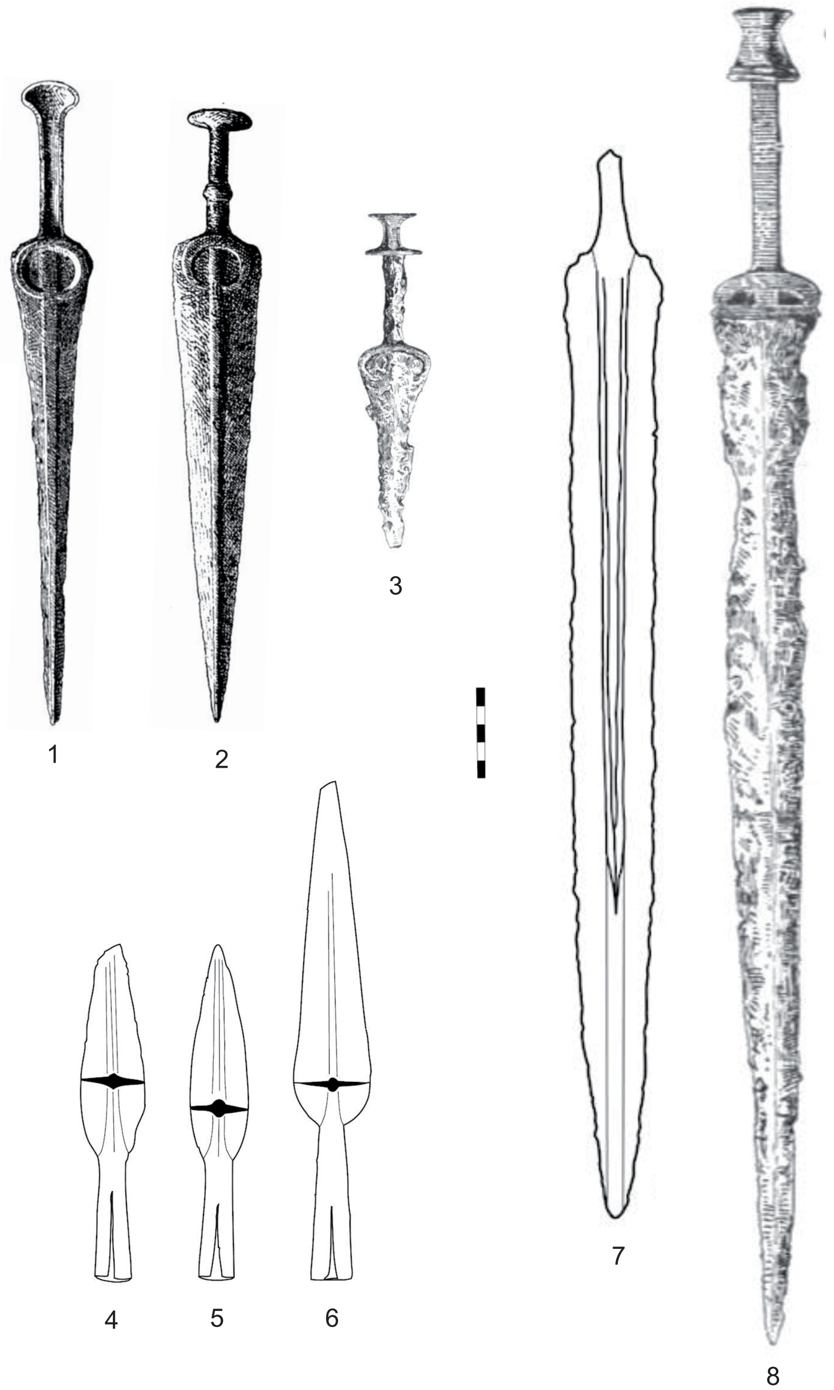

Fig. 3 – Weaponry discovered in the Talysh. 1-2: copper alloy dagger, Veri. 3: iron and copper alloy dagger, Chagoula-Derre. 4-6: iron spear head, Conu. 7: copper alloy sword, Conu. 8: iron and copper alloy sword, Chagoula-Derre. (1-2 and 8: after Morgan, 1896; 3: after Morgan, 1905; 4-7: after Haze, 2018).

– *Knives:* This category of material is defined by single-edged weapons, which must therefore be distinguished from double-edged weapons such as daggers or swords. There are only a few examples of such weapons in the Talysh graves, all varying in size and shape. Sixteen are made of iron and nine of copper alloy. Knives are very rare in funerary contexts, certainly because their status was not that of a weapon. Most of these objects were definitely everyday tools, and very few were actually used as weapons. Their rarity and poor state of preservation make them difficult to date typochronologically.

– *Daggers:* Daggers are by far the most common bladed weapon found in Talysh graves. There is little variability in the shape of the two-edged blades, which are mostly triangular, ogival or biconcave. Talysh daggers differ mainly in the way they are fitted, usually with a simple tang to which is attached a handle, probably most commonly made of wood, which has now disappeared. The other hafting technique, which is very common in this region, involves daggers with a metal handle cast and welded to the blade, or daggers cast in a single piece, handle and blade, in a mould. The corpus of Talysh daggers involved in our study includes 59 artefacts, the vast majority of which are made of copper alloy: 55 daggers in copper alloy, one in iron and three bimetallic, combining copper alloy and iron. Daggers with a tang were very common throughout the Near and Middle East from the third millennium BC. Triangular blades were particularly common in Transcaucasia during the Early Bronze Age (Gernez, 2007, p. 449). Regarding moulded-handled daggers, various works have already established typologies of daggers from north-west Iran, including some examples of the Talysh. I. N. Medvedskaya bases his typology on the shapes of the handles and classifies the Talysh daggers in the South Caspian context (Medvedskaya, 1982, fig. 9), while much more recently, B. Rafiei Alavi has proposed a typology of daggers based on the crescent-shaped guards very common innorth-western Iran and in Talysh (Rafiei Alavi, 2014). These daggers feature a wide variety of handle shapes. Thus, daggers with a non-functional crescent guard are the most represented in Talish (fig. 3, 1–3). These daggers show an evolution of the models with a functional crescent guard that appeared in Iran in the Late Bronze Age between 1600 and 1300 BC (Rafiei Alavi, 2014, fig. 3). Talysh models developed with the Iron Age, which saw their number increase considerably. Numerous examples can be found in north-western Iran at Marlik, Khurvin and as far as the Oman peninsula (Rafiei Alavi, 2014, fig. 9 and 10). All these daggers date back to the Early Iron Age, between 1300 and 1000 BC. Iron and bimetallic daggers appeared with the Iron Age II in Iran around 1000-800 BC (fig. 3, 3). Daggers with a non-functional crescent hilt were still in use, but in decreasing number. A new type of weapon appeared, on which the crescent-shaped guard became functional again (Rafiei Alavi, 2014, p. 14). These types of daggers are the most recent to have been discovered in Talysh tombs.

– *Swords:* Talysh swords are all made of copper alloy and all have the same type of fittings: a tang with or without a rivet. With no very specific morphological features, these swords are difficult to date precisely. A type of rapier that is elongated, fairly thin and has a very pronounced midrib is characteristic of Transcaucasia, where it developed during the Middle Bronze Age and up until the beginning of the Late Bronze Age (Abramishvili, 2001).

A bimetallic sword, unique in the Talysh corpus, was discovered at the Chagoula-Derre site and is the only one with a moulded handle. It consists of a large iron blade and a functional crescent-shaped copper alloy guard (fig. 3, 8). This sword is very similar to the bimetallic daggers described above and dates from the Iron Age II, between 1000 and 800 BC (Haze, 2018, p. 209).

THE ARCHAEOMETALLURGICAL STUDY: THE CASE OF DAGGERS

The archaeometallurgical study had two purposes. On the one hand, it was to determine precisely the elemental composition of the copper alloys used to cast the different types of objects. For that purpose, PIXE analyses were conducted on metal objects with the AGLAE Particle Accelerator (Accélérateur Grand Louvre d'Analyses Elémentaires). On the other hand, it was to better identify the hafting techniques. For that purpose, the C2RMF used X-radiography on 13 daggers, resulting in the establishment of a new typology of these daggers, based on this particular feature. This study would allow us to create a reference framework that could be further expanded in the future through similar analyses.

Experimental methods

Samples were analysed by PIXE, which is at present the most adequate method to conduct this study (fig. 4). The heritage value of the objects selected meant that the least invasive and destructive method possible had to be used. So the analysis had to be done directly on the surface (corrosion layers were carefully removed from a 1 mm diameter zone, prior to the analysis). The element list needs to be as large as possible, with for each element a low limit of detection (from 10 to 100 ppm). The PIXE technique using the AGLAE facility perfectly met our needs: it combines a good accuracy and an excellent sensitivity, thanks to the very low background of the spectra and the use of an energy selective Cobalt filter. The external micro-beam allowed us to focus the analysis only on the small zone of interest (50 micrometres diameter), thus avoiding most of the contamination problems due to corrosion.

Moreover, a series of X-rays have therefore been taken from the front, side and three-quarter views and allowed us to determine the different types of handling technique (fig. 4).

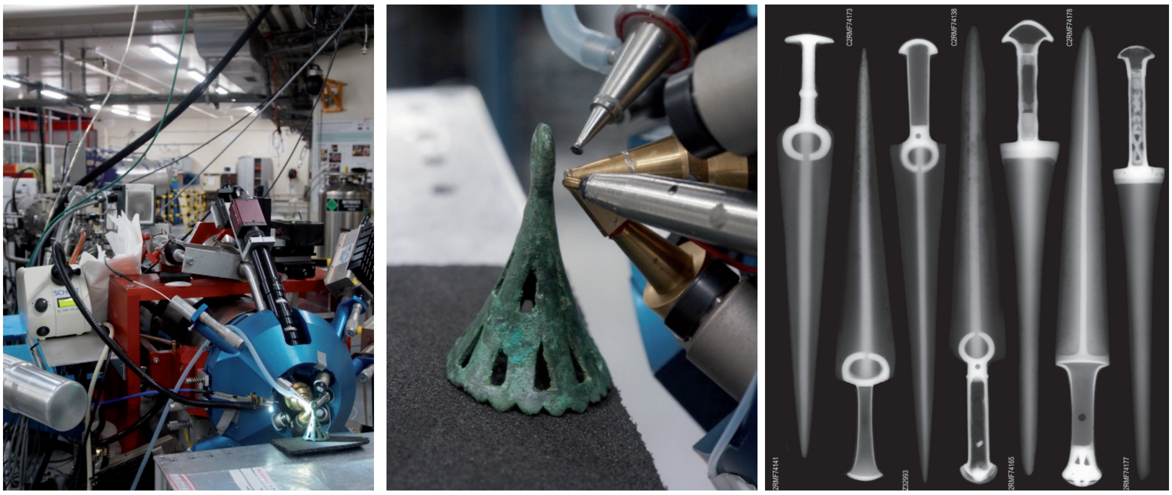

Fig. 4 – The various methods used during this study. PIXE analyses AGLAE and X-radiography.

The corpus

Analyses were conducted on 58 metal objects including 43 weapons (table 3). These objects come from sites in southern Azerbaijan (Mistan, Aspa Hiz, Amarat, Veri, Hovil, Cucu Tuk and Conu) and North-Western part of Iran (Agha Evlar, Tchila Khané, Chagoula Derré, Chir Chir and Khodja Daoud Köprü). These different sites are only known for their necropolises dating back to the Late Bronze Age and Early Iron Age, around 1600 and 1000 BC, that is to say a relatively long-time span. Among these artefacts we find ornaments such as bracelets, pendants, zoomorphic figurines, beads, pins or belt plaques, and weaponry such as spearheads, daggers and swords only discovered in funerary contexts.

Results

Alloy compositions

On the first graph (fig. 5), the artefacts are categorised here by type of ornament or weapon: bracelet, figurines, spearheads or daggers, each represented by a different symbol. On the abscissa is indicated the tin content in each object, and on the ordinate, the lead content. Thus, we can distinguish three categories of alloy:

– Low-tin bronze: with a tin content between 0 and 6 %.

– Bronze: with a tin content between 6 and 12 %.

– High-tin bronze: with a tin content exceeding 12 %.

Tin contents are extremely variable. For example, two spearheads are made of unalloyed copper, whereas others are made of bronze, in which the tin content ranges from 1 to 19 %

We see as well that most artefacts are made of unleaded bronze (Cu-Sn, with less than 2 % lead). Finally, the results also show that there is no simple correlation between the alloy composition and the type of artefact.

The second graph (fig. 6) is similar to the previous one, but at this point, the objects are being studied according to their place of discovery. And it is possible to note that there is no simple correlation between the alloy composition and the place of discovery.

Impurities pattern

This new figure (fig. 7) shows the level of impurities present in the 58 objects. Copper, lead, tin, antimony and arsenic, contents which are present in larger quantities for some artefacts, do not appear here. Each bar corresponds to one artefact and presents the cumulative content of different impurities. We see that the trace elements are also very heterogeneous, suggesting diverse metal provenance. For example, the spearhead numbered C2RMF74160 on the graph (MAN : 33760.03), has a high level of iron, whereas the other spearhead, numbered C2RMF74159 on the graph (MAN : 33742.02), while very similar in shape and alloy, exhibits a totally different impurities pattern.

Outline of the metal composition

To sum up concerning the metal composition of the artefacts from the Southern Caucasian collections of the MAN, we first may recall that we identified a large discrepancy both for the alloy composition and for the associated impurities pattern (fig. 8).

The whiskers plots here presented help us to give a better definition of the metal composition. The central square dot plots the median value for each chemical element, whereas the two whiskers define the interquartile range: half of the artefacts fit into this range. Small circles and stars represent the outliers.

The most common alloy composition consists therefore in a bronze containing virtually no lead, the tin content varying from 5 to 12 %, whatever the artefact type or place of discovery. At this stage, no attempt will be made to discuss the metal provenance, given how diverse the impurities patterns we recorded were. To be noticed

Site	N° MAN	Type	N° EROS base
Mistan (Az)	33998	Dagger	C2RMF74137
Aspa Hiz (Az)	33958	Dagger	C2RMF74138
Amarat (Az)	34003.01	Spearhead	C2RMF74139
	34003.02	Spearhead	C2RMF74140
Veri (Az)	33543/A	Dagger	FZ32993
	33543/I	Dagger	C2RMF74141
	33543/F	Dagger	C2RMF74142
	33539	Dagger	FZ33022
	33540.01	Dagger	FZ33023
	33540.02	Dagger	FZ33024
	33541	Dagger	FZ33025
	33554	Knife	C2RMF74143
	33537.04	Sword	FZ33040
Hovil (Az)	33983/A	Dagger	FZ33033
	33983.02	Sword	FZ33034
Conu (Az)	33856.02	Armour plate	C2RMF74147
	33865	Dagger	C2RMF74158
	33867	Sword	FZ33032
	33866	Dagger	FZ33031
	33742.02	Spearhead	C2RMF74159
	33760.03	Spearhead	C2RMF74160
	33742.03	Spearhead	C2RMF74161
	33742.01	Spearhead	C2RMF74162
	33743.02	Spearhead	C2RMF74163
	33868	Spearhead	C2RMF74164
Djuodji Kach (Az)	34028	Sword	FZ33036
Agha Evlar (Ir)	57938	Dagger	C2RMF74165
	57937	Dagger	C2RMF74166
	57940	Sword	C2RMF74167
	57942	Spearhead	C2RMF74168
Tchila-Khane (Ir)	57736	Dagger	C2RMF74171
	57740	Dagger	C2RMF74172
	57738	Dagger	C2RMF74173
	57734	Dagger	C2RMF74174
	57732	Dagger	C2RMF74175
	57727	Dagger	C2RMF74176
Chagoula-Derre (Ir)	57840	Dagger	C2RMF74177
	57841	Dagger	C2RMF74178
Shir Shir (Ir)	57857	Dagger	C2RMF74179
	57849	Dagger	C2RMF74180
	57856	Dagger	C2RMF74181
	57851	Dagger	C2RMF74182
Khodja Daoud Köprü (Ir)	57701	Sword	FZ33035

Table 3 – List of analysed weapons.

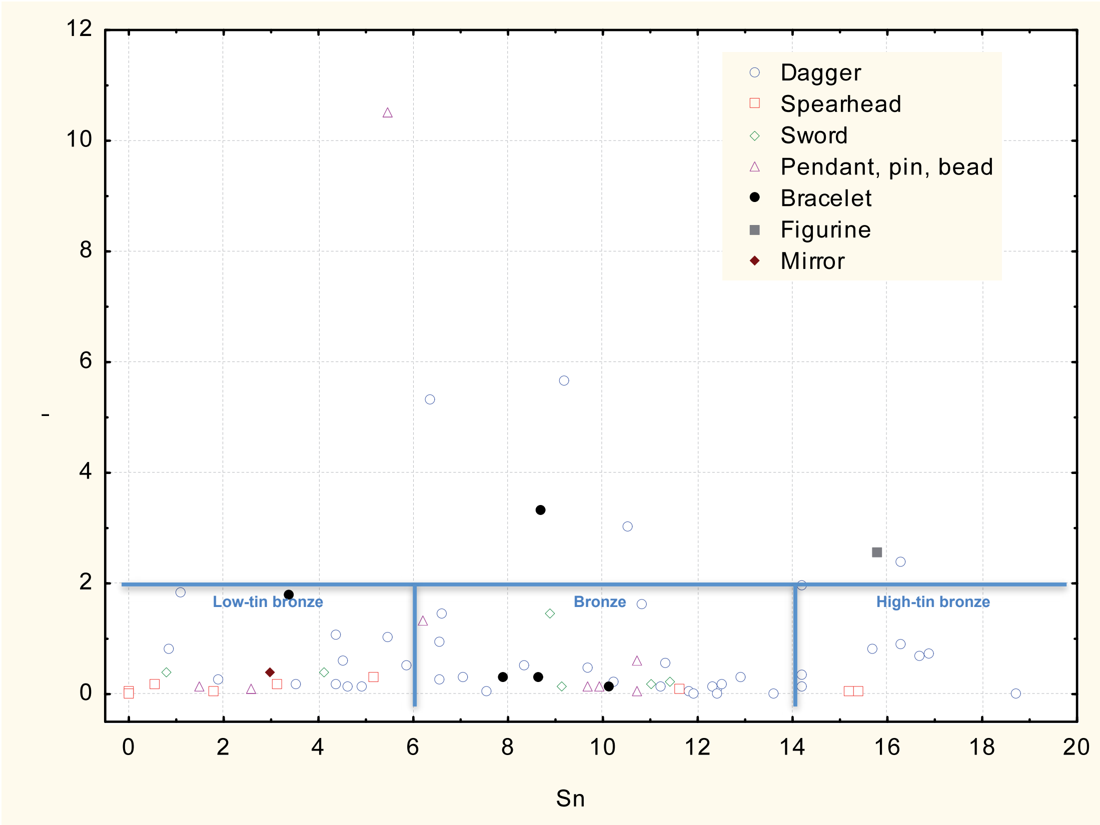

Fig. 5 – Alloy composition in relation to artefact types.

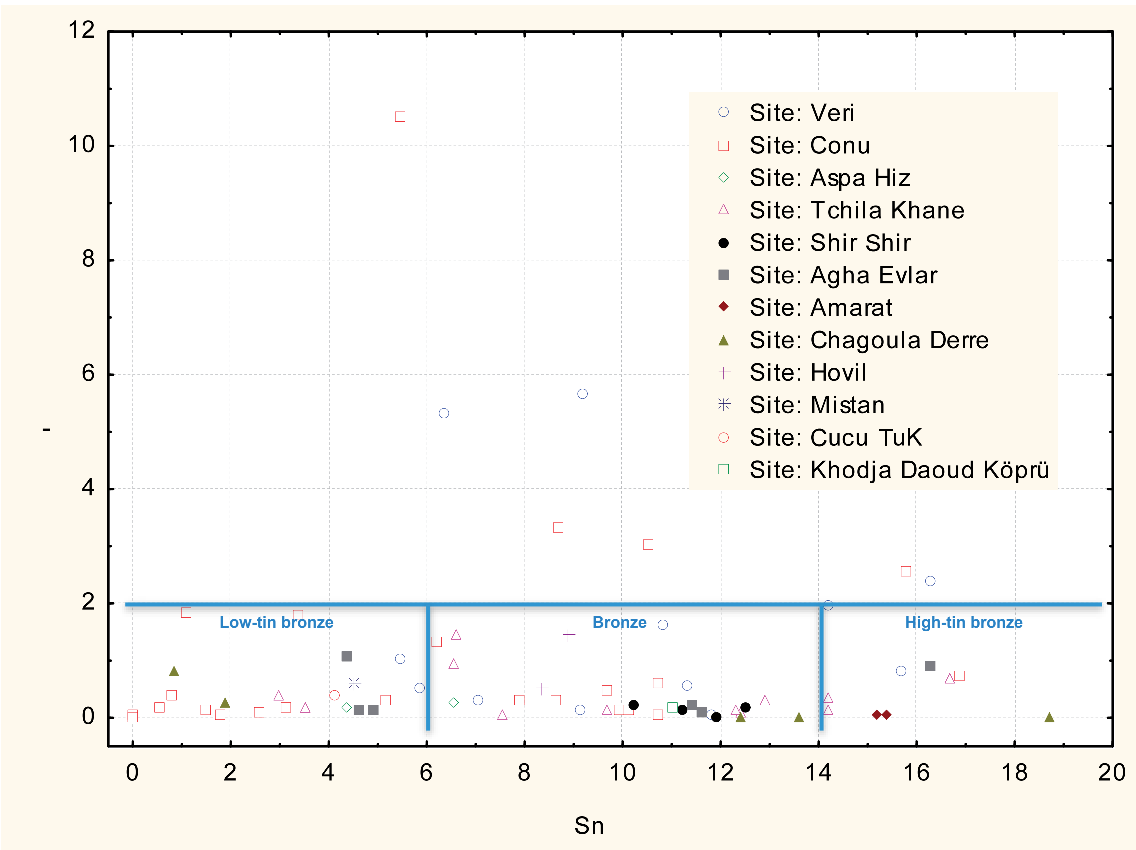

Fig. 6 – Alloy composition in relation to place of discovery.

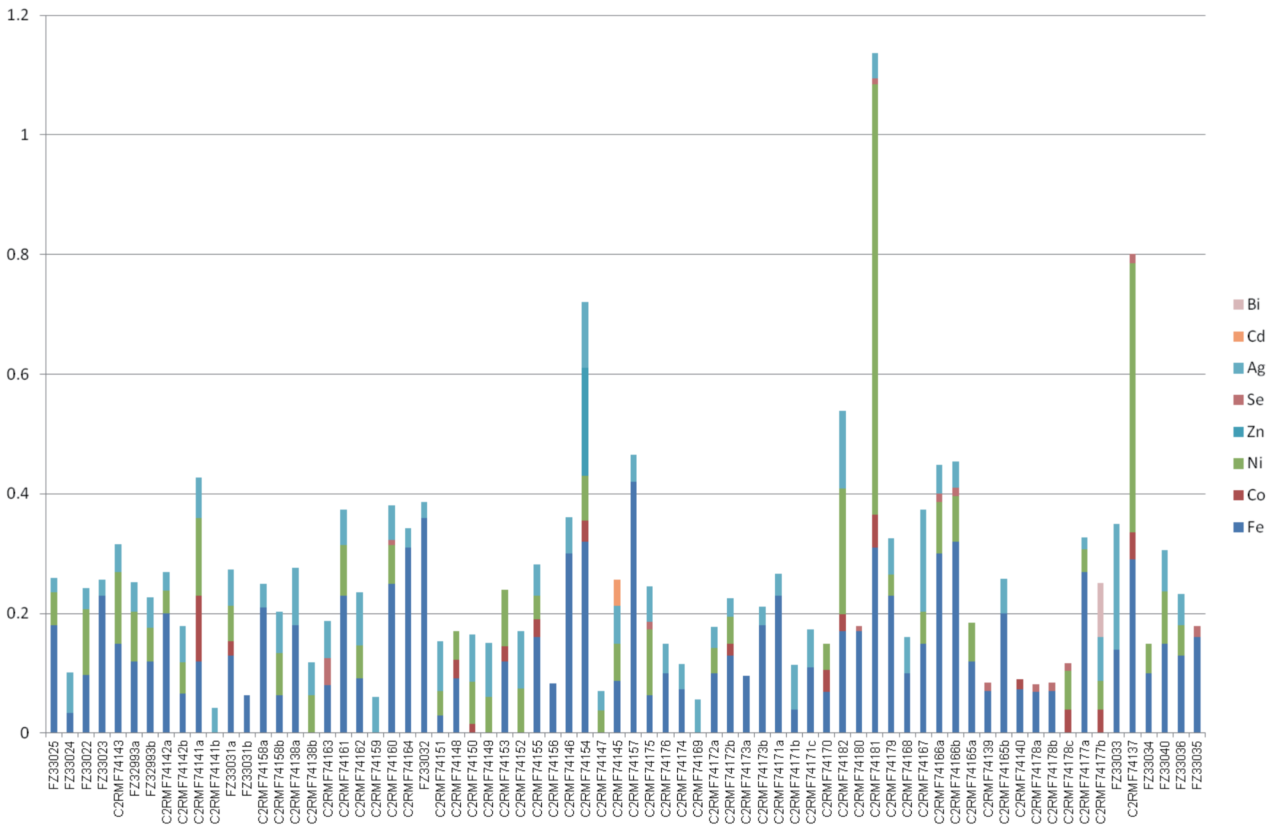

Fig. 7 – Trace elements in alloy compositions of every artefact (ornaments or weapons).

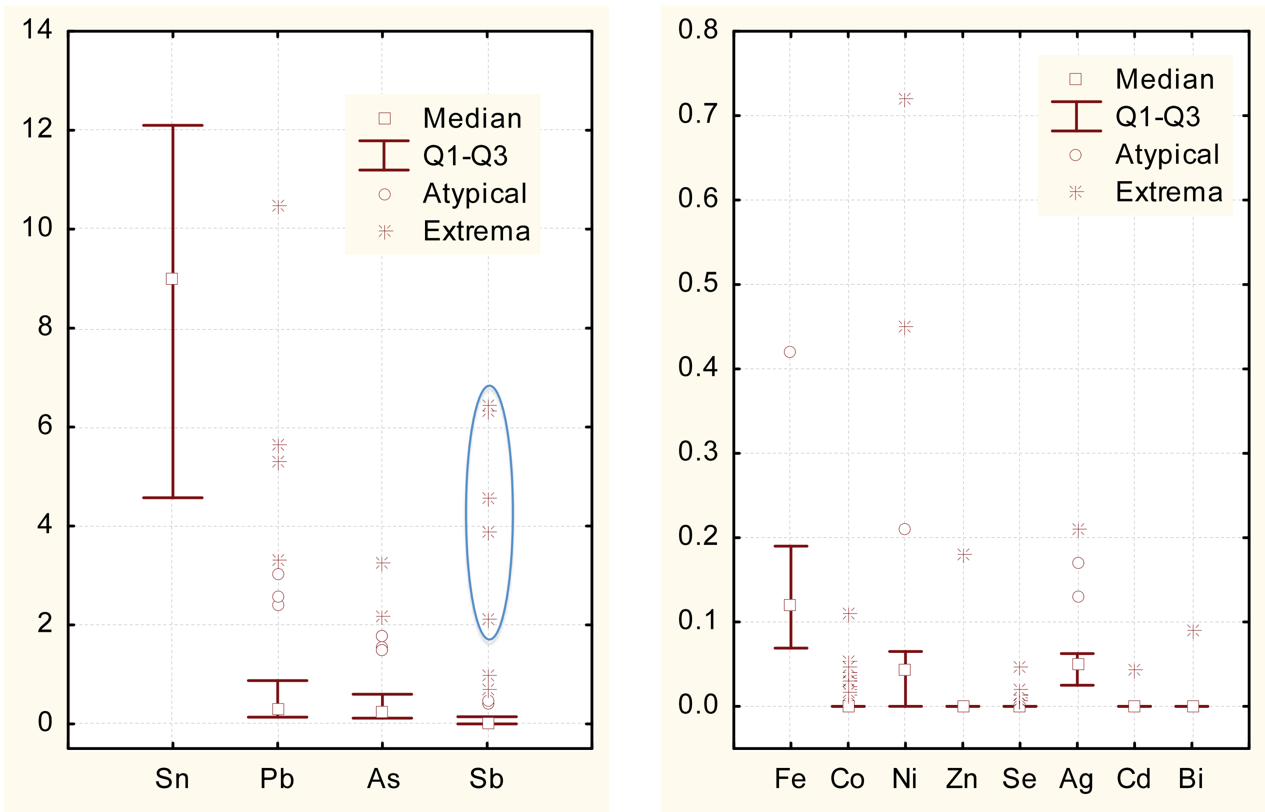

Fig. 8 – Southern Caucasian collections from the MAN: outline of the metal composition.

is the fact that some very high levels of antimony were detected: five artefacts contained more than 2 % of antimony (up to 6 %!). Since four of them are related to dagger handles, we will come back later to this point: we first need to give more details of the manufacturing technique used to cast the different daggers.

A focus on the daggers: alloy composition

Out of the 27 tested daggers, 13 daggers were tested by PIXE in two or three different locations, both on the blade and the hafting, in order to check the homogeneity of the metal composition, since it already appeared, as we have just seen, that they were cast in several pieces.

As a result (fig. 9), firstly there are the tin and lead contents and associated impurities, where high levels of antimony are particularly obvious for four handles. It is very apparent here that the alloy composition of the blades clearly differs from the handles:

– most of the blades are related to the Caucasian canonical bronze definition given, that is to say a bronze containing 5 to 12 % tin;

– extreme values of the alloy composition systematically refer to the handles (low-tin, high-tin, high-antimony).

A question then arises: did metallurgists want to achieve a metal polychrome effect, a yellow blade opposed to a red handle (with low-tin) or to a white handle (with high-tin, or with high-antimony)?

The contribution of the X-ray analysis

The X-radiography of the 13 daggers led us to establish a new typology of the daggers, based on the hafting techniques. We not only took X-rays from the front, but also from the side and from a three-quarter profile. This allowed us to determine four different types of hafting techniques (fig. 10).

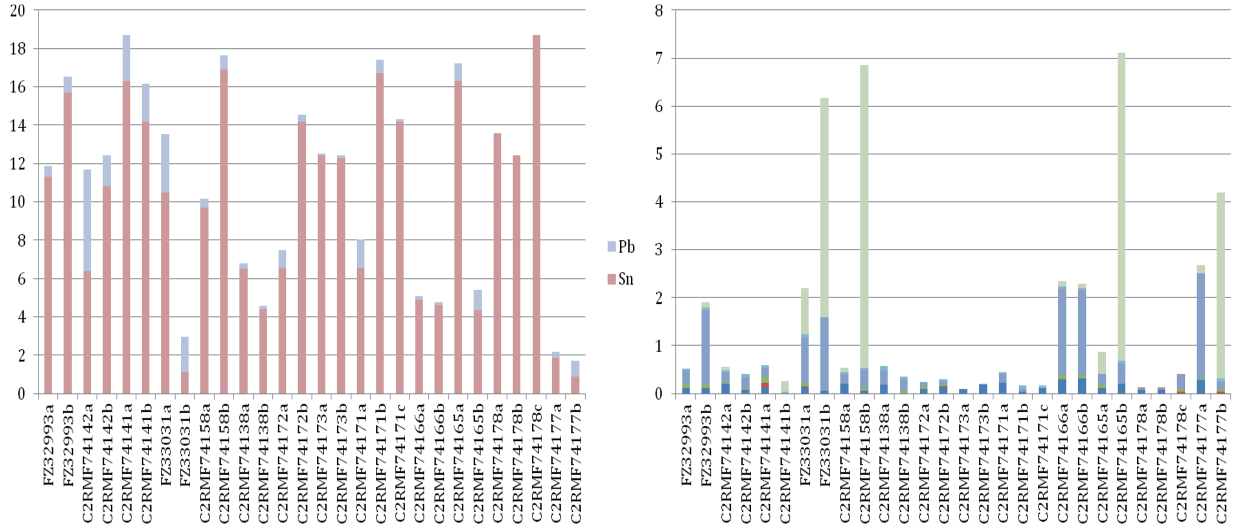

Fig. 9 – Several analyses have been conducted on each dagger (a, b, c) to compare the alloy compositions of the various parts (blade, handle, guard, pommel). Comparison of tin and lead levels (left) and level of impurities (right).

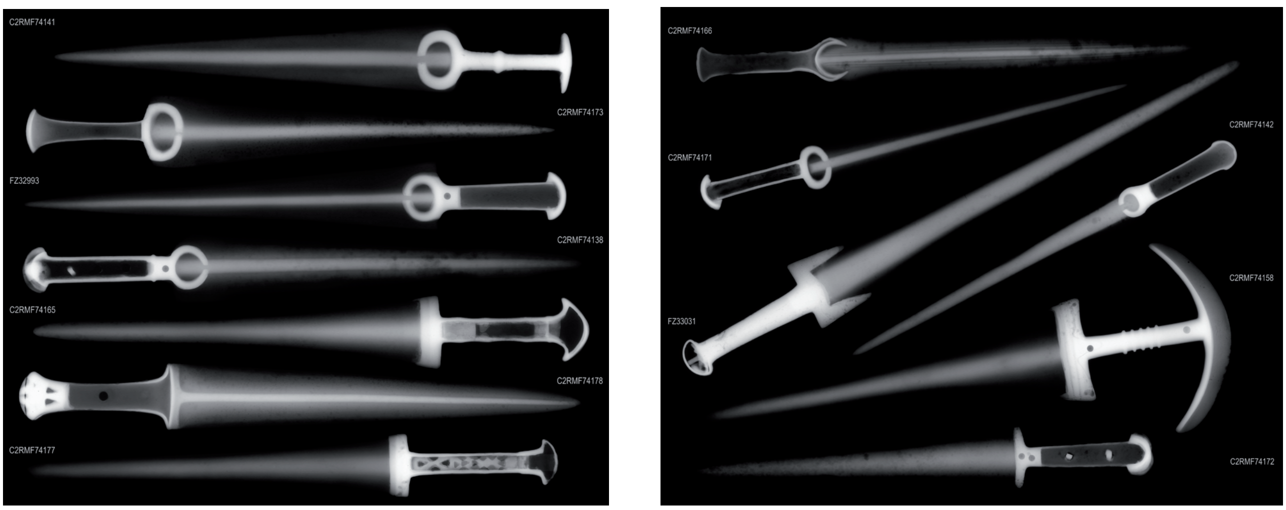

Fig. 10 – X-ray radiograph from the front side.

Fig. 11 – General view, radiograph and detail of type 1 dagger (Agha Evlar : 57937).

Type 1 (fig. 11): The dagger was cast in one piece, in a unique primary casting. We cannot see in fact any evidence of joining on the radiography, and the alloy composition is exactly the same at both locations tested. Only one dagger belongs to this category (Agha Evlar : 57937).

Type 2 (fig. 12): The dagger was cast in one piece except the pommel. During a primary casting, the blade, the guard and the grip were cast together, as one unique piece. Then during a secondary casting, the pommel was directly cast on the grip, using a lost-wax cast technique. On the radiograph we can see evidence of joining between the pommel and the grip but none between the guard and the blade. Only one dagger belongs to this category as well (Chagoula Derre : 57841).

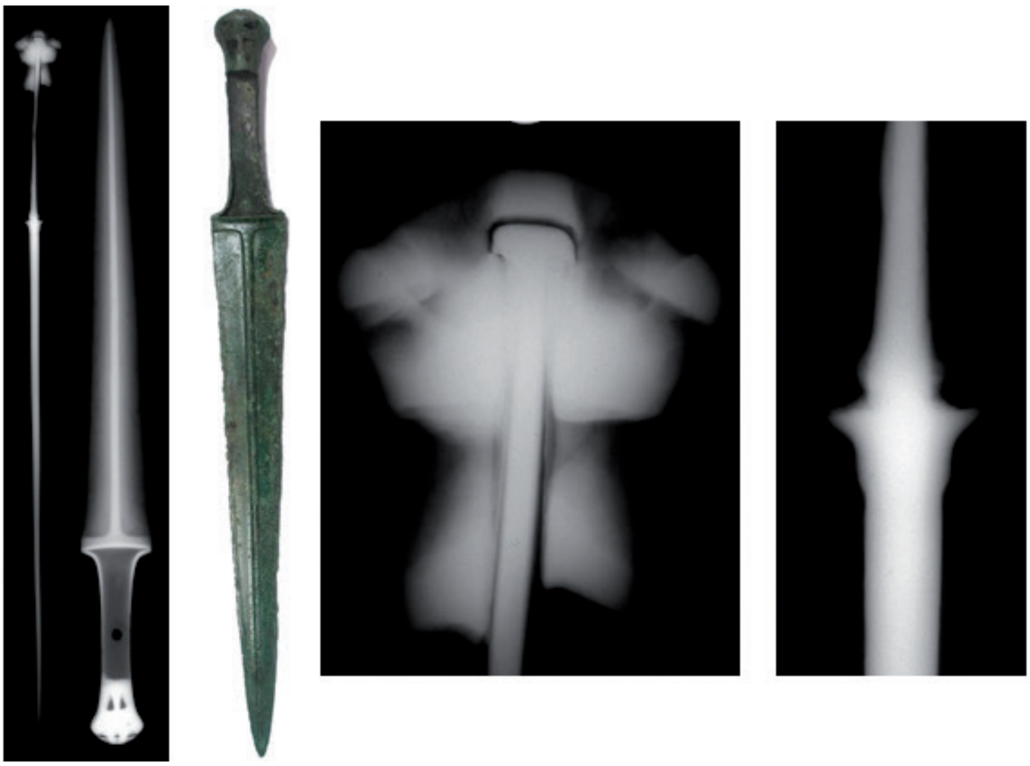

Fig. 12 – General view, radiograph and details of type 2 dagger (Chagoula Derre: 57841).

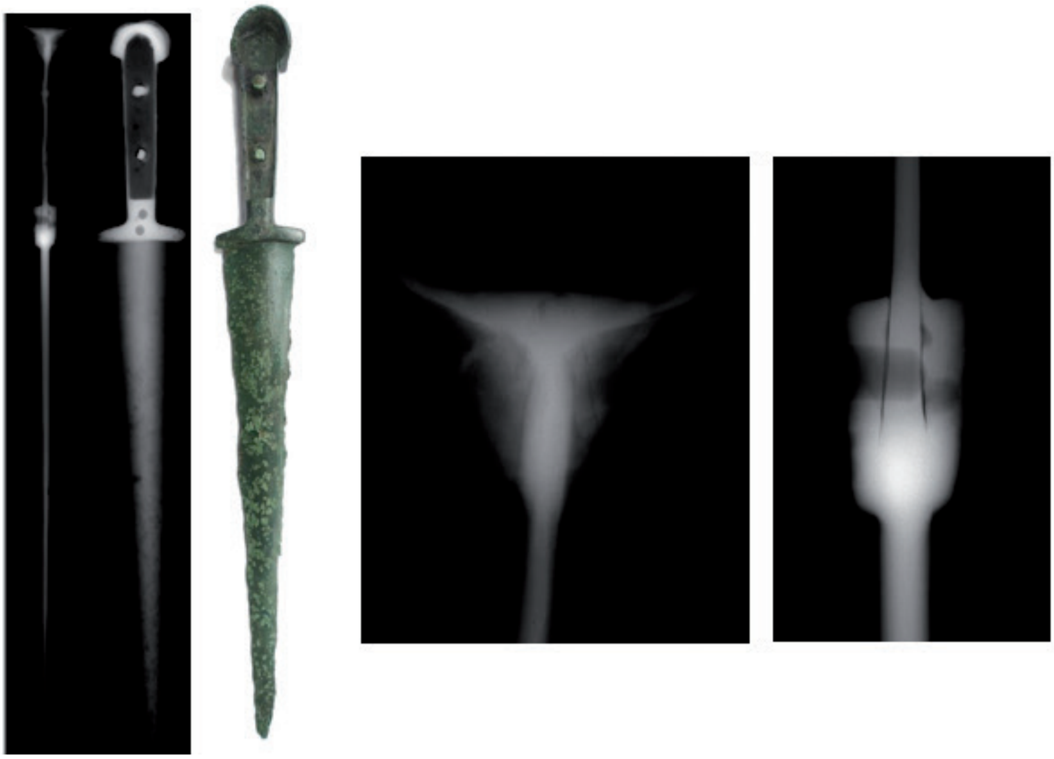

Fig. 13 – General view, radiograph and details of a type 3 dagger (Tchila Khane: 57740).

Type 3 (fig. 13): The dagger was cast in one piece except the guard and the pommel. During a primary casting, the blade and the grip were cast together. Then during a secondary casting, the guard and the pommel were separately cast on the grip, using a lost-wax cast technique. We can clearly see on the radiograph evidence of a join between the pommel and the grip and another between the guard and the blade. Five daggers belong to this category (Veri : 33543.A, 33543.F ; Tchila Khane : 57736, 57738, 57740).

Type 4 (fig. 14): The blade was shaped with a tang and obtained from a primary casting. The handle –that is

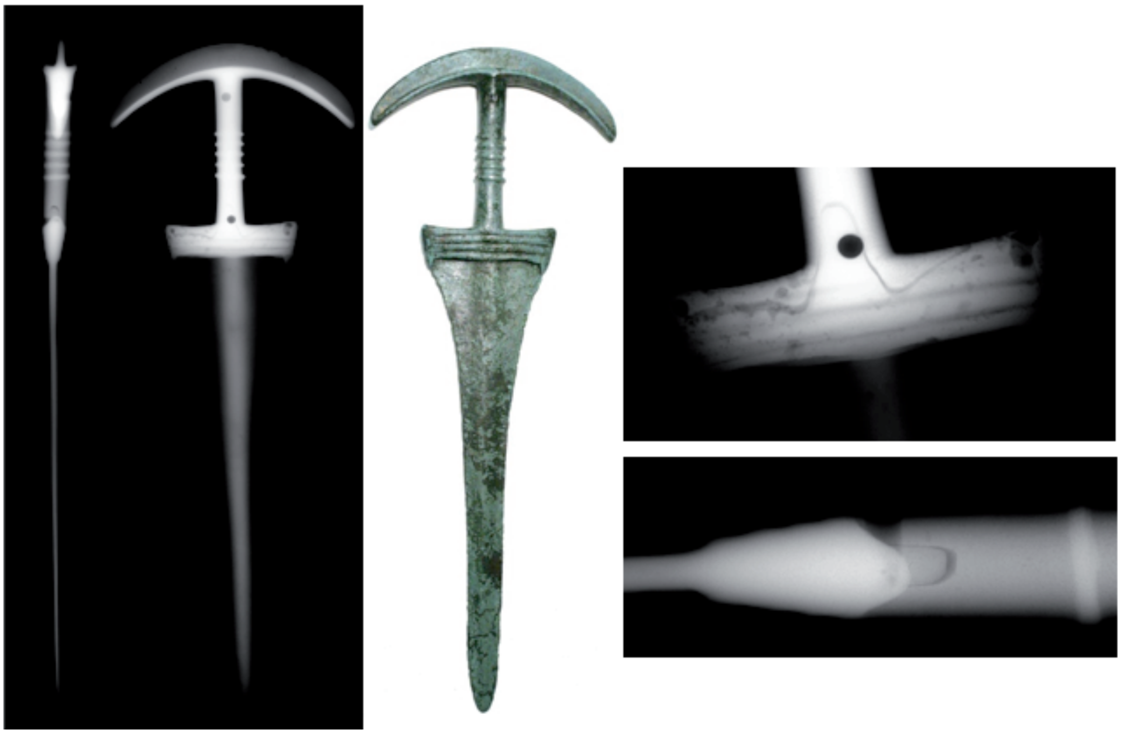

Fig. 14 – General view, radiograph and details of a type 4 dagger (Conu: 33865).

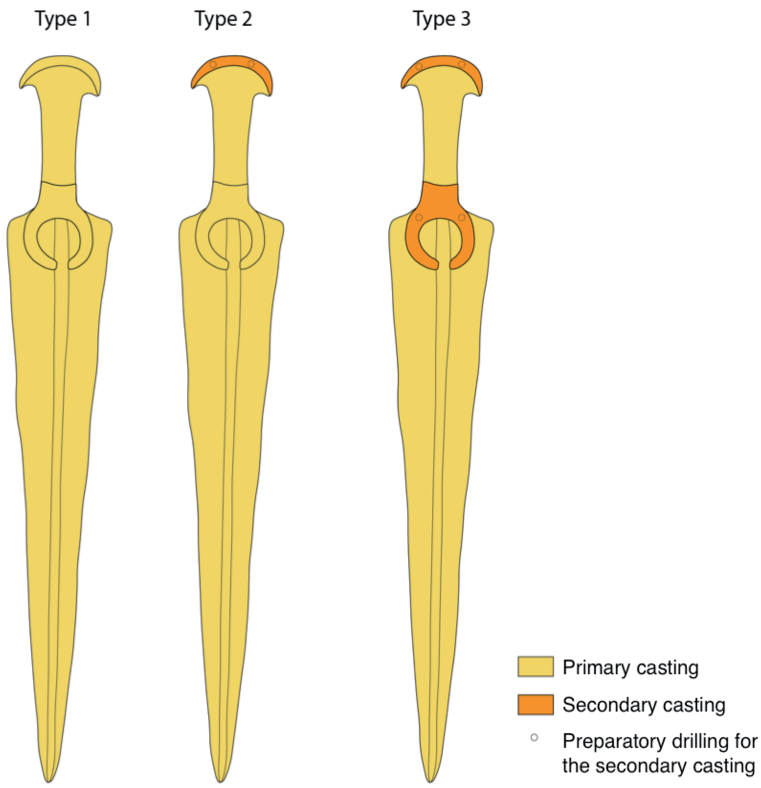

Fig. 15 – Primary casting and secondary casting for types 1, 2 and 3.

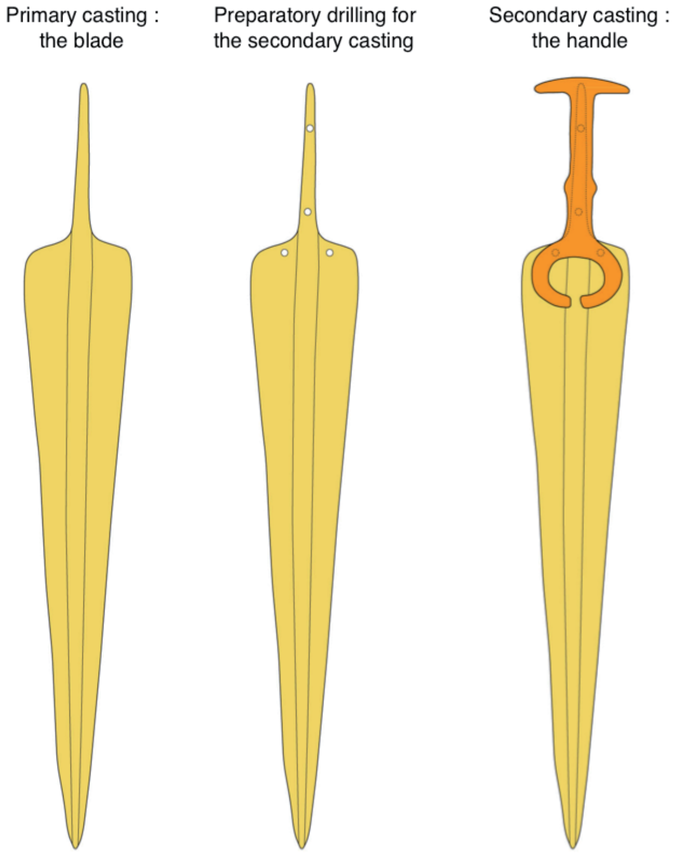

Fig. 16 – Primary casting and secondary casting for type 4.

to say a unique piece encompassing the guard, the grip and the pommel – was cast on the tang during a secondary casting. On the radiograph we can see here the tang inside the handle. This is the most common type, with 20 daggers of which only 6 still possess their grip (Conu : 33865, 33866 ; Veri : 33543.I ; Aspa Hiz : 33958 ; Agha Evlar : 57938 ; Chagoula Derre : 57840).

Various phases of manufacturing: patterns of primary and secondary casting

For types 2 and 3, preparatory drilling can be made on the guard and the pommel to prepare the secondary casting (fig. 15). This ensures that the secondary casting is held to the primary casting by mechanical means. In this way, assembly is inevitably successful, even if welding of the secondary casting to the primary casting is not achieved. For the assembly of the knob, when the preparatory drilling does not seem to be present on the radiograph, it seems obvious from observation that the knob is moulded during the primary casting to a very specific shape that can allow mechanical assembly during the secondary casting.

For type 4, the blade is cast with its fitting tang during a primary casting, then preparatory drilling is carried out on the tang and/or on the base of the blade (a part which is then covered by the guard) to ensure the fixing of the secondary casting on the primary casting (fig. 16).

CONCLUSION

These analyses by PIXE have allowed us to determine that there was a wide variety of alloy compositions, both in proportions of lead and tin and in the level of impurities. This great diversity unfortunately does not allow us to discuss the source of the metal. Nevertheless, it appears that the most common alloy composition consists of a bronze almost not containing lead and with a tin content varying from 5 to 12%, this regardless of the type of object or the place of discovery. This study has provided data that we can compare with the studies already carried out or bring in as a first reference to the geographical area of the Talysh Mountains.

Radiography carried out on the daggers also allowed us to identify four types of fitting characterised by the identification of primary and secondary casting during the manufacturing process. These X-rays, combined with PIXE analysis, which detected high levels of antimony in four handles, show a tendency among metallurgists to use two distinct alloys for making the same dagger, perhaps in order to obtain a metal polychrome effect.

In recent years, these types of archaeometallurgical studies have been developed in Iran and in the Caucasus. Studies have been conducted, for example in Iran, in the Luristan area, to determine the origin of the ores thanks to the chemical composition of artefacts (Begemann et al., 2008), or in the Caucasus in order to determine the origin of bronze and iron metallurgies.

There are similarities with some studies conducted in Iran, where, in Haft Tappeh, for the Middle Elamite Period (1500-1100 BCE), the variety of copper alloy composition shows that the metalworking may not have followed a specific process and that an uncontrolled smelting and alloying procedure has been applied. But we must also remember that the ore sources of Elamite metallurgy have not been identified yet (Oudbashi et al., 2012, p. 167). Moreover, in Sangtarashan Iron Age site, the analysis performed on 10 broken vessels shows that the variability of the tin content cannot be considered as an alloying pattern based on tin (Oudbashi et al., 2012, p. 167).

In the Caucasus, this kind of study, although still rare, has been multiplied in the last couple of years. So, studies have been carried out in Georgia to determine the emergence of iron metallurgy (Erb-Satullo et al., 2014) and in Azerbaijan to understand the origins of metallurgy from the end of the Neolithic period (Courcier et al., 2016). But these pieces of research are based on the study of metallurgical production areas. Here is the limit of our corpus which is only composed of objects coming from a funerary context. It will be necessary in the future to find out settlements and craft production areas in a region where only the necropolises have been documented.

Awaiting such discoveries, it appeared to us interesting to keep on studying bronze objects from a well identified and undisturbed burial context. In this regard, the metallic objects discovered in the graves excavated on the site of Monidigah in 2016 by the French-Azerbaijani archaeological Mission of the Lenkoran Valley, always within the NABIALLA program, were the subject of similar analyses. So, 20 copper alloy objects, ornaments and weapons coming from two clearly identified graves, were analysed by the same PIXE method. Although it has not yet been possible to exploit the results of these analyses, this new data, extending the sample in terms of the typology of objects and the variety of provenances, would make it possible to obtain more statistically significant results and would help to considerably improve the referential for the South Caucasus area.

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