دانش و فن‌آوری جوامع نوسنگی قدیم در ایران،
صنایع استخوانی تپه سنگ چخماق و تپه عبدالحسین، موزهٔ ملی ایران

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چکیده

در این مقاله نتایج اولیه مطالعه فن‌آوری اشیا استخوانی دوره آغاز نوسنگی و جنبه‌های اقتصادی - اجتماعی آن ارائه شده است. تاکنون مطالعه روشمند مواد سخت جانوری (استخوان و صدف) در مجموعه‌های باستانی فلات ایران انجام نشده است. این در حالی است که مجموعه‌های محوطه‌های مهمی چون تپه سنگ چخماق و تپه عبدالحسین در موزه ملی ایران نگهداری می‌شوند. ظهور شیوه زندگی جدید با اهلی شدن جانوران و پرورش گیاهان بدون شک در سلسله مراتب تولید (زنجیره عملیاتی) و بهره‌برداری از مواد اولیه مثلا استخوان و صدف تحولاتی ایجاد کرده است.

در ایتجا چند مورد ابزار استخوانی از تپه سنگ چخماق و تپه عبدالحسین که منشا آن استخوان جانوران وحشی یا اهلی است را ارائه می‌دهیم و خصوصیات فن‌آوری و مشاهدات مرتبط را توصیف می‌کنیم. از این مشاهدات می‌توان به برخی از ویژگی‌های فن‌آوری صنایع اوایل دوره نوسنگی مثل الگوهای برداشت از طریق شقه کردن یا شکستن است. این شیوه کار نشان‌دهنده سازگاری تکنیک‌ها با ویژگی‌های ریخت‌شناختی قطعات مواد اولیه استخوانی است که برای تولید گونه‌های خاصی از ابزار از جمله سوراخ کن، صاف و نرم کننده و اشیا چند کاربردی استفاده می‌شود. نتایج اولیه این تحقیق در روشن کردن وضعیت دانش فن‌آوری جوامع پیش‌ازتاریخ ایران در زمینه مواد سخت جانوری و گام‌های اولیه در فهم مراحل تکامل این دانش در اوایل هولوسن در فلات ایران مهم است.

واژگان کلیدی: فرآورده‌های استخوانی، دانش فناوری، جنبه‌های اقتصادی، نوسنگی بدون سفال، فلات ایران.

https://doi.org/10.22034/JINM.2021.252978

The technical knowledge of Early Neolithic Iranian Societies. The bone industries of Tappeh Sang-e Chakhmaq and Tepe Abdul Hosein, Iran National Museum.

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Abstract

The paper presents the first results of an on-going study on the characterisation of the technological and socio-economic aspects of bone objects from the Iranian Early Neolithic period. The systematic study of hard animal material products on large collections from the Iranian Plateau is lacking while larges series exist for iconic Early Neolithic sites of Tappeh Sang-e Chakhmaq and Tepe Abdul Hosein, stored at the National Museum of Iran. The advent of a new way of life with the domestication of plants and animals has undoubtedly introduced new transformation sequences (chaîne opératoire) in the exploitation of raw material, namely bone and shells. We present here case studies, on osseous materials from these two sites, and highlight the technological characterisation of the Early Neolithic industries based on the exploitation of animal resources, wild and domestic.

Some technical peculiarities of the Early Neolithic industries are illustrated (debitage schemes by bi-partitioning and fracturation) that indicate adaptability of techniques to the morphological features of raw material blocks for the production of certain tool classes (awls, smoothers, intermediate objects etc.). These preliminary results are important to establish the state of technical knowledge of prehistoric communities of Iran and to initiate a debate on the technological evolution for the hard animal mater (bone and shell) during the Early Holocene of the Iranian Plateau.

Keywords: Bone production; Technical knowledge; Economic aspects; Aceramic Neolithic; Iranian Plateau.

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Cultural background and scientific objectives

Between 9,500 and 8,000 BC the people of Zagros and of the neighbouring areas experienced major cognitive transformations that affected economic and symbolic societal structures (Price et al. 1995; Kozłowski and Aurenche 2005; Ibanez et al. 2018). The domestication of plants and animals, sedentism, increased tool production related to animal products and the processing of foodstuffs, changes in transformation schemes of lithic industry, emergence of ceramic technology, architectural innovation, and the sophistication of rituals all contributed to the increasing complexity of early Neolithic societies. These gradual changes were also accompanied by climatic amelioration (9,600-5,500 BC) marked by the replacement of cold steppe and Artemisia brush with oak and pistachio savannah, indicators of increasing heat and humidity (Djamali et al., 2008, 2010; Van Zeist and Bottema, 1982). Domestic animal and plant exploitation observed in faunal and botanical assemblages also indicates important changes that necessitated techno-economic and socio-cultural adaptations (Zeder 1999, 2006; Zeder and Hesse, 2000; Riehl et al., 2013; Daujat et al., 2016; Roustaei and Mashkour, 2016; Daly et al 2018, 2021). The exploitation of hard animal materials is an integral part of these changing processes in Neolithic societies.

Applying a diachronic and geographical approach, the aim of this study is to use hard animal material productions as a proxy for tracking social evolution on the Iranian Plateau and in the Middle East, where the earliest evidence for the emergence of Neolithic culture appeared around 11,000 years ago and spread eastwards (Broushaki et al., 2015). To understand these radical changes in subsistence and social organisation we chose to work primarily on the Early Neolithic (9,600-7,000 BC).

Archaeological evidence indicates that the economy of Neolithic agropastoral societies was mainly based on domesticate herbivores, such as goats, sheep, pig and cattle, but that the hunting of gazelle and hemione and the consumption of molluscs was still regionally practiced. There is evidence from this period of the exploitation of domestic animals, principally caprini, for the production of osseous tools, and of the preferential transformation of skeletal parts, mainly metapodials or scapulas. The overwhelming presence of awls and points of various sizes indicates the use of these tools for a wide range of craft activities (Tsuneki, 2014; Roustaei et al., 2015; Richardson, 2017, 2019). However, the production of a wide variety of other types of artefacts may also be observed, including beveled tools, pins, needles, and spatulas. As during the preceding late Mesolithic, information on the methods of transformation and the use of osseous materials is very poor for Iranian contexts, in contrast with the Natufian and Neolithic sites in the Levant and Caucasus areas (Campana, 1987, 1989; Stordeur, 1991; Le Dosseur, 2008, 2014; Taha and Le Dosseur, 2017). Shell exploitation, present at both coastal and inland sites, seems to be restricted to the manufacture of ornaments: beads, plaques, and pendants. The beginning of a craft specialisation also appears to begin in Levant for discoid beads production (Le Dosseur, 2006, 2008).

From animals to objects: environmental, economic and cultural aspects

In light of recent discoveries in south-west Asia, the exploitation of animal resources for the production of tools and ornaments predates the Early Holocene. However, technological, economical and functional data on the transformation of these raw materials, and their involvement in the emergence of technical innovations, is currently lacking in the archaeological literature on the Iranian Plateau region.

Hard animal materials cover a large variety of raw materials (bone, antler, tooth, shell) that are differentiated by their composition, their morphological characteristics and their mechanical properties. These characteristics have allowed prehistoric and historic groups to produce a wide range of instruments with a richness in typological, morphological and functional properties. The use of these tools in various spheres of ancient societies (domestic, funeral, hunting, social and symbolic) therefore

provides critical information on the markers of the evolving techno-economic and social systems.

In the diachronic technical-economic and functional study of these artefacts, data was obtained on:

- The palaeo-environment and ancient habitats: the chronological sequences show the exploitation of different species over time: wild species during the Palaeolithic, primarily domestic species during the first Neolithic period and a partial return to the exploitation of wild species in the following phases. The reconstruction of the environment in respect to the identified species and their probably proximity to the sites also describes the movements of people and objects, including the circulation of certain precious raw materials, such as shells, during the prehistoric and protohistoric periods.
- Palaeo-economy: the choices made in the sequences of acquisition, transformation, use, and management of manufactured products offer valuable data on the types of production and productivity of human groups. These criteria may be used to identify the origin of craft activities and their evolution, as well as possible variations in the availability of raw materials in respect to regional, environmental, or cultural peculiarities.
- Palaeo-technology: this topic includes innovation, persistence, knowledge transmission and the loss of technical knowledge. These are recurring phenomena in the past that are indicative of mobility and flexibility, the impact of external influences, and the influence of social cohesion and traditions. These criteria are potentially detectable through the diachronic study of hard animal material industries. The first studies carried out on some of the series at the Iran National Museum illustrate a partial continuity between the Epipalaeolithic and Neolithic industries for the production of ornamental objects. During the Epipaleolithic, dry seashells were sourced from beaches to be worked (site of Ali Tappeh; Manca et al. 2018, 2021) whereas during the Neolithic there is the production of discoidal beads produced from the valves of freshly collected inland shells (site of Tepe Abdul Hosein). Even though the basic techniques used remained the same, the two production sequences differ considerably due to the decidedly greater complexity of the processing procedures for the Neolithic pearls. Data are however still too limited to allow for comment on other sectors of production, but with the continuation of our research more detailed results are being obtained on the hard animal material industry, as well as on a larger number of archaeological series over a longer period.

The extensive study of the hard animal material series from the Iran National Museum will provide vital insight on the lives of ancient populations, and their evolution over time.

Archaeological contexts, materials and methods

This study focuses on two Early Neolithic series that are among the most important in the Iranian Plateau region: the osseous and shell products of Tappeh Sang-e Chakhmaq (Roustaei et al. 2015) in the Alborz mountain region, and the animal products from Tepe Abdul Hosein (Pullar 1990, Broushaki et al. 2015) in the Zagros Region (Fig. 1). These two sites have been chosen principally due to the presence in the assemblages of both pre-pottery and pottery Neolithic occupation. This contemporaneity makes it possible to compare these two phases and to begin to reflect on the transmission (and/or regionalisation) of the technical aspects of the osseous and shell industries during the ancient Neolithic. The possible technical differentiation between the exploitation systems of domestic and wild animals is obviously a key question to be explored, closely linked to the understanding of Neolithic cultural transmission.

Tepe Abdul Hosein is a little mound located around 24 km from the city of Nurabad, in the fertile valley of the Ab-i-Qishlaq in Western Iran. This site is situated at an altitude of circa 1860 m above sea level. The excavations were carried out under the direction of J. Pullar in the summer of 1978, and published more than ten years later (Pullar 1990). Ten soundings were dug during the excavations, uncovering two main phases of site occupation during

Fig. 1. Map showing the location of Tepe Abdul Hosein and Tappeh Sang-e Chakhmaq (red stars) and present-day cities (black rectangular).

the Neolithic. The first was during the pre-ceramic Neolithic period (7th millennium BC), and the second contained ceramic finds and was dated to the end of the Early Neolithic (5th millennium BC). These two phases, dated in absolute chronology (Pullar 1981; Daly et al. 2021), are stratigraphically separated by a sterile layer that indicates the abandonment of the site between the two occupation phases. The particular abundance of hard animal industry, the good preservation of the faunal finds and the good chronological framework of the techno-complex make this site one of the most promising for the characterisation of the Zagros bone industry. Several elements of material culture, such as pottery finds, clay objects, flint artefacts, and biological remains were found in the site at all levels. The faunal assemblage of Tepe Abdul Hosein, currently under study by Marjan Mashkour and her research team, consists of bones from both domesticated and wild animals. The first results of the study on the goats from this site were recently presented (Mashkour et al., unpublished report; Daly et al. 2021). These remains do not exhibit the small twisted horns and reduced body size that characterise the domestic goat morphology that appeared during the ceramic period. At this early stage of domestication, the demographic profile does suggest however that the goats were already managed. The remains of very young individuals indicate that these animals lived near the site.

Tappeh Sang-e Chakhmaq ('Mound of Flintstone' in Persian) is located on the south-eastern side of the Alborz Mountains (North

Iran), approximately 1400 m above sea level (Tsuneki 2014). Archaeological excavations began in the 1970s under the direction of the late Prof. Sei-ichi Masuda, and restarted in 2009 through the initiative of Kourosh Roustaei (Roustaei 2012, Roustaei et al. 2015). The site consists of two main mounds, West Tappeh and East Tappeh, that were alternately occupied during the Early Neolithic period with a hiatus of at least 300 years. According to the 14C dating results (Nakamura 2014; Roustaei et al. 2015), the occupation of West Tappeh dates between the end of the 8th millennium BC and the early 7th millennium BC. The occupation of East Tappeh dates between the late 7th millennium and the late 6th millennium BC. The study of the faunal assemblage collected by the Japanese team and housed in Tsukuba reveals that in the western mound, goat already had a domesticated status, and in the east mound there are domesticated sheep and cattle (Mashkour et al 2015, Roustaei et al. 2015). Various wild animals also had an important role in the subsistence economy of Tappeh Sang-e Chakhmaq Neolithic groups, including: herbivores (wild goat and sheep, gazelle, red deer, boar, onager, hare) and carnivores (bear, canids namely wolf, dog and fox; beech marten), and tortoise. The presence of species from different biotopes suggests the exploitation of a wide territory around the site toward the mountains or the desert. Many tools and ornaments of both bone and shell are reported from both mounds. Awls and spatulas seem to comprise the greater part of the bone tool assemblage (Tsuneki 2014; Roustaei et al. 2015).

Our goal was primarily to define the technical and economical peculiarities of these products and to compare the hard animal material products from the two sites in order to define possible common points.

In order to achieve these goals, two working sessions were organised at the National Museum of Iran in 2017 and 2018. The objectives of the 2017 mission were twofold: to evaluate the research potential of the hard animal material industry from the Neolithic site of Tepe Abdul Hosein and to begin the technological study of the assemblage. During this mission, we started the study of Tepe Abdul Hosein, selecting 252 elements of faunal remains (from a total of about 500 bags in 8 boxes) that likely contained osseous and shell industries. There were three primary selection criteria: i) the presence of technological traces and morphological anomalies that may correspond to anthropogenic traces of transformation; ii) that the element does not correspond to refuse from food consumption; iii) the presence of macroscopic use-wear traces. We also studied 17 remains that had been selected during the excavations and stored in the Museum's depots.

One of the main objectives of the mission in 2018 was to continue the study of the Tepe Abdul Hosein series and to begin the typo-technological study of certain pieces from the Neolithic site of Tappeh Sang-e Chakhmaq. In continuity with the previous mission, in 2018 we studied the surfaces of the 252 elements selected in 2017 with macroscopic and microscopic instruments (Insize ism-pm 200sb portable digital microscope, with magnifications of 10× to 200×). This research phase allowed us to identify and characterise the technical marks and functional macrotraces in order to better select the elements that composed the industry assemblage. After this phase, only 142 pieces were included in the osseous and shell material industry assemblage. All these artefacts were characterised for class determination (e.g. Scaphopoda, Gasteropoda, Bivalvia, Mammalia, Aves, Reptilia …) followed by a more detailed examination to determine genus or species and to identify the species, anatomical element, and taphonomical characteristics. In the second phase of the analysis, the technical, taphonomical and functional data were expanded to allow the reconstruction of the production schemes. In 2018 we also studied 90 remains coming from Tepe Abdul Hosein that were stored in the Museum's depots, and five remains that were exhibited in the Museum's gallery. Finally, 10 remains from the site of Tappeh Sang-e Chakhmaq exhibited in the Museum's gallery were also studied, and of these finds, only seven had anthropogenic signs of transformation for the production of tools.

More than 60% of hard animal industry from Tepe Abdul Hosein were selected from the faunal assemblage (NR: 134). Many other finds, selected during excavation and post-excavation operations, did not show any anthropogenic traces related to the processing of raw materials. These selection phases demonstrate the importance of the preliminary work of the hard animal material technologist, who worked in close collaboration with the archaeozoologist on the entire faunal assemblage.

This preliminary selection work allowed not only the finished objects to be identified, but also the other categories of artefacts (rough-outs, blanks, and wastes), that frequently remain unidentified by non-specialist researchers. Thanks to the identification of diverse artefacts, a higher number of industry processes have been described, allowing for a better comprehension of the technical strategies in the transformation of osseous and shell raw materials.

Results. Some case studies of early Neolithic bone production from Tepe Abdul Hosein and Tappeh Sang-e Chakhmaq

In total, a worked faunal assemblage composed of 229 remains was recovered during the excavations at Tepe Abdul Hosein. Various raw materials were exploited: bone, antler, tusk, turtle shells and seashells. Bone artefacts compose the most important portion of industry with 159 pieces; 61 artefacts are represent by seashells, and there are only 6 antler artefacts and 3 tusks (Tab. 1).

At the current state of the project, the studied bone industry from Tappeh Sang-e Chakhmaq encompasses seven remains. All of these pieces come from the 1970s excavations (Tab. 1).

We have chosen to present here some of the most important case studies concerning the osseous industry of Tepe Abdul Hosein found in the layers corresponding to the aceramic period, which are the most commonly represented part of industry (NR: 111 remains). These results are accompanied by some observations made on bone artefacts from Tappeh Sang-e Chakhmaq (NR: 7 remains). From a strictly typo-technological point of view, this bone industry is mostly composed of finished objects. Despite the rarity of other technical products (preform, blanks, wastes), and the small proportion of the finds related to production sequence, we were still able to obtain a great deal of information from the analyses. The rest of the items, either too fragmentary or too transformed to provide useful indications for technological attribution, remain indeterminate. Among the identified production sequences,

Tepe Abdul Hosein								
	Aceramic period	Aceramic (mixed)	Divide the aceramic from ceramic levels	Ceramic period	Ceramic (mixed)	Surface	Mixed	TOT.
Bone	105	4	2	18	5	/	25	159
Antler	4	/	/	/	/	2	/	6
Tooth	2	/	/	/	1	/	/	3
Shell	55	1	/	2	/	1	2	61
TOTAL	166	5	2	20	6	3	27	229

Tappeh Sang-e Chakhmaq				
	West Mound	East Mound	East Mound/ Level III	TOTAL
Bone	/	5	1	6
Tooth	/	1	/	1
TOTAL	/	6	1	7

Tab. 1 Distribution of osseous and shell worked materials by chronological affiliation.

two are the most widely represented (just under half of the total): blank production by bipartitioning and blank production by fracturation (for the translation of the scientific terms from french to english, see Averbouh 2016) . These sequences of production are illustrated and characterised here.

The debitage scheme by bipartitioning, a method of transformation used for the production of pointed objects?

In general, debitage by partitioning aims to divide the blocks of raw material into two or more parts by acting on its main axis (Averbouh 2000; Manca 2017). In order to achieve this, the technical action is realised longitudinally on a voluminous raw material block (for instance a tibia, metapodial or femur) or transversally on a flat block (for instance a rib or scapula). The aim is to obtain regular, elongated supports of minimal thickness.

During the aceramic period of Tepe Abdul Hosein, this scheme of production is represented by tools (NR: 10) and some wastes consisting of fragments of epiphyseal portions of long bones (NR: 6). Three finds from Tappeh Sang-e Chakhmaq can also be ascribed to this transformation scheme.

The processed raw material blocks are almost all long bones of either sheep or goats (NR: 8), or small mammals of goat size (NR: 4), or large mammals (NR: 2). The remaining finds are a long carnivore bone (fox size; NR: 1) and a lower incisor of a pig (Sus scrofa sp.). The predominance of metapodials suggests a preferential application of these raw material blocks, probably due to their regular shape and size.

The splitting process follows two procedures: the first one is implemented by indirect percussion performed from a distal end, sometimes aided by direct transverse percussion; the second is practiced by longitudinal grooving or sawing accompanied by an indirect transverse percussion. The blank thus obtained is then shaped into the active tool part and sometimes regularised on the mesial and proximal parts. This method produces objects of a standardised dimension and shape that require considerable technical investment and the use of material and human resources (lithic instruments, time of realisation).

- *Tools*

The inhabitants of the site of Abdul Hosein created blanks using this method for the production of various tools: a smoother, a beveled object, and three awls (of which only one is not fragmented) (Fig. 2, 1-5). The other five tools are fragmented with only the proximal part preserved, preventing a more detailed classification (Fig. 2, 6-9). However, their general morphology seems to correspond with pointed objects obtained by fracturing (cf. Fig. 5). Three objects found at Tappeh Sang-e Chakhmaq are identified as two smoothers and an indeterminate object (Fig. 2, 10-11).

The majority of the finished objects correspond with production by longitudinal grooving or sawing realised with flint tools accompanied by an indirect transverse percussion (Fig. 3, 1-2). The shaping techniques identified include scraping (Fig. 3, 3a) and abrasion (Fig. 3, 3b). These two techniques are used individually (scraping, NR: 4; abrasion, NR: 2) or in association (NR: 2). In two cases, the shaping techniques remain unidentified.

- *Technical products*

The technical objects identified, exclusively wastes, are all from metapodials (4 metatarsus and 2 metacarpal) of small goat-sized mammals (Fig. 4). All identified finds are related to the indirect longitudinal percussion transformation sequence, with characteristic stigmata: longitudinal fractures planes with a flattened portion of surface located on the distal end of the metapodials (Fig. 4, 2).

The debitage scheme by fracturation, an expeditious method for the production of diverse instruments

This debitage scheme produces splinters by violently striking the block of raw material. This scheme does not allow for control of either the size or the shape of the blanks obtained (Averbouh 2000; Manca 2018).

Fig. 2 . Tools obtained from a debitage scheme by bipartitioning: smoother (1), bevelled object (2), awls (3-5) and indeterminate tools (6-9) from Tepe Abdul Hosein; a smoother (10) and an indeterminate object from Tappeh Sang-e Chakhmaq.

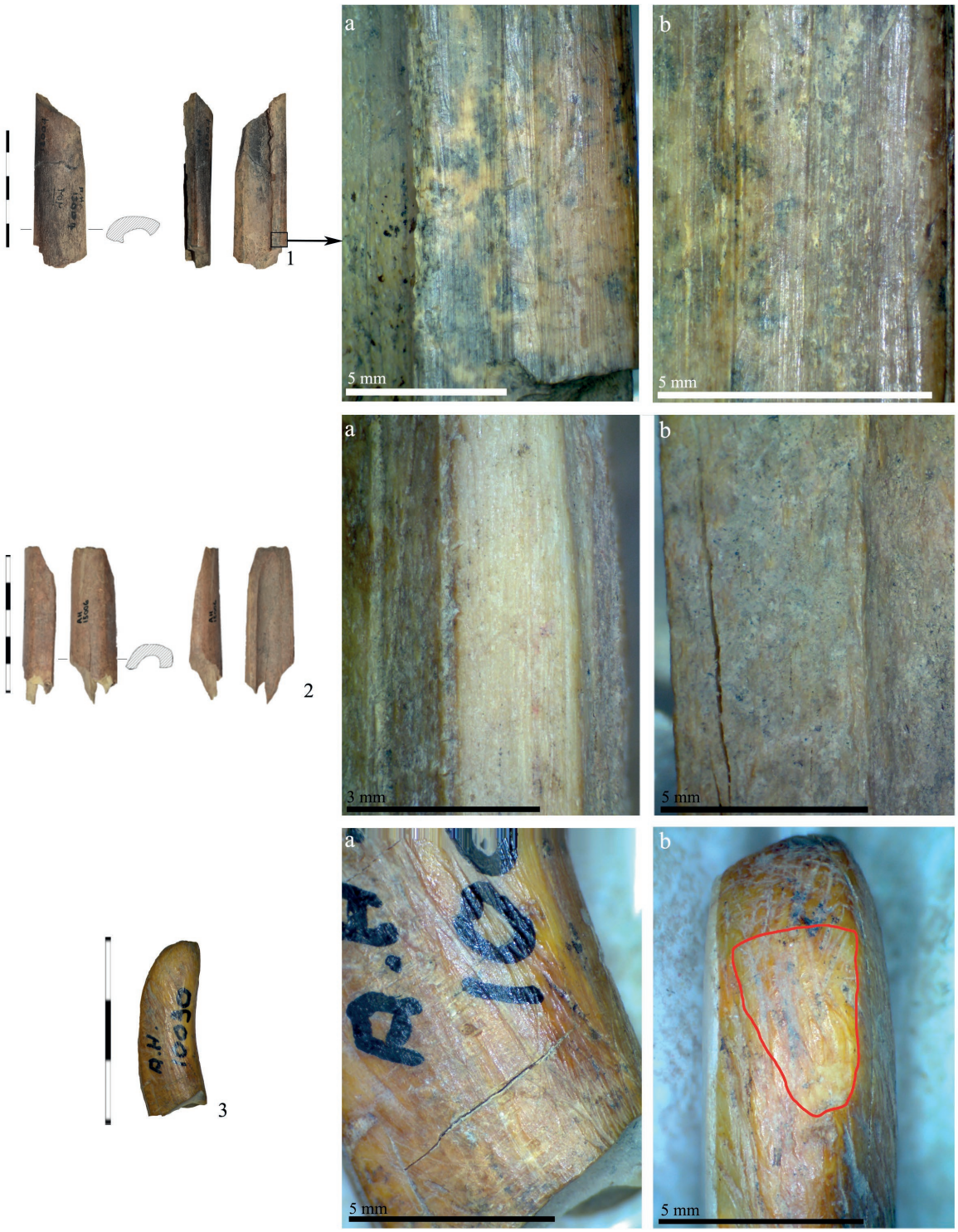

Fig. 3. Technical stigmata identified on the tool surfaces: longitudinal grooving (1a, 1b, 2a) and the fracture plane (2b) realised with flint tools during the debitage steps; longitudinal scraping (3a) and abrasion (3b) realised during shaping operations.

Fig. 4. Wastes linked to the debitage scheme by bipartitioning showing characteristic technical stigmata of longitudinal indirect percussion.

The presence of impact points associated with fracture planes are identified on the long bones of large, medium and small-sized mammals. The association of taxonomic, technical and taphonomic data allows a more precise characterisation of this debitage method, highlighting repeated forms of debitage operations. The impact points can be single or double, often inflicted just below the epiphysis (metapodials) or along the medial section (humerus and femur). The percussion is rarely performed on an anvil, attested by a single piece where backlash was identified.

The numerous wastes that represent this fracturing method may be explained either by the exploitation of animal resources for food purposes (the recovery of marrow) or by the transformation of these materials for artisanal crafts.

- *Tools*

During the aceramic period of Tepe Abdul Hosein, this production scheme was used to produce several finished objects: pointed objects (NR: 11; Fig. 5, 1-5), intermediate tools (NR: 5; Fig. 5, 6-7), smoothers (NR: 2; Fig. 5, 8) and a bevelled tool (NR: 1; Fig. 5, 9). Four objects are mesial fragments of unidentifiable instruments.

The raw materials are mainly long bones of sheep and goats (NR: 5) and small mammals (NR: 13). Large mammals are represented by only three remains. The rest of the technological group is undetermined (NR: 2).

The technical stigmata include parallel fracture planes and impact points identified on five pieces. The morphology of the fracture planes and impact points indicate that bone fracturing

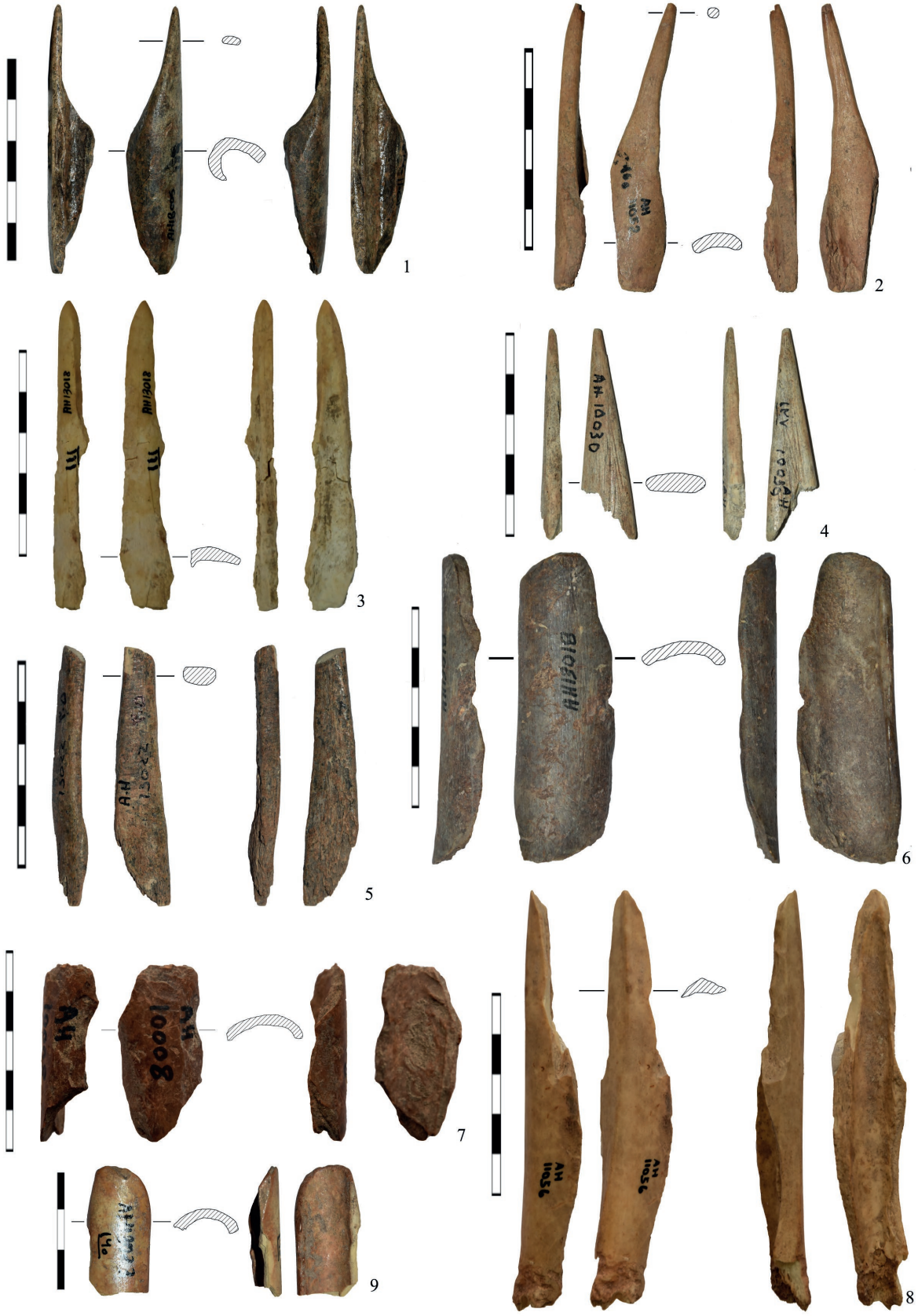

Fig. 5. Tools obtained from the debitage scheme by fracturation: pointed objects (1-5), intermediate tools (6-7), a smoother (8) and a bevelled tool (9).

occurred in the fresh state of the raw material. The size of the impact points suggests the use of punctiform point active strikers (between 8 and 15 mm in length; Fig. 6, 1a and 2a).

Just over half of the blanks (NR: 13) were transformed by scraping during the shaping phase (Fig. 6, 2b). In two cases, the active part of the tools was shaped by retouching. For the rest, the use of abrasion (NR: 1) and the use of both scraping and abrasion (NR: 1; Fig. 6, 1b) were observed. Finally, in five cases the blanks were used without specialised shaping of the active part, such as for the intermediate tools.

- *Technical products*

In the case of debitage by fracturing, technical stigmata may identifiable on blocks fractured to extract bone marrow. For this reason it is very difficult, if not impossible, to differentiate the food waste from the wastes and blanks associated with the production of objects. The recurrence of species and anatomical elements as the base material for finished objects and of wastes and blanks, combined with recurring positions of impact points, may suggest that fracturing was carried out for the production of objects. However, the presence of one activity does not exclude the other: a bone may be fractured both to extract marrow and to produce blanks for bone industry.

At Tepe Abdul Hosein, the wastes potentially linked with the debitage scheme by fracturation are the medial fragments of long bones in which the impact fracture points are clearly identifiable (NR: 15; Fig. 7, 1-4). These mostly use bones obtained from small mammals (NR: 10) and ovicaprines (NR: 4).

Only one potential rough-out was identified. It is a bone splinter, obtained from the long bone of an ovicaprine, which started to be scraped at the medial part and was subsequently abandoned before the shaping phase.

Fig. 6. Technical stigmata identified on the surfaces of tools: direct percussion (1a and 2a) realised during debitage steps; abrasion (1b) and longitudinal scraping (2b) applied during shaping phases.

Fig. 7. Wastes linked to the debitage scheme by fracturation showing characteristic technical stigmata of direct percussion.

Discussion and conclusion

The study of the assemblage of Tepe Abdul Hosein in respect to the two main sequences of transformation indicates that bone material was exploited for the production of instruments. The metapodials of medium-sized mammals (Caprini) are the most commonly exploited raw material blocks. The exploitation of domestic animals seems to be the preferential material, but a high number of undetermined species makes this conclusion uncertain. The excellent quality of the collection and the identification of all types of products with a majority of finished objects and wastes linked to the same transformation sequences (blank production by bipartitioning and blank production by fracturation) suggest that production that took place at the site.

Theses series are representative of all stages of the industry, but also illustrate the deficiencies in the recovery of identified technical items due to the partial excavation of the site. The reconstructions of specific methodological stages are incomplete. The objects associated with the transformation scheme by bipartition mainly indicate procedures carried out by single-sided or double-sided scraping, or sawing followed by a percussion. The inverse analysis of the wastes from the same transformation scheme suggest a priority application of a longitudinal partition by indirect percussion, which is visible in two finished objects (Fig. 2, 3 and 8). The concentration of manufacturing wastes in the excavation areas (11G and 12H) suggests the practice of production activities in specific areas of the site.

The transformation schemes and the production techniques used within them indicate considerable breadth in technical knowledge. The standardisation of procedures is already identifiable in the production of certain types of artefacts such as pointed objects, intermediate tools and smoothers. The morphology of blanks indicates the preferential production of flat and elongated blanks of regular dimensions. Standardised production is achieved not only with the use of the bipartition method, applied to a selection of blocks of raw material, but also with the fracturing method by repeating successive strikes. These standardised

approaches are combined with high productivity. A maximum of four blanks may be obtained from a single block of raw material (debitage scheme by bipartitioning).

The majority of the objects were abandoned only once they were beyond repair. This shows the constant maintenance of the active parts and the use of these tools until exhaustion. In numerous fragments of active parts, we note the presence of shaping stigmata and only rarely the presence of use-wears traces due to prolonged utilisation of the artefacts.

The production of the Tappeh Sang-e Chakhmaq site, which is slightly more recent than the assemblage of Tepe Abdul Hosein, shows the application of the debitage scheme by bipartition on metapodials and ribs with the same aim to produce elongated and regular blanks. The shaping operations are limited to the active part of the pieces, revealing great precision during the debitage phase. The absence of debitage wastes prevents a detailed description of the production dynamics, which will be examined in more detail after further analysis of the finds in the faunal assemblage.

Despite the small size of these series, these analyses illustrate the technical and cultural choices linked to the exploitation of osseous materials. In conclusion, in the economy of early Neolithic groups there is evidence of production adapted to the exploitation of particular anatomical parts, such as goat metapodials, in association with production methods aimed at the production of numerous supports (bipartition debitage scheme). Fractured remains represented a higher variety of long bones of different calibres, showing however that attention was paid to the morphology of the obtained blanks. These first techno-economic aspects will expanded during the complete study of these series, and the study of other key series from the Iranian Plateau. All the data collected in the framework of this study provide essential information for understanding the exploitation system of the first domesticated species and, in so doing, better understand the major consequences of these upheavals for the first populations of the early Neolithic period.

Acknowledgements

This study was funded by the National Museum of Natural History in Paris in the context of project "EXAMS project - The EXploitation of hard Animal MaterialS and the diffusion of knowledge. Exploring technological innovations and adaptations from the Neolithic to the Bronze Age along the transcultural corridor from the Zagros to the Indus valley (financed by Alliance Sorbonne University – Paris). This research was performed within a MOU – Memorandum of Understanding – between the Iran National Museum and the National Museum of Natural History in Paris. The authors thank Dr. Jebrael Nokandeh, General Director of the Iran National Museum, Fereidoun Biglari, the Deputy Director of the Museum, and Firuzeh Sepidnameh, the Director of Ancient History Department, for their support and help during all the stages of the work. We also wish to thank Omolbanin Nahid Ghafoori, head of the Research Department on Pottery, Nayereh Nazari, keeper of the Department of Osteology in the Museum, Yousef Hassanzadeh, head of Research Group, Sepideh Moghaddam and Masoumeh Ahmadi, for their time and kind support during the analyses conducted at the Iran National Museum. Finally, we are grateful to Aline Averbouh whose expertise has helped to improve this paper.

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