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Placing the transmission of technical knowledge in the system of blade production. A case study from the Early Neolithic flint mine of Casa Montero (Madrid, Spain)

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Abstract

Casa Montero has provided key information to understand the earliest Neolithic technical system of lithic production at the flint mine. This is a result of a complex network of seven different operational sequences. They were all successfully harmonised in order to allow the performance of other sequences. This organisational knowledge was a substantive part of the social capital of Early Neolithic communities and, as such, required of its inter-generational transmission.

Both the aging process and the continental nature of Casa Montero's flint limited the efficiency of blade production. As a result, most of the extracted raw material was discarded throughout the process. However, a resourcefully planned management allowed its reuse for other socially critical purposes such as learning how to knap.

The relation between blade production and the learning of knapping happens by impeding the competition between both sequences over raw material and by encouraging the apprentice´s motivation.

Keywords: Early Neolithic, Casa Montero, flint mining, knowledge transmission, blade production.

Résumé

Casa Montero a fourni des informations clés pour comprendre le premier système technique néolithique de production lithique au sein de la minière à silex. Le résultat est un réseau complexe de sept séquences opérationnelles différentes, qui ont toutes été harmonisées avec succès afin de permettre la réalisation d'autres séquences. Ce savoir organisationnel était une partie substantielle du capital social des communautés du Néolithique ancien et, en tant que tel, exigeait sa transmission intergénérationnelle.

Le processus de recristallisation du silex de Casa Montero et sa formation continentale ont limité l'efficacité de la production laminaire. En conséquence, la plupart de la matière première extraite a été rejetée tout au long du processus. Cependant, une gestion planifiée de manière efficace a permis de la réutiliser pour d'autres fins socialement critiques, tels que l'apprentissage de la taille.

La relation entre la production laminaire et l'apprentissage de la taille passe par éviter la concurrence entre les deux séquences opératoires basée sur la matière première et par l'encouragement de la motivation chez les apprentis.

Mots-clés : *Néolithique Ancien, Casa Montero, minière à silex, transmission des connaissances, production laminaire.*

1. INTRODUCTION

The work in a Neolithic flint mine is a complex phenomenon that implies a variety of factors, ranging from economic tasks to social interactions. One of the most interesting questions postulated by modern research, is how work among miners was managed and organised: whether they were under control of small specialised groups (BOSTYN & LANCHON, 1992, p. 221) or, on the contrary, it was a manifestation of communal effort in which all the members of a group or aggregation of groups worked together (DÍAZ-DEL-RÍO & CONSUEGRA, 2011, p. 228). Despite the fact that most European flint mines can, in general, present different forms of exploitation and management, throughout a spacious chronological period between the Neolithic and the Bronze Age, we can conclude that all of them are the result of collective work that could involve from small groups of people to much larger eventual aggregations.

The Neolithic exploitation of Casa Montero (Madrid, Spain) belongs to this last group. Recent investigations reveal that the work in this mine was carried out during different mining events that were produced by important concentrations of groups at a certain time (5400-5200 cal BC) and place (interior of the Iberian Peninsula), during which the density of the regional population was very low, and human groups relatively small and mobile (DÍAZ-DEL-RÍO & CONSUEGRA, 2011).

The concentration of people under such circumstances would require an efficient organisation and planning of tasks to avoid conflict. A mining event would include a series of processes, such as the extraction of the raw material, the management of the extracted flint, comprising both production and management of the residues that were generated, as well as the distribution of the final products. But furthermore,

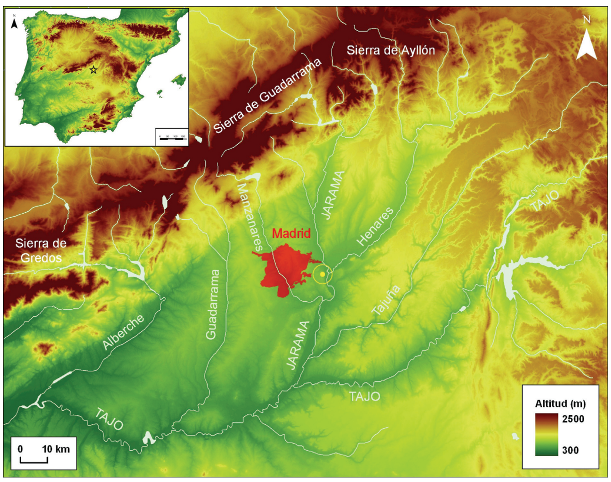

Fig. 1 – Location of Casa Montero Flint mine. © Casa Montero project (CONSUEGRA & DÍAZ-DEL-RÍO, 2015, p. 407, fig. 1).

other endeavours would take place, such as subsistence tasks and social or even symbolical interactions (CONSUEGRA *et al.*, 2018).

The objective of this paper is to analyse in which manner a social task, such as the transmission of knowledge of flint knapping to the next generation, was interrelated with the other tasks that were being carried out at the mine of Casa Montero, mainly the production of blades, which it competed against for the use of raw material. Both tasks had to be possible, compatible and simultaneously harmonic to guarantee the whole technical system and that the individuals in the phase of apprenticeship could be completely integrated within the group and the community.

2. Casa Montero: An Early Neolithic Flint Mine

Casa Montero was a flint mine located in the centre of the Iberian Peninsula, in one of the elevated moors next to the convergence of the Jarama and Henares rivers (Fig. 1). The region is well known for its abundance of siliceous material that was exploited since the Lower Palaeolithic. Until the discovery of Casa Montero in 2003, no Prehistoric flint-related mining or quarry works had been identified in the area, though some related to certain historical periods had been.

Furthermore, it was the first Neolithic flint mine to be confirmed and excavated in the Iberian Peninsula (CONSUEGRA *et al.*, 2004). Its discovery and further study bolstered investigation regarding Neolithic mining -until then represented by the works of La Venta (RAMOS MILLÁN *et al.*, 1997) and the variscite mines of Can Tintorer (Gavà, Spain) (for example CAMPRUBÍ *et al.*, 2003)- with the incorporation of new and interesting contributions (for example ODRIOZOLA & VILLALOBOS-GARCÍA, 2015; TARRIÑO *et al.*, 2014). The research project, carried out by the *Consejo Superior de Investigaciones Científicas* (CSIC) between 2006 and 2011, has contributed abundant information regarding a chronological period with almost no representation in the interior of the Iberian Peninsula.

Within the intervened sector of 4 ha, 3794 Neolithic flint mining shafts were documented (Fig. 2). These shafts were, in general, deep and narrow, dug in vertical piercing the three upper episodes of silification documented in the geological formation of the area. Presenting a circular shape, with certain variations of the section, these structures re-adapt to the disposition of the siliceous episodes affected by the collapse of lower evaporitic strata. They present an average diameter of 1.12 m and a depth that varies from 0.98 m to 9.26 m. The separation of the shafts located in a large concentration (CAPOTE *et al.*, 2008; CONSUEGRA *et al.*, 2004) varies from 1.38 m to scarcely a few centimetres (0.04 m), and in some occasions the entrances of some shafts are in direct contact.

The process of excavation of the shafts was perfectly organised to avoid possible accidents or collapses (CAPOTE *et al.*, 2008). After having excavated the structure and having extracted the flint, they were filled in with sediment, knapping waste and other elements, until they were refilled almost completely.

The refitting of artefacts that represent a minority in the general assemblage, such as ceramics and quartzite percussion tools, proves that groups of 6 to 22 shafts were opened at the same time, organised in different mining events (CAPOTE, 2011, p. 238). On the other hand, the chronology obtained by radiocarbon dating indicates that the exploitation of the mine barely lasted 100 years, between 5337 and 5218 cal BC at 1sigma (DÍAZ-DEL-RÍO & CONSUEGRA, 2011, p. 226).

These results are surprising if we take into consideration the scarce data related to the Neolithic in the Community of Madrid (DÍAZ-DEL-RÍO & CONSUEGRA, 2011, p. 228), which indicates that during this period the population consisted in small groups dispersed throughout the territory, whose economy was based on agriculture and pastoralism (DÍAZ-DEL-RIO *et al.*, 2011, p. 119). Therefore, to be able to carry out a task with the dimensions as the one documented at Casa Montero must have necessarily required an aggregation of different groups in the region that would have probably had to travel many kilometres to the mine.

In this context, the mine would not only secure the function of obtaining flint, but was also the place for other social interactions (DÍAZ-DEL-RÍO *et al.*, 2011). Some of the characteristics of the mining structures, as well as the documentation of other non-extractive activities and maintenance tasks at the mine, seem to indicate the participation of the totality of the group in the mining experience, including different groups of age and sex.

3. The role of mines and provisioning sources in the process of knapping apprenticeship

The reduction process of siliceous rocks is the result of the implementation of a complex network of know-how of diverse nature: abstract knowledge, mental images and motor experience (APEL, 2008, p. 99). Therefore, to learn how to knap requires more than just the correct and precise execution of gestures to extract rock fragments, including knowing how to manage the volume of the rock, abstractly fix the shape of the final product, anticipate shape changes with each removal (HOVERS, 2009, p. 12; NONAKA *et al.*, 2010, p. 157), plan the expected productivity and repair eventual errors or accidents that may occur during the knapping process. To obtain all this know-how it is necessary to include the apprenticeship of all the aspects of the *chaîne opératoire*: the obtaining and selection of the appropriate nodules (BARKAI & GOPHER, 2013, p. 130; STOUT, 2002, p. 696) in shape, size and quality; the management of the residues that are generated during knapping, recycling, reuse or reconfiguration; and, of course, the eventual hafting, use and maintenance of the final tool (BARKAI & GOPHER, 2013, p. 130).

An individual belonging to a Neolithic community would have been exposed to a phase of impregnation (for example BAMFORTH & FINLAY, 2008; NISHIAKI, 2013, p. 179), in which the person would have observed how different members of the group would have made and used different stone tools. Nonetheless, the person may not have always been in contact with the initial processes of the work that were carried out at the siliceous outcrops, quarries or mines. Furthermore, in the places of the final use of the lithic objects, there are no reserves of raw material with which one could practice the fabrication of a tool, since only the material that was going to be used, in general, was transported. Therefore, if the individual did not go to the place of extraction, all that part of know-how of the process would be foreign to that person.

Due to all these reasons, the sources of supply of lithic materials would be the ideal places to acquire the knowledge of the complete work process. In these areas, were raw material was abundant (for example AUDOUZE & CATTIN, 2011; MILNE, 2012, p. 119), the first phases of extraction and selection were carried out, and there were enough and appropriate resources to practice knapping techniques.

Furthermore, in general, these places were located at a certain distance from the living spaces, which adds the experience of the journey (MILNE, 2012, p. 120, 138-140), the better recognition of the territory that they frequent, and the estimate of the needs that may appear during the trip without the supporting resources that are offered by their usual settlement. In enclaves where collective work was carried out, such as in mines and, namely in Casa Montero (DÍAZ-DEL-RÍO & CONSUEGRA, 2011, p. 228), the apprenticeship of an individual also included meeting members of other groups and cooperating with them. Therefore, mines were

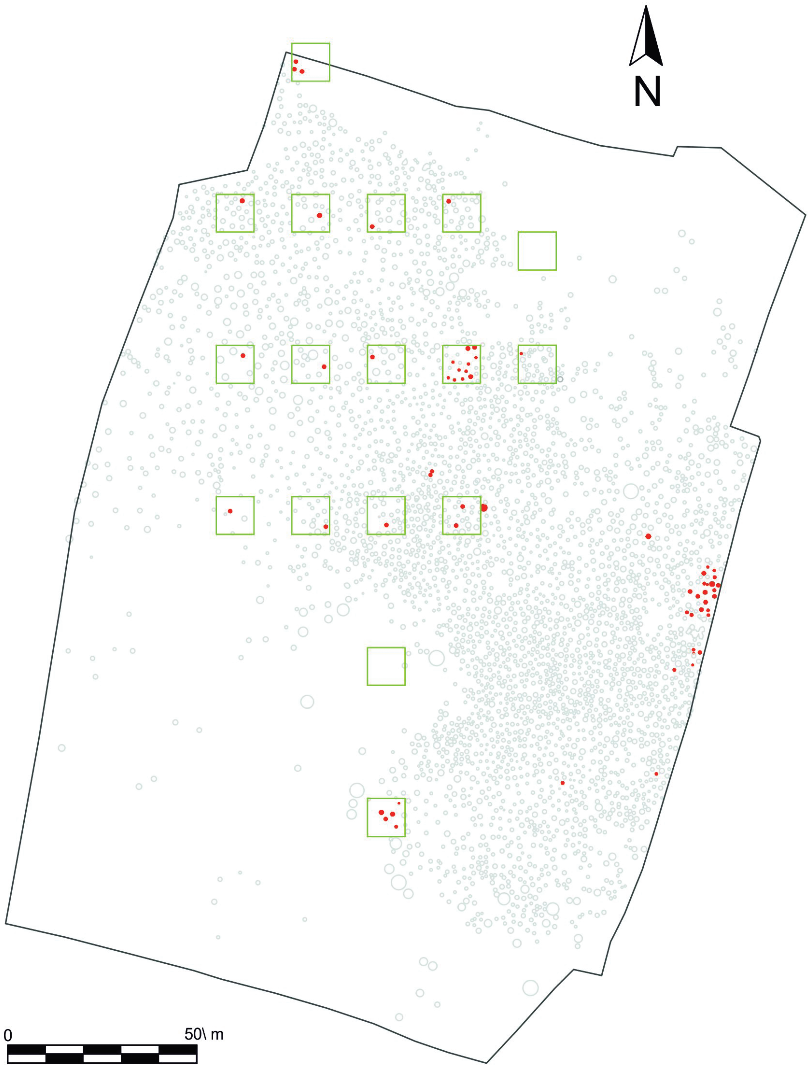

Fig. 2 – Casa Montero flint mine. The shafts analysed are coloured in red © Casa Montero project.

ideal places for technical, social and individual education that could be understood as part of an initiation for the youngest members.

The recent research carried out at Casa Montero has offered interesting results regarding the evidence of knapping apprenticeship that was carried out at the mine (CASTAÑEDA, 2018). Given the demographic parameters that are known for the Interior of the Iberian Peninsula during the Early Neolithic, being scarcely populated with a high dispersion of small, mobile groups, with a low life expectancy, we must understand that the transmission of knowledge had a critical importance to secure the continuity of the way of life of a group, including its own survival. Learning how to knap would be a transcendental task, as was extraction and production in a mine or quarry (CASTAÑEDA, 2018, p. 716). That is the reason for the importance of understanding the strategies that were used so that such activities were compatible and simultaneous.

4. The technical system of Casa Montero

Within the demographic and social-economical context that has been described, mining exploitation must be organised in such a manner that the flint supply would be eminently practical. Groups could not carry large volumes of material, and this may be the reason for carrying out the lithic reduction almost completely at the mine. With the objective of understanding the standards used for the management of siliceous resources on a technical and social level, the study of a significant assemblage of lithic remains recovered during the excavation has been carried out.

The analysed sample belongs to 62 mining shafts, and is composed of 168,000 lithic items, of which 2867 are cores, and 4565 discarded blades, being the largest collection of lithic elements belonging to the Peninsular Neolithic. The study has allowed the identification of Casa Montero as a large centre of blade production, unique to date. Its double nature, as a large-scale extraction and production centre, gives this site a unique character which hampers its comparison to other contexts from the same period. The main production at the mine was oriented to obtain blades for deferred use, such as sickles (CASTAÑEDA *et al.*, 2015). Blade products have a mean predetermined length of around 5 cm (Fig. 3). This means that, even though the size of the flint nodules of Casa Montero allows the extraction of longer blades, this length was previously and intentionally established. The predetermined length was obtained by using three strategies: the selection of large flakes used as blanks for cores, the orientation of this initial blank to locate the blade front on an axis of 5 cm, and the extraction of a tablet from the platform of the core to shorten it, if necessary, before starting the production (CASTAÑEDA *et al.*, 2015, p. 482-483).

This determination for obtaining a product with a specific dimension indicates that the products must comply to certain specifications regarding the moment of hafting or use, with the objective of facilitating a fast and simple replacement. Thus, it is a highly anticipated production that leaves very few traces or remains in other archaeological contexts such as habitats. The evidence that Casa Montero has provided are two sickle blades with diagonal hafting, scarcely documented in the Iberian Peninsula (IBAÑEZ *et al.*, 2008, p. 190).

Nonetheless, though the main objective at Casa Montero was the production of blades, a complex network of up to seven lithic operative sequences with different objectives was implemented there. All these sequences were harmonically organised to allow the correct functioning of each of them, working as if they were a set of gears. These operative sequences correspond to percussion elements (CAPOTE, 2011); the mining extraction; the production of large flakes; the production of tools from recycled blanks; the production of flakes for making tools; blade production (CASTAÑEDA, 2014, p. 313-314); and apprenticeship. Even though all these sequences are interrelated, this paper focuses on the relation between the last two. For this, it is important to consider apprenticeship as an operative sequence in itself, with its distinctive tasks, its specific phases, its own residues, its own execution times and, as we have seen, its appropriate places.

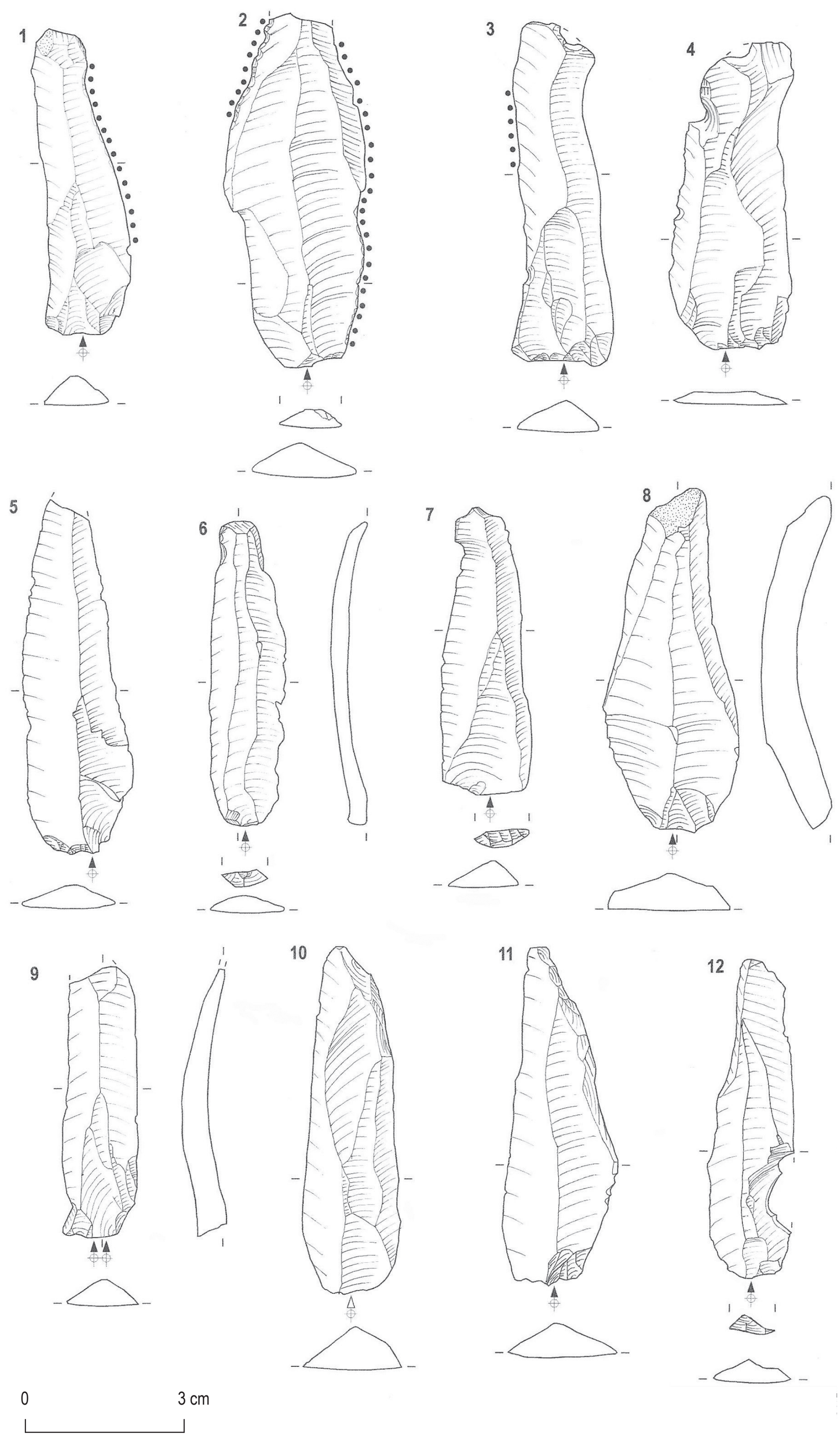

Fig. 3 – Discarded blade products. Drawings: Paco Fernández © Casa Montero project (DÍAZ-DEL-RÍO *et al.*, 2012, p. 467, fig. 10).

5. Apprenticeship at Casa Montero

As has been previously stated, an individual who had not visited the mine could not learn to make a sickle. The individual´s only contact with the final product would be through observation and participation in the harvest. Let the predetermination of the length of the blades products be an example to assess the complexity of the technical actions that would only take place in Casa Montero, and would seem alien to those who had not participated in the actions that happened at this site. As a blade production centre for deferred use, Casa Montero would hold almost the totality of all the know-how on the production of lithic elements. In consequence, this place site would act both as a production centre and disseminator of the technical knowledge regarding flint in all the community.

The apprenticeship that was carried out at the mine left evidences in the object of that apprenticeship: lithic products. Three levels of dexterity have been detected in Casa Montero blade production: expert, advanced apprentice, and novice (Castañeda, 2018, p. 721-729). The criteria used to identify these levels are based on the presence of two types of mistakes: in selection and in execution. The first type expresses the lack of experience regarding the selection of adequate blanks in size, quality and shape or percussion tools. On the other hand, the mistakes regarding execution indicate the inexperience in the gestures or the abstraction of the final product. Among the last group we can find knapping accidents; the excessive or insufficient convexity of the knapping surfaces; the inadequate location of the removals and parts of the core; and evidences of insistent percussion on edges or inadequate places of the core.

The analysis of the characteristics of the cores, once classified by skill levels, reveals that the most important aspect shared by both advanced apprentices and novices is the premature abandonment of the reduction process, mainly due to errors in selection and execution, being its correction impossible (Castañeda, 2018, p. 724-725).

The presences of many cores (18.30 %) abandoned by experts and advanced apprentices that could have continued been worked on, together with some very elaborate elements made on low quality raw material blanks, systematically discarded at the site, support the hypothesis regarding a guided learning by means of demonstrations that are later imitated by the apprentices (Castañeda, 2018, p. 725-726).

6. Blade making and transmitting knowledge

The way in which blade production and apprenticeship sequences relate each other at Casa Montero depends, at least, of two factors: the characteristics of the raw material and the learning in context.

Regarding the raw material, the flint from Casa Montero presents some distinctive characteristics (Bustillo *et al.*, 2009, p. 177, 193) if compared to the other abundant siliceous outcrops in the Madrid basin. Silicification was produced on magnesium smectites leading to the formation of opals and opaline flint. The different siliceous episodes were then affected by an aging process that lead to the inner re-crystallisation of the opaline nodules, transforming them into flint with high quartz contents (Bustillo *et al.*, 2009, p. 193-194). As a consequence of this process, up to three siliceous varieties with different levels of silicification and different knapping responses can occur within a Casa Montero nodule.

The groups of miners developed a selective strategy in which the opal and opaline flint outer parts of the nodules were systematically discarded at the beginning of the reduction process during the initial configuration, or by selecting initial blanks that did not contain these less silicified varieties (Castañeda *et al.*, 2015, p. 481). This strategy added to the heterogeneity of continental flint, led to the abandonment and discard of a high percentage of flint extracted from the shafts (99.81 % of the total mined weight; Castañeda, 2014, p. 321). This result indicates that the amount of raw material available for apprenticeship was limited, since this activity would require large amounts of stone. Therefore, to be able to carry out both activities simultaneously avoiding competition over flint, it is possible to think that the discarded material from blade production would be used for the operative sequence of apprenticeship.

To analyse the relation between the operative sequence of apprenticeship and it source of raw material, we have carried out a multiple correspondence analysis of 822 cores (Fig. 4). The variables used are the three identified skill levels (expert, advanced apprentice, novice); the predominant siliceous variety present in the blanks (opaline, recrystallised); the quality of the blank (heterogeneous, homogeneous, in relation with the presence/absence of geodes, veins or fissures), the origin of the blank (original, such as flakes and nodules, or recycled/reconfigured); and their size (extremely small for blade reduction or of the proper size). The first two obtained factors explain 40.81 % of the variance of the sample (F1: 21.35 %; F2: 19.46 %).

The results relate the three levels of dexterity with different qualities of the blanks that were used. Novices appear next to the most heterogeneous material. During this phase of apprenticeship, initiation to knap would be focused on acquiring the gestural practice. This phase consumes large amount of stone since inexpert strikes produce internal fissures on the core, and failed removals produce the destruction of appropriate surfaces and edges. The abandonment of these cores happens at an early stage (CASTAÑEDA, 2018). Therefore, novices would use the lowest quality raw material that would be discarded even during the phase of extraction from the shaft. Nevertheless, it is very hard to improve and continue learning more complex processes using this type of material.

Advanced apprentices are mainly related to opaline varieties of flint blanks, discarded in the initial configuration of blade cores. This variety of flint is more fragile than recrystallised flint, since its quartz content is lower (BUSTILLO *et al.*, 2009, p. 185). Therefore, it presents good attributes for learning how to manage the volume of the core and how to shape it, but not enough for the use of the final products. Furthermore, the use of this

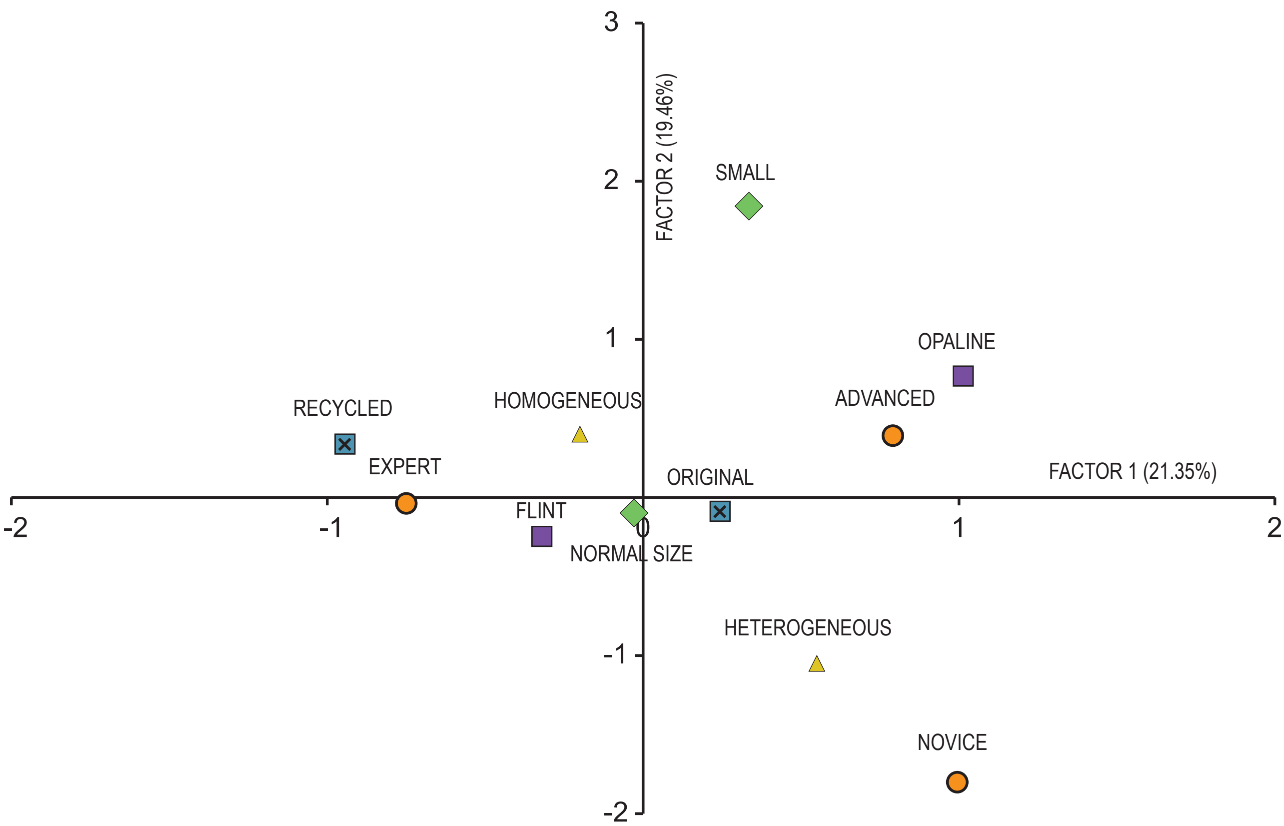

Fig. 4 – Multiple Correspondence Analyses between raw material selection and skill: factors 1 and 2.

material does not affect the productivity of blade production at the mine. In the same way, this skill level occasionally uses nodules that, due to their small size, cannot be complex shaped, but may have a better quality (Fig. 5).

Lastly, the cores made by experts are related to the best quality homogeneous blanks in recrystallised flint, which are also reconfigured for its maximum exploitation.

Taking into account these results, blade production and apprenticeship were possible and compatible, in the case of Casa Montero, thanks to the implement of an extraordinary strategy of raw material selection and management strategy of the raw material that consists in three core ideas (Fig. 6). Firstly, the selection of useless nodules, both the heterogeneous and extremely small ones; secondly, the recycling of opaline discards from blade production; and thirdly, the reconfiguration of cores that were productive and still preserve high quality flint. The first two principles contribute to avoid the competition with blade production over raw material. Nevertheless, the last one would be related with motivation (GRIMM, 2000, p. 64; STOUT, 2002, p. 694), since products made with good quality flint could be useful, which would allow the apprentice to advance in their learning.

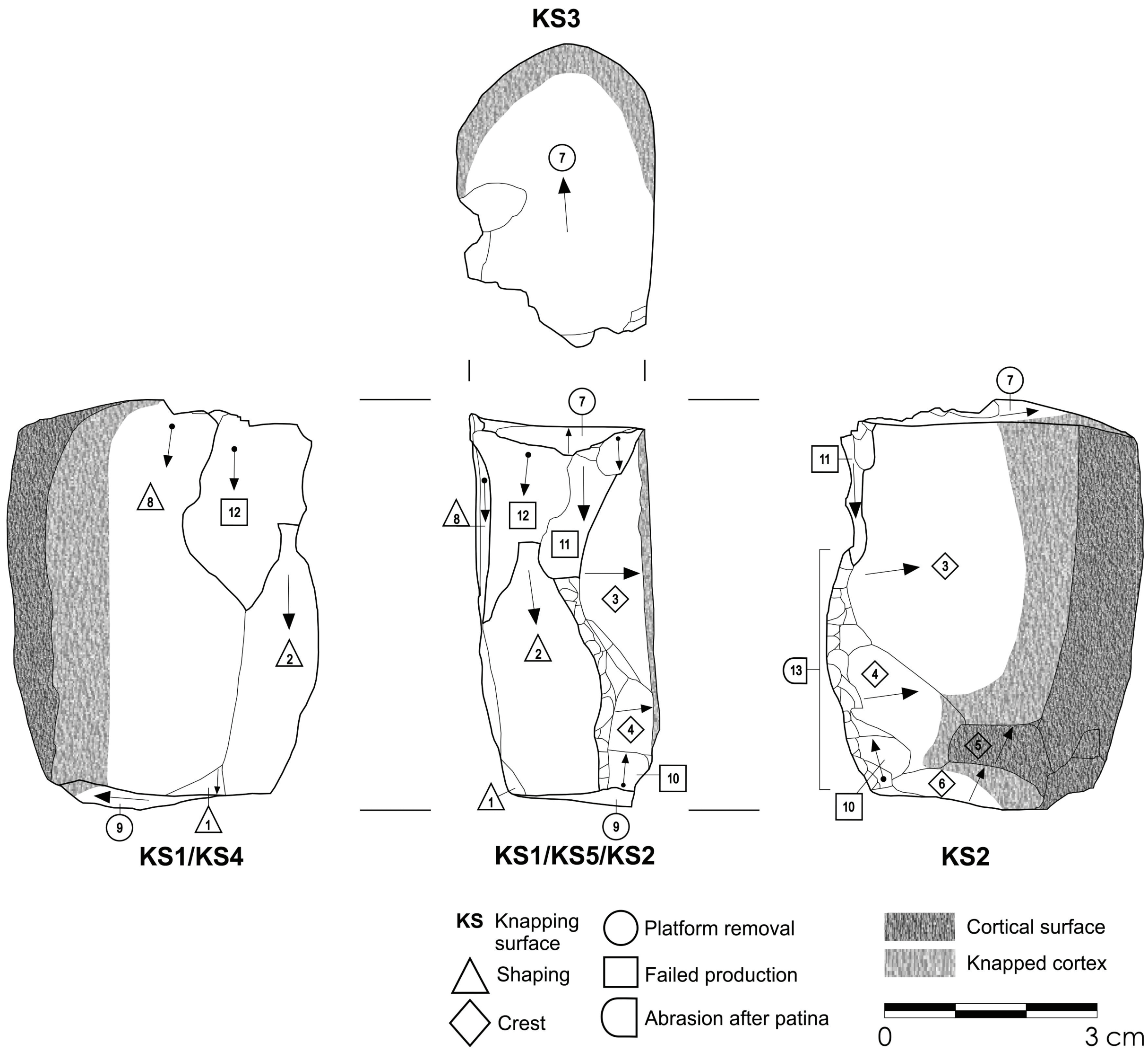

Fig. 5 – Example of a core elaborated by a beginner knapper. Number: 1600_389_3. Drawings: Paco Fernández © Casa Montero project.

According to learning in context theory, apprenticeship takes place whenever it is useful for the whole group, beyond the transmission of knowledge itself (BARKAI & GOPHER, 2013, p. 129; LAVE & WENGER, 1991, p. 110). The objects made by an apprentice cannot only stay at a level

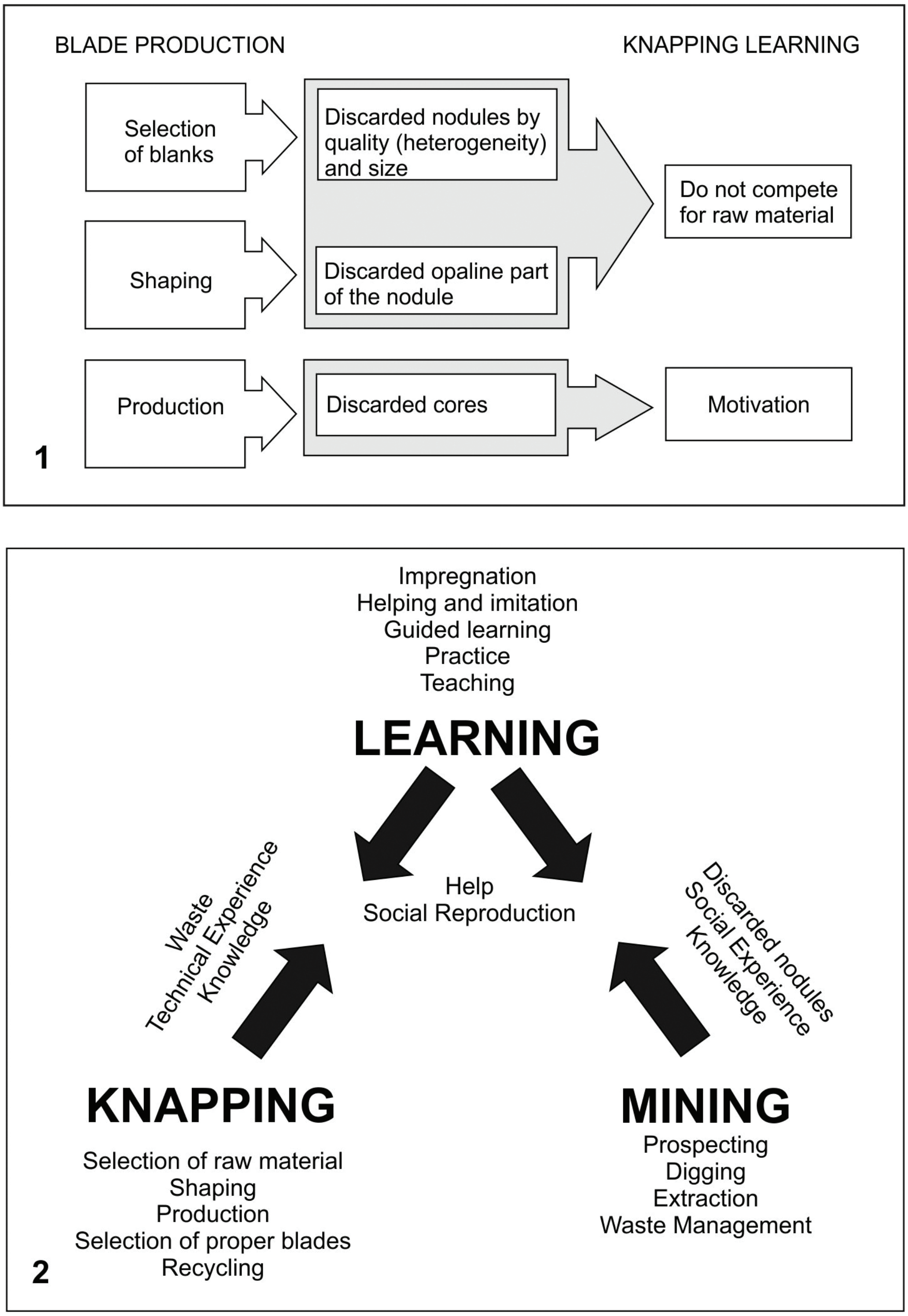

Fig. 6 – 1. Knapping learning raw material selection sources from blade production waste.
2. Relationship between mining, knapping and learning.

of pedagogical practice; rather they must be able to be used. The final use of an object works as a reward for the apprentices and reinforces their motivation for further learning. This would be a benefit that would allow social reproduction.

Therefore, the youngest members of the community would progressively be introduced into this complex technical system, participating in different tasks and phases of the complete productive process, from extraction to the recycling and management of waste. Mining offered them discarded raw material, social experiences and knowledge; blade production would give them large amounts of waste, technical experience and skill; while the participation of new generations would provide the community with a workforce and would allow social reproduction.

7. Conclusions

The analysis of the transmission of knowledge in Holocene chronologies in which the evolution of human cognition is not on the light-spot, allows us to study the phenomenon as an independent operative sequence around which human groups develop strategies *ad hoc* for the generational transmission of technological knowledge.

Mines, together with quarries and different knappable rock outcrops, can be favourable places for the identification of evidence regarding knapping apprenticeship (Audouze & Cattin, 2011), which in many occasions is given for granted and is not specifically studied.

Recent studies of the lithic assemblage from Casa Montero have provided knapping learning evidences (Castañeda, 2018). This apprenticeship, itself, can and must be considered as an operative sequence, in which different phases in the acquisition of knowledge that can be distinguished and that produce their own remains.

The operative sequence of learning at Casa Montero was not isolated. It conformed, together with another six interrelated operative sequences, the complex technical system that was performed at the mine. This paper has evaluated the interaction between the sequences of apprenticeship and blade production that was simultaneously carried out at the same place, using the same lithic resources.

The analysis has determined that its coexistence was possible thanks to the existence of a strategy that solved the two main problems: the restrictions of raw material and the necessity of motivation. In the first case, the use of discarded material from blade production as a raw material source for learning prevented the competition of both sequences over raw material. In the case of the second problem, the inclusion of younger individuals in production tasks as they learned, together with their progressive access to higher quality flint allowed for a better apprenticeship and their inclusion as members of the group.

New socio-economic context triggered by the first Neolithic traits and technologies created the conditions for the development of new political scenarios, a result of the renegotiation of previous collective social arrangements. At this point in time, Casa Montero acted as the arena for the transmission of technical knowledge, collective action and political negotiation among small autonomous social groups.

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