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Bronze and Iron Age carnelian bead production in the UAE and Armenia: new perspectives

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Summary
During the Bronze Age, the Harappan civilization was characterized by its great production of carnelian beads, widely exported in the Middle East. Etched carnelian and classical Harappan beads are considered, rightly, as cultural hallmarks of the Indus Civilization. Indeed, this theory has become so firmly rooted that many believe that all carnelian beads come from the Indus valley. But were there other sources? Did bead production on a more local scale exist, outside these vast circulation networks?

This study examines beads that originated from two distinct geographical and cultural areas: the UAE and Armenia. In the third millennium BC, workshops in the Indus Valley produced most of the carnelian beads found in the UAE. In contrast, in the second millennium BC, another network of exchange came into existence. This study focuses on the material from the Shimāl and Dāyah necropoleis, which comprises more than 2300 objects. On the other side of Iran, in Armenia, carnelian beads are equally common. Where did they come from? The study of material from six sites distributed throughout the country, constituting a total of more than 1300 artefacts, raises a number of interesting questions about the products of this region.

This technological study reveals the existence outside the Indus Valley of different productions and levels of technical skill. It suggests that we should revise our understanding of Bronze and Iron Age exchange networks, by offering another reading of carnelian production in this part of the world.

Keywords: carnelian, technology, protohistory, UAE, Armenia

Introduction
Carnelian beads first appear during the Neolithic (fifth millennium BC) in the Oman peninsula (Kiesewetter, Uerpmann & Jasm 2000; Kiesewetter 2006: 121–125; de Beauclair, Jasm & Uerpmann 2006: 177), but it is only in the Bronze Age (third millennium BC), with the appearance of the Harappan civilization in the Indus Valley, that we observe an increase of this type of ornament in Oman. Indeed, this civilization is notably characterized by the manufacture of these beads, which were widely exported. This can be explained partially by the presence in this region of the world’s biggest source of carnelian, in the central part of the Indian subcontinent, on the Deccan Plateau, in the Gujarat (Inizan 1999; 2000) (*Fig. 1).

The great majority of objects connected to the Indus appear in the Oman peninsula at the end of the third and beginning of the second millennium BC (see e.g. Cleuziou & Tosi 1989; Potts 1993; Vogt 1996), although the origins of this trade appear to be earlier (Cleuziou 1986). Carnelian beads are an integral part of a characteristic group of artefacts imported from the Indus to Oman, much in the same way as Indus weights or ivory combs (see Potts 1993 for an example of these artefacts). Etched carnelian beads (During Caspers 1971; Francis 1980; Kenoyer 1986: 22; Possehl 1996: 153–154; De Waele & Haerinck 2006) and classical Harappan beads (Inizan 1999; 2000) are considered, rightly, to be cultural hallmarks of the Indus civilization (Fig. 2).1 This has led to a strongly held belief that the origin of all carnelian beads can be traced back to the Indus Valley. But are there not other sources? Did bead production exist on a much more local scale, outside these vast circulation networks?

Within the framework of my PhD thesis concerning the study of ornaments, especially those in carnelian from the Oman peninsula, I had the opportunity to study beads from two distinct geographical and cultural areas.

Firstly, in the United Arab Emirates (UAE) the necropoleis of Shimāl and Dāyah, situated in the Ra’s
al-Khaymah Emirate, which include twelve graves and more than 2300 beads (Vogt & Franke-Vogt 1987). These archaeological sites date back to the Wādī Sūq and Late Bronze Age periods, i.e. between 2000 and 1250 BC (Velde 2003).

Secondly, Armenia, a volcanic region situated in the Transcaucases, has an abundance of carnelian. Beads in this material first appeared in the Kura basin at the end of the local Neolithic period (sixth millennium BC), but the most ancient pieces in Armenia date from the Bronze Age (end of the fourth millennium BC) (Santrot 1996; Sintès 2007). The study made in this territory is based on six archaeological sites distributed throughout Armenian territory, which date from the Bronze Age (late fourth to late second millennia BC) and the Iron Age (twelfth to eighth centuries BC), thus being largely contemporary with the sites in the UAE. The Armenian group comprises more than 1300 beads. Most of the carnelian artefacts were found in graves, and those from the Talin, Kalavan,  

**Figure 1.** A map showing the location of the regions mentioned in the text.

**Figure 2.** A necklace found in Tello (Mesopotamia), a classical Harappan bead is located at the top. (From Inizan 2000: fig. 3).
and Sisian sites in particular supplied the majority of the material (Fig. 3). This material was essentially used to make ornaments, accompanying the deceased in their afterlife.

Carnelian is a volcanic stone of the chalcedony family. It is an agate but with a red colour. It can be knapped, abraded, and polished like flint. We can undertake a technological study of carnelian using the same methods that we use on flint, since these two materials have the same hardness as well as the same concoidal fracture due to their structure.6

Various ethno-archaeological studies on the manufacture of carnelian beads, made in India and Yemen, all agree on the following working process (Possehl 1981; Kenoyer, Vidale & Bhan 1991; Inizan, Jazim & Mermier 1992; Inizan 2000; Roux & Pelegrin 1989). The beads are made in six stages: extraction, heat treatment, knapping, abrasion, perforation, and polishing/glossing. From this analytical principle is it possible to know where the UAE and Armenian beads come from? Is the treatment of the carnelian in the various stages of the working process identical to that practised in the Indus Valley?

**Figure 3.** A map of the location of Armenian archaeological sites where carnelian beads were present in the Bronze and Iron Ages.
Extraction of the raw material

In nature, carnelian can be present in two forms: as a primary deposit in the form of veins or as a secondary deposit in the form of pebbles.

Primary deposit

United Arab Emirates

Only one carnelian source has been detected in the UAE to date. This source is in Ra’s al-Khaymah Emirate near the village of al-Ghayl (Vogt 1996: 112), in a mountain with veins which run for the greater part of its west side. Its formation seems sedimentary because the chalcedony shows internal vacuoles and carbonate powder. The observed veins sometimes extend over more than 20 m: it is thus a deposit of significant quantity. The carnelian there is naturally of an orange-red colour, pale and opaque. It is often mixed with other minerals, such as agate or flint, or
with various impurities.

**Armenia**

As a region of ancient volcanoes, Armenia has a number of carnelian deposits throughout the country. In 2007, I was able to make a survey across Armenia to find the sources of this material. Primary deposits of carnelian constitute about 90% of the sources of this chalcedony. The carnelian seems to be broken by the frost and is present in cracks in the rock (diaclace), which allows it to be collected in small manageable pieces. Some of the veins of these geological sites have a range which stretches to several hectares.

The Armenian carnelian has certain similarities with chalcedony of an especially fibrous nature. It is for the greater part pale pink, opaque, with white veins. It is often mixed with other minerals such as agate or jasper. However, certain veins, very rarely, deliver carnelian of an orange-red colour, which is translucent. Of lower quality than its Indian counterpart, it approximates much more closely to the Ra’s al-Khaymah carnelian.

The fifteen carnelian deposits found can be grouped into four main areas: three in the north, and one in the south of Armenia (Fig. 4). In most of the villages, several outcrops are concentrated within a very small territory (a few square kilometres); it is, in fact, the same veins of carnelian, which run for several kilometres, with carnelian blocks appearing at intervals. These blocks measure from 0.20×0.20 m (Metsavan 3) for the smallest, to 2×1 m for the biggest (Tsater).

Of the fifteen deposits, four offer translucent, red-orange carnelian in its natural state (even if in small quantity); others contain opaque, pale-pink carnelian.

These two materials can be seen in beads from Armenian archaeological sites in the same proportions as the raw material in nature, and on all the sites studied we found some carnelian of inferior quality. In contrast, only the Talin, Sisian, and Nor Khachakap (formerly, Saral) sites yielded superior-quality material.

The quantity of material on the mineral outcrops is sufficient to have been the subject of large-scale exploitation. These deposits very probably correspond to the proto-historical mines used to produce carnelian ornaments. It should also be noted that eight supplementary sources were discovered, which they are too small to have been exploited on a large scale but they could have been used occasionally.

The same quality of carnelian can be seen as far afield as the Nagorno-Karabakh region. The geographical extension of this stone is therefore several hundreds of kilometres.

**Secondary deposit**

The secondary deposits consist of pebbles that generally roll from the mountain to the riverbed, as is the case with the most important source of carnelian in the world, the Ratampur basin in the Indus Valley (Inizan 1999: 130; 2000: 477). In Armenia, this type of deposit represents less than 10% of sources. In the UAE, it has yet to be detected.

**The quality of the archaeological beads**

The Indus beads are generally translucent and homogeneous with a red-orange colour. Transparency is one of the qualities that is looked for in carnelian beads. The beads from Shimâl and Dâyah are not of very good quality. Rather opaque, they possess numerous impurities, including traces of limestone. The Armenian beads are for the greater part pale pink or red in colour but also very opaque. The carnelian of these ornaments is mixed with
other minerals or chalcedony. We thus observe a similar quality in the carnelian of these two regions (Figs 5 & 6).

Those who made the UAE and Armenian beads for the greater part used a material of inferior quality. It demonstrates either that there was a shortage of the raw material — so that the craftsmen were forced to choose all types of material, even of bad quality — or that there was a poor ability to recognize the best raw material.

Heat treatment

The second stage of the working process is the heat treatment, a very important stage that has a double aesthetic and technical objective. It allows the red colour of the stone to be enhanced, and it is by this method that the Indus red carnelian is produced from what were originally yellow pebbles. It is the heat treatment that creates this orange-red or bright red colour. This stage also enhances the shine of the material, but only on the inside. Thus in practice it is only observed when the beads are broken, which is one of the criteria by which heat treatment on an archaeological piece can be recognized.

From a technical point of view, the heat treatment makes the grains of the siliceous matrix somewhat finer, especially in micro-fibrous rocks such as carnelian. The pressure that one would need to exert on the rock to get the same final result of parallel touching can be twice as much in the absence of heat treatment: from 20 kg when exerting the pressure on a heated item to 40–50 kg, on the same non-heated item (Inizan & Tixier 2000: 26). This process also facilitates the polishing to a certain degree.

Finally, it should be stated that the heat treatment does not alter the translucency of the carnelian. If the heat treatment makes the knapping easier, it nevertheless results in a more fragile and more breakable stone.

Experimental archaeology

A heat treatment experiment on samples from the UAE and Armenia was carried out by Dr J. Pelegrin. The UAE samples came from the Ra's al-Khaymah source and the Armenian samples were taken from two outcrops situated some kilometres from one another, Tsaghkavan and Varagavan. Located in the east of Armenia, carnelian may involve two outcrops of the same geological formation, in which case, the deposit would potentially extend several kilometres.

Two major problems guided this experiment. Do these two groups of materials, from two different regions, react in the same way? Once heated, are they similar to proto-historical carnelian beads found in these territories?

The methodology used was as follows: fragments of carnelian taken from the samples were placed in an iron box filled with ash, then placed in a fireplace under approximately 4 cm of ash. A fire was then lit and maintained for a period of four to five hours. We know that the temperature reached by a heap of red live charcoals is of the order of 300 °C. The box was extracted still warm from the fireplace about ten hours after the fire was extinguished, and the samples were recovered by means of a fine sieve.

It turned out that the carnelian of the Emirates
reacted very well to heat treatment. The colour changed significantly and was sharply enhanced, from a yellow-orange to a red colour. Furthermore, the knapping was greatly facilitated. We were able to observe a shine, which appeared after removal of a flake (Fig. 7).

In contrast, the Armenian carnelian reacted less well than its UAE counterpart. The colour did not evolve on the Varagan sample. On the other piece (Tsaghkavan), the opaque red-pink material became opaque pink. The material seemed shinier but only very slightly and was much less apparent than on the UAE carnelian. The highly fibrous nature of this chalcedony does not therefore perceptibly alter during heat treatment (Fig. 8).

**Overheating**

Heat treatment needs to be carefully controlled and requires a certain level of skill and knowledge of the nature of the raw material. When beads are left at a high temperature for too long, they overheat. This overheating is evident from a white film on the surface of the bead. Shimāl and Dāyah present an abnormally high rate of overheated beads.11

This excessive heat treatment does not seem to have occurred during the utilization of the ornament. The people who wore the beads are unlikely to have voluntarily put them in the fire. This also did not occur *a posteriori* in the grave, since the practice of cremation had already disappeared by the Wādisq period and the Late Bronze Age. It would not have been caused by an accident either, as it is much too systematic. Logically, it is therefore a question of overheating during the manufacturing phase by people who showed too little care about the quality of their production. These people demonstrate a very low skill level, with poor knowledge of the heating treatment in particular. It should also be noted that the Armenian beads showed no trace of heat treatment (shine, cracking from heat treatment), or a white film from overheating.

**Knapping and finishing phases**

The knapping and finishing phases present numerous similarities in the quality of execution.12 The Shimāl and Dāyah beads are badly knapped, with irregular shapes and a lot of visible knapping traces. Knapping scars are of two types: pre-form negatives and knapping negatives. The first relate to remains of the knapping techniques, which are so fresh that one can very easily imagine the pre-form. They involve longitudinal jointed knapping, either on the whole length or on only half of the artefact. The knapping leaves significant removal scars that cannot be erased during the phase of abrasion without making the artefact considerably smaller.

These knapping traces are sharply marked because abrasion and polishing are absent or little practised. These operations consist of forcefully rubbing the bead with an abrasive to erase knapping traces. Ethnoarchaeological studies made in India (Cambay) indicate that abrasion polishing was done by bow-polishing with grindstones (d’Errico, Roux & Dumond 2000). In Yemen, these various procedures were executed on stone, certain grindstones being more abrasive than others (Inizan, Jazim & Mermier 1992). The main evidence consists of “bundles” of parallel lines visible on the bead.

Fine polishing is also practically absent. Its principle and its process are the same as for abrasion polishing. Its aim is to increase the beads’ shine still further.

The same observations can be made for carnelian beads from Armenia. For the greater part, only the simplest forms (spheres and discs) were made, but the numerous knapping traces result in irregularly shaped beads. Their non-homogeneous morphology as well as the absence of abrasion streaks, reveal that these beads were not abraded. There is also an absence of fine polishing on all the beads.
The perforation process

The perforation process most often used in Armenia and in the Oman peninsula in protohistory was the rotary drilling technique — more than 90% in both cases. This technique is seen in the Neolithic in Anatolia, at the site of Kumar Tepe (sixth millennium BC) (Calley 1990). In the Chalcolithic, it was notably associated with Mehrgarh (fifth millennium BC) (Barthélémie de Saizieu 2000: 442).

Before drilling, both sides of the bead were dotted, so as to prepare the surface before it was bored with the drill. The dotting flakes are rarely visible on the truncations because, as a general rule, they are polished. We can observe concentric, quite regular, and circular grooves inside the bead. Two techniques may be used for the drilling: manual drilling and bow-drilling (Sela & Roux 2000: 178). Concentric grooves would be characteristic for drilling with a bow.

In Armenia, the majority of beads were drilled by bipolar rotary drilling. However, another perforation technique is also present. Called the “Larsa Technique”, it was discovered by J. Chevalier, M-L. Inizan, and J. Tixier on the Larsa site in Iraq (1982). It involves dotting only one side of the bead and, when close to the opposite side, using the same tool as a “punch” to complete the perforation (Fig. 9).

In Shimāl and Dāyah, 95% of the beads were drilled using the bipolar rotary drilling technique but with a noticeable difference: two drills were in fact used, one drill to perforate the surface of the bead (arrow 1 on Fig. 10), then the craftsman used a second smaller drill to reach the centre of the bead (arrow 2 on Fig. 10), and this process was repeated on both sides. This technique is present on a large majority of beads and I have called this “double bipolar rotary drilling”.

This process is present in the UAE in the previous Umm an-Nar (Umm al-Nār) period, but on an extremely low percentage of beads. In the Wādī Sūq and Late Bronze Age period, this practice is too systematic to be a mistake but shows that they managed the perforation of the beads in a different way. Did they employ a second drill which had already been extensively used, and was thus more worn and smaller, for the centre of the bead? Did it depend on the drill or on the shape of the bead? Even if it results in a neater perforation, the use of two drills to drill beads that are no more than 3 mm in length indicates a relatively low skill level.

Discussion

Throughout this study, two groups of very different beads were evident. The first group consisted of carnelian beads originating from the Indus Valley, which have a technical level and a raw material quality that is far superior to the beads that we are concerned with here.

The second group consists of second-millennium UAE and Armenian Bronze and Iron Age beads, which reflect a technical and skill level that was much lower. Firstly, the quality of the raw material, whether average or poor, does not correspond to that of the Indus, where the carnelian is translucent and orange-red. Secondly, the knapping phase is badly executed in the UAE and Armenia. Finally, the finishing phases are clearly insufficient, or even absent, while the Indo-Pakistani region shows finishing phases
which are highly successful.

Thus, while the second group of beads is totally different from the Indus ones, there are very strong similarities within the group, whether considered in terms of the quality of the raw material, or in terms of the skill level of the working process. Only a fundamental difference separates them. Heat treatment does not seem to have been applied to the Armenian carnelian, while it is very evident in the UAE samples.

If they do not come from the Indus Valley, where do they come from?

If, for the majority of the third millennium BC an Indus origin is very likely for beads found in the UAE (Inizan 1999; Brunet 2006; 2007), it is debatable for the second millennium BC. Although beads presenting all the Indus characteristics exist in Shimâl and Dâyah, they are in very insignificant quantity, and the majority of the ornaments are of a much lower technical level. On the one hand, the quality of the raw material as well as the techniques employed on most beads from Shimâl and Dâyah do not credibly correspond to beads imported from the Indus Valley. On the other hand, the proximity of a deposit of carnelian in Ra’s al-Khaymah would indicate a local production of these beads. What is the proportion of the local production? Others carnelian deposits also occur, situated in a wider geographical scale, and are present in Yemen (Inizan, Jazim & Mermier 1992: 163–164) and in Iran (Fritfelt 1991: 116; Inizan 1999: 130), but were they used to produce these beads?

Although certain carnelian beads found in Armenia could have come from the Indus, I think that the majority of them entered through another more internal network of circulation. The Armenian carnelian sources yield a raw material that is visually similar to that used for the manufacture of ornaments in the same region. Furthermore, the local stone’s lack of reaction to heat treatment coincides with the absence of traces of heat treatment on archaeological beads. The same material could be involved in both cases. The technical and skill level confirms that we should not seek for the origin of these beads in the Indian subcontinent, and local manufacture of carnelian beads seems highly probable.

According to the first results of this study, a more internal, more regional circulation of the carnelian would have to be envisaged in the Middle East during the Bronze and Iron Ages, whether it is in the Oman peninsula or in the Lower Caucasus. The technological study of carnelian ornaments allows us to question current ideas about their networks of circulation in the East, something that will be further explored in the next stage of the study.

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Notes

* Unless otherwise stated, the illustrations are from the author.

1. There are carnelian beads that measure more than 10 cm long. The Indus Valley is the only region in the world capable of producing such beads.
2. The Transcaucasus is the region that includes the territories of Armenia, Georgia, and Azerbaijan.
4. This study relies on the material of archaeological sites of Kalavan (UF 8), Talin (Graves 6, 35, 43, 44, and 75), Sisian (Grave 6), Mastara (Grave 24), Artashavan (Grave 6), and Nor Khachakap.
5. Talin, Kalavan, and Sisian sites group 1209 beads from a total of 1377.
6. Carnelian and flint have a hardness of 7 on the Mohs scale, diamond — the hardest stone — being set at a hardness of 10.
7. To begin the survey, we referred to the works of the following researchers: Chukhov 1955; Jrbashyan 1935; Mezhlumyan 1949.
8. Nagorno-Karabakh is a territory situated east of Armenia, within Azeri territory.
9. This deduction is made from the translucence of the classical Harappan beads. They are the most sophisticated beads to have been manufactured. They also had the most value, were the most exported, and were the most imitated (Kenoyer 2001: 164). In Mesopotamia, translucent beads are also those most commonly found.
10 Dr J. Pelegrin, CNRS, UMR 7055, “Préhistoire et Technologie”, Nanterre.
11 The percentage can reach 83%, as in the Shimāl grave 96, for example.
12 The finishing phases include abrasion, polishing, and glossing.
13 These beads, of a high quality of raw material and very well produced in all the stages of the working process, account for less than ten individuals within a total of 2300 beads.

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