

New perspectives on recycling of lithic resources using refitting and spatial data

Neue Nachweismöglichkeiten der Wiederverwendung von lithischem Rohmaterial mittels Zusammensetzungen und räumlicher Verteilung

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ABSTRACT - Ethnographic data suggests that recycling of lithic resources could be a far-reaching process in the formation of archaeological assemblages. Reuse of previously discarded lithic artefacts was probably a common provisioning strategy, especially in Palaeolithic times. Nevertheless, recycling has received relatively little attention by researchers, since it is particularly difficult to identify in the archaeological record. Apart from the methods traditionally used to recognize the practice of recycling, refitting and spatial data can bring additional information about its importance in past human behavior. We present in this paper some examples from the Middle Palaeolithic layers of the Abric Romaní site (Capellades, Spain). Attention will be focused on levels J and L – dated to 50-52 kyr BP by U-series –, in which recycling has been inferred from artefact transport and differential scattering of artefacts from single reduction sequences. We finally discuss the factors that can explain recycling and the temporal dimension of recycling in the formation process of lithic assemblages.

ZUSAMMENFASSUNG - Ethnohistorische Daten legen nahe, dass die Wiederverwendung lithischen Materials bedeutenden Einfluss auf die Entstehung archäologischer Inventare gehabt haben kann. Die erneute Nutzung weggeworfener Steinartefakte war im Paläolithikum wahrscheinlich eine gängige Strategie, um sich mit Rohmaterial zu versorgen. Trotzdem ist das Thema „Recycling“ in der Forschung kaum beachtet worden, da der Vorgang im archäologischen Material nur schwer zu erkennen ist. Neben der traditionellen Vorgehensweise beim Erkennen von Materialrecycling können durch Zusammenpassungen und Raumanalysen zusätzliche Hinweise auf seine Bedeutung im menschlichen Verhalten gewonnen werden. Im vorliegenden Beitrag werden einige Beispiele aus mittelpaläolithischen Schichten des Abric Romaní (Capellades, Spanien) vorgestellt. Untersucht werden die Fundschichten J und L, die durch Uran-Seriendatierungen auf 50-52 kyr BP datiert werden können. Hier kann durch den Artefakttransport und die variierende räumliche Verteilung von Artefakten aus einzelnen Abbauprozessen die Wiederverwendung von Steinartefakten erkannt werden. Faktoren die als Ursache für Recycling und seine zeitliche Dimension für den Entstehungsprozess von Inventaren werden zusammenfassend diskutiert.

KEYWORDS - lithic provisioning, raw material, spatial analysis, Middle Palaeolithic, Abric Romaní
Steinmaterial-Versorgung, Rohmaterial, Raumverteilung, Mittelpaläolithikum, Abric Romaní

Introduction

Among the processes at work in the formation of lithic assemblages, recycling poses some particularly complex interpretive challenges. Nevertheless, recycling has received relatively little attention in technological studies, perhaps due to the difficulties related to identifying recycling episodes in lithic assemblages. Because of the analytical problems surrounding the concept, it has even been suggested that recycling is not a useful tool for interpreting the archaeological record. "Since I have virtually exhausted the logical ways that recycling can be measured and have failed to find one that works, I conclude that we would be better off acknowledging the concept but working on something else" (Odell 1996: 59).

However, it is important to recognize that recycling may play a relevant role in various aspects related to the interpretation of archaeological evidence. Recycling is a potential factor in the variability of lithic assemblages and may be particularly significant in characterizing the technological and economic behavior of human groups. Since that behavior partly depends on settlement patterns, recycling may also provide insight into issues like mobility or site function. It may also be of interest for questions related to the formal design of artefacts, especially with regard to factors such as composite or multifunctional tools and their cognitive or economic implications. Furthermore, the cultural characterization of assemblages can also be affected by the recycling of artefacts from different cultural horizons.

In fact, some researchers have indicated that recycling was probably a more common provisioning

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strategy in prehistoric times than the scarce archaeological evidence suggests (Amick 2007; Galup 2007). Although there are relatively few ethnoarchaeological studies on lithic production in current traditional societies, some ethnographic data indicates that the scavenging of artefacts encountered on exposed surfaces is not uncommon among some hunter-gatherer groups (see references in Amick 2007: 225-226 and Camilli & Ebert 1992: 118). According to Binford (1977), the recycling of worn out items was perfectly integrated in the technological organization of the Nunamiut: "The Nunamiut are a classic case of a system in which the technology is highly organized curatorially, and is frequently characterized by recycling." (Binford 1977: 34). Moreover, the recycling potential of some items may be a primary concern in refuse disposal strategies. The Inupiat Eskimo place items with a potential future use close to their household areas and only remove them to the refuse midden when they are considered to be non-recyclable (Chang 1991). Potential value is also a major concern of the secondary refuse disposal behavior in the Maya Highlands (Hayden & Cannon 1983). Potentially recyclable objects go through several stages of discard and are placed in provisional refuse areas, where they are kept for varying lengths of time depending on their recycling possibilities.

It seems clear that the concept of recycling is employed to designate a form of reuse, but there is no general consensus among researchers about the precise meaning of the term. The seminal work of Michael B. Schiffer treats the main terminological issues that we are discussing today. Through several publications, Schiffer distinguished different varieties of reuse: recycling, secondary use, lateral cycling, and conservatory processes. Recycling corresponded to the process of remanufacturing a used item into a new item. Secondary use was defined as the employment of an unmodified item in an activity different to that it was previously used for. Lateral cycling designated the transfer from one user to another, without changes in form or use. Finally, conservatory processes were considered a specialized form of secondary use and consisted of a change in the use of an object such that preservation was intended (Schiffer 1972, 1976, 1977; Schiffer et al. 1981).

However, these are ethnoarchaeologically-derived concepts and some of them may be difficult to identify in archaeological contexts. This is particularly true in the case of lateral cycling, since the distinction between different individual actors normally goes beyond the scope of archaeological inquiry. Nevertheless, some examples are emerging from the use of refitting and spatial data in conjunction with technological analysis. For instance, Almeida (2008) pointed out that some blocks were shared between different individuals during the knapping process in the Late Gravettian occupation of the Lagar Velho rock-shelter. The use of the terms recycling and

secondary use in the field of archaeology seems more feasible, although this distinction is not always applied and both phenomena tend to be called recycling. This may be due to the fact that reuse is easier to identify when some kind of modification took place (Camilli & Ebert 1992: 120) and, therefore, most of the available examples of reuse correspond to recycling in Schiffer's sense. Modification is essential in the characterization proposed by Amick (2007: 223), who distinguishes between two kinds of recycling: 1) lateral recycling, which designates the use of a tool either as a core for flake production or as a blank for creating a different tool, and 2) secondary recycling, which corresponds to the scavenging of lithics from the archaeological record to be reused, reworked or used as cores. According to Camilli and Ebert (1992), the function of the reused/recycled artefact is the main criterion. They use the term *recycling* when the function of the secondary use of the artefact is different to the original one, and prefer the term *reuse* when the original function is maintained in the secondary use.

Amick's definition highlights a very important issue in recycling studies: the temporal dimension of recycling. This is even more explicit in the distinction made by Baker (2007) between short-term and long-term recycling, which is based on the length of the time span between the use events. Short-term recycling occurs within an individual lifetime, by the individual that carried out the first use event or another individual of the same group. Long-term recycling occurs after a more or less extended period from the first use and probably by a different individual or even a different group. This temporal difference also has important behavioral implications. In the short-term, recycling is a facet of the technological behavior of the first user, who may be conscious of the recycling potential of the object and anticipate the recycling event. Consequently, the potentially usable artefacts may be placed in particular locations in order to be easily located when needed. Specific disposal areas for recyclable materials may be expected in this context. On the other hand, primary and secondary usages are entirely independent events in long-term recycling, and the behavior of the first user is therefore not conditioned by the potential future use of the artefacts.

From a conceptual point of view, a clear distinction should be made between recycling and other behaviors, like resharpening, commonly found in curated technologies. The purported association between recycling and curation (McAnany 1988) deserves further attention. The recycling of tools was considered by Bamforth (1986) as one aspect of lithic curation, in addition to maintenance, transport, design for multiple purposes, and production in advance. Although both recycling and rejuvenation may be sometimes explained by similar factors associated with the scarcity of lithic resources, they are very different phenomena and therefore have different archaeo-

logical implications. Several studies on recycling have suggested that it would be more likely to occur in contexts characterized by a relative scarcity of raw materials and, consequently, a need to maximize the profitability of lithic resources (Dibble & Rolland 1992; Close 1996; Amick 2007; Galup 2007; Hiscock 2009). It should be stressed that raw material scarcity is only one of the factors that may explain the appearance of curated technologies. Curation may be also caused by mobility patterns, time stress or the need to increase the efficiency and reliability of tools. Nevertheless, the curation concept has been subject of debate since the original proposal of Binford (1979). There is actually a huge bibliography on the definition and explanation of curation (see, for instance, Nash 1996; Odell 1996; Shott 1996; Andrefsky Jr. 2008). In this sense, recycling would be expected in curated technologies. However, it can also appear in expedient contexts, as a way to quickly solve immediate needs. Therefore, recycling should not necessarily be associated solely with curated contexts.

However, as Baker (2007) points out, the primary difference between recycling and curation lies in the previously discarded character of the recycled items. In curated technologies, the purpose of resharpening is to extend the use-life of artefacts. As the artefacts become worn out, they are rejuvenated in order to maintain their utility, but there is no prior period of abandonment. A phase in which the item has been discarded between the different use events can be considered as one of the defining characteristics of recycling. Recycling is not an extension of the use-life of the artefact, but the beginning of a secondary use-life after the first one has ended. These two use-lives are normally separated by a temporal gap of variable length during which the artefacts are considered refuse. This disposal period may be very short, perhaps only a few minutes. For example, an exhausted core may be recycled into a tool immediately after the end of the reduction sequence, but the important point is that it was previously discarded as a core. The length of the discard phase may be an important component of identifying recycling events, especially if in the course of this period the items underwent some kind of modification, either in their physical attributes (e.g., patina, abrasion, fire damage) or in their location (e.g., movements caused by post-depositional processes).

From this perspective, recycling is one of the best expressions of the temporal nature of archaeological assemblages. These assemblages are the outcome of a cumulative process characterized by the successive addition of material remains from multiple activity events. Various natural and cultural formation processes contribute to the formation and modification of these palimpsests, whose temporal depth depends on sedimentary rhythms specific to each location (Brochier 1999). These geological processes also condition the time during which the items are

exposed on the surface, although certain cultural processes, like reoccupation and trampling, can play a significant role. As exposure time increases, recycling – particularly long-term recycling – becomes more likely, regardless of economic or raw material constraints (Camilli 1988; Camilli & Ebert 1992). These time-dependent processes are also important in assemblage variability, since the characteristics and constraints of the activity events may vary over time. As formation length increases, the likelihood that different activities will be carried out at the site also increases, including some uncommon ones. Archaeological assemblages are therefore not homogeneous entities that can be explained as a whole, but mixed bags formed by the aggregation of remains from different functional, behavioral or even cultural contexts. Recycling cannot be separated from the temporal issues related to the formation of archaeological assemblages, since it is essentially a temporal phenomenon.

How to identify recycling in archaeological assemblages

Different kinds of evidence have been used by archaeologists to identify recycling in the material record. Some can be considered indirect evidence, as it may appear as a consequence of recycling. Although not necessarily explained by recycling, these features can be considered heuristic devices, making the possibility of recycling worth exploring. For example, it has been suggested that bipolar knapping would be a good measure of lithic recycling, since this reduction strategy is particularly suited to the exploitation of small blanks (Kelly 1988; Hiscock 2009). However, the exploitation of small cores is not necessarily associated with recycling, but may be caused by other factors like nodule size or raw material economy. Bipolar reduction cannot therefore be equated to recycling (Amick 2007), but may be common when recycling is focused on the exploitation of small blanks.

Attributes indicating that a single artefact fulfilled different functions can be also considered as evidence of recycling. Some examples would be the use of artefacts as both hammerstones and cores, both cores and tools, both hammerstones and hearth rocks, etc. However, in order to interpret these artefacts as evidence of recycling, it is important to have some clue about the temporal relationship between these different uses. The alternating use of an artefact for different functions cannot be characterized as recycling. Rather, this would only be evidence of the versatile or multifunctional nature of some objects. To be qualified as recycling, the different uses would have to follow one another in a chronological sequence. A particularly interesting case within this context is that of composite tools, which are notably common in some techno-complexes. These tools may

be designed as composite objects from the start, but they may be also the product of the successive addition of new functions once the original purpose was completed. The latter can be considered as recycling, but not the former. Data about the timing of the sharpening process must be found in order to make that distinction.

Chrono-cultural arguments can be also used to identify recycling. The identification of artefacts indicative of earlier cultural periods in a lithic assemblage may be explained by the scavenging of lithic resources from older archaeological deposits (McDonald 1991). For example, this would be the case of the mid-Holocene assemblage of the Cedar Creek site, which contained some projectile points from Early Holocene cultural horizons (Amick 2007). Some archaic artefacts – handaxes, cleavers, sidescrapers – found in the Lower Magdalenian of Las Caldas suggested recycling of Acheulian tools in Upper Palaeolithic times (Corchón 1993). In this assemblage, the presence of double patina on some of these artefacts strengthens this hypothesis. Nevertheless, in other cases it is difficult to exclude more parsimonious explanations, like post-depositional mixing or the formation of palimpsests due to low sedimentary rates.

The most reliable examples of recycling correspond to those artefacts whose surface was chemically or mechanically altered before the recycling event, indicating a more or less prolonged temporal gap between the two use-stages. Some raw materials that are more susceptible to surface damage are particularly suitable for this approach, while others are more resistant to alteration agents and therefore do not yield much information. For example, the hydration process affecting obsidian artefacts that absorb water when exposed to air forms an alteration rind whose thickness increases with age (Michels 1969). The presence of hydration rinds of different thicknesses on a single artefact is therefore a good indication of recycling and facilitates its identification in assemblages in which obsidian is a common raw material, like in certain areas of North America (Amick 2007). Another common piece of evidence pointing to recycling is a double patina on flint items, in which the secondary modifications can be clearly differentiated from the older patinated surface. The formation of patina on flint implements depends on different factors such as soil chemistry, temperature and flint microstructure, but is particularly common on artefacts exposed to the elements, especially in hot climates with broad temperature ranges (Rottländer 1975). Both hydration bands and patina need considerable time to form and are perhaps the best criteria for identifying long-term recycling. For example, double patina is the most common criterion for identifying recycling in Palaeolithic assemblages (cf. Barkai et al. 2009: 66; Debenath 1992: 55; Galili & Weinstein-Evron 1985: 40; Mora et al. 2004: 428; Navazo & Díez 2008: 136;

Nishiaki 1985: 221-222).

Other evidence of recycling can be provided by burnt artefacts, especially when the fire damage can be determined as unintentional and occurring after disposal. Fire exposure changes the mechanical properties and appearance of lithic materials. Thermal damage is especially evident in fine-grained rocks, like flint, which shows different types of macroscopic modifications – color changes, potlid fractures, fragmentation, and crazing (Olausson & Larsson 1982; Purdy & Brooks 1971; Sergant et al. 2006) – depending on temperature and exposure time. Experimental studies indicate that heat damage appears at only around 300 °C in artefacts that come into direct contact with fire (Sergant et al. 2006). Thermal alteration allows two temporal stages to be distinguished: pre-heat damage and post-heat damage. Modifications made after fire exposure are macroscopically identifiable due to the greasy luster on surfaces flaked subsequent to heat damage. Artefacts showing such lustrous flake scars might be interpreted as the result of recycling. The main analytical problem is how to differentiate the items burnt after disposal from those intentionally exposed to fire in order to improve their flaking qualities. This problem might explain why the contribution of burnt artefacts to the discussion on recycling remains an unexplored line of research.

However, artefact attribute analysis is not the only way to gain insight into recycling behaviors, and in this paper we focus on a different type of data, those derived from refitting and spatial analyses. These data are useful in looking at recycling behaviors because of their ability to temporalize the archaeological record, that is, to define time relations between artefacts or artefact assemblages. Refits are especially informative regarding the temporal relationships between different activity areas. Although lithic connections through refits have sometimes been considered as evidence of contemporaneity, it now seems clear that only bidirectional connections can be used to argue that two activity areas or clusters of remains were contemporaneous. Due to the potential recycling of lithic remains, unidirectional connections cannot be used to support contemporaneity (Larson & Ingbar 1992; Rapson & Todd 1992). On the contrary, a unidirectional pattern may be the result of recycling and can therefore provide a good argument in favor of a temporal gap of unknown length between the formations of the two accumulations (Close 1996). Maybe there was simply a temporal gap of some minutes, or weeks, or years. We don't know and perhaps we will not be able to know it with our current methods. A unidirectional refit pattern suggests a sense of time that allows distinguishing between what happened prior and what happened after the artefact movement. Only the correlation of refits with other data, like artefact surface damage or degree of scattering, may suggest relatively long time gaps.

The most compelling information is achieved when refits are combined with data from lithic scatters. We use the Raw Material unit as starting point. A Raw Material Unit (RMU) incorporates the artefacts produced during the reduction of a single nodule (Roebroeks 1988) and is defined by the macroscopic characteristics of the raw material. This procedure, also known as minimum analytical nodule analysis (Odell 2004: 93-95), is especially useful in assemblages with lithics of variable appearance. Although they come from the same nodule, the artefacts forming an RMU do not necessarily correspond to the same technical event, since different reduction or retouch episodes can be carried out at different times and places on the artefacts detached from a single nodule. In the Abric Romaní, the reliability of the RMUs distinguished by their macroscopic features was corroborated by refits in most cases. The spatial distribution of the lithic remains from a single Raw Material Unit is largely determined by the length of time those artefacts remained exposed on the surface. From this perspective, the scattering of RMUs is also important in studying the temporal dynamics in the formation of the lithic assemblage. The degree of dispersion of the artefacts resulting from a knapping episode depends on its temporal location in the sequence of technical events forming the lithic assemblage (Stevenson 1985 & 1991). Earlier episodes tend to be more widely scattered, since they would have been more affected by intentional and unintentional dispersion factors associated with human occupation. As knapping events approach the latest phases of occupation, their lithic scatters are less subject to these dispersion processes and they therefore tend to be more clustered. The potential of this approach as a source of information about recycling is magnified when successive reduction stages of the same RMU exhibit different degrees of dispersion, as this suggests that they correspond to different time periods in the formation of the archaeological assemblage.

Recycling of lithic resources in the Middle Palaeolithic assemblages of Abric Romaní

I will present in this paper some examples of recycling from the Middle Palaeolithic assemblages of Abric Romaní (Capellades, Barcelona), a rock-shelter site located on the Northeastern Iberian Peninsula. This site was discovered in 1909 by Amador Romaní and was excavated at different times throughout the 20th century. Current research at the site started in 1983 and is based on the excavations of large surface areas in order to construct a spatial interpretation of the archaeological record. The Mousterian sequence has been U-series dated at between 40 and 70 kyr BP. Thirteen Middle Palaeolithic layers (from level B to O) have been excavated so far, although only from level H downwards was the surface area large enough to make

a spatial analysis feasible. Natural formation processes are particularly favorable for studies on spatial organization. The 20 m-thick stratigraphy is made up of different sedimentary facies, but tufas are dominant. The archaeological levels are thin layers separated by thick and sterile tufa deposits, which create a clear vertical separation of the human occupation horizons. This is particularly important from the point of view of spatial analysis, because it limits the amount of occupation events overlapping in the same layer and, therefore, the formation of palimpsests. In addition, the thermal impacts and combustion structures in these calcareous sediments are well preserved, making them easier to document than in other sedimentary contexts (Courty et al. in press; Vallverdú et al. in press), and a large number of hearths have been identified in all the archaeological layers.

Hearths played a central role in spatial organization. The spatial distribution of bone and lithic remains indicates that most activities were carried out around hearths, which produces a spatial pattern characterized by well-defined hearth-related accumulations (Vaquero & Pastó 2001). In most layers, this formation dynamic produces a discrete distribution pattern, similar to that documented in modern hunter-gatherer campsites. The focus of activities in hearth-related areas has been confirmed by bone and lithic refits (Vaquero et al. 2007), which are fairly abundant and corroborate the good spatial preservation of activity areas.

Recycling evidence should be analyzed in the context of raw material provisioning strategies. Flint is the dominant raw material in all the archaeological layers, although it is extremely rare in the immediate surroundings of the site. Quartz and limestone are the most common raw materials within a 5 km radius. The use of these materials is variable throughout the archaeological sequence, but they are always present in lower percentages than flint. Flint-bearing primary outcrops correspond to the Tertiary formations of the Ebro basin, like the Valldeperes formation (20 km from the site), the St. Martí de Tous formation (15 km), and the Montmaneu formation (25 km). In addition, flint nodules also appear in a secondary position in the river terraces and other colluvial formations located in an area ranging between 5 and 25 km from the site.

As far as the identifying criteria are concerned, two varieties of recycling have been documented at Abric Romaní. The first one has been identified by attribute analysis and corresponds to artefacts that show evidence of a secondary use for a function different from the original purpose. Two main examples have been recorded so far: 1) limestone cobbles first used as percussors that were transformed into cores for flake production, and 2) cores used as blanks for the manufacture of tools. The former can be seen in some cores with percussion marks on their cortical surfaces.

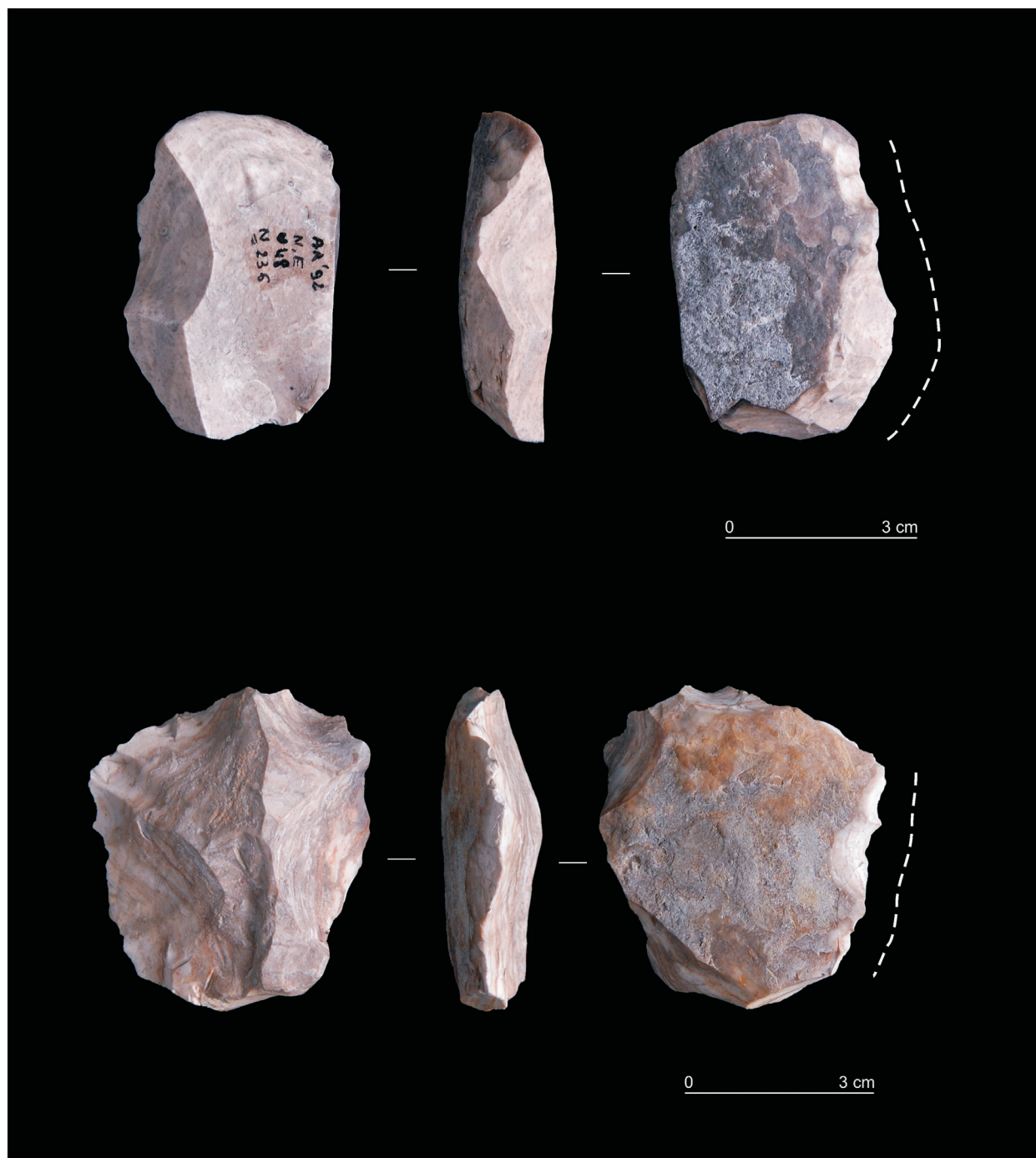


Fig. 1. Cores from level E of Abric Romani that were recycled as tools. The broken line indicates the edge affected by retouch.

Abb. 1. Kerne aus der Schicht E des Abric Romani die als Werkzeuge wieder verwendet wurden. Die gestrichelte Linie markiert die Kante die retuschiert wurde.

The latter is documented in some flint cores that exhibit a side retouched posterior to the end of the reduction sequence. Two examples from level E can be seen in Figure 1. In these cases, recycling is inferred from the combination of two different functions on the same artefact, but the temporal gap between the two use events is unknown. Only the few artefacts showing a double patina can be linked to long-term recycling.

However, this paper focuses on the second type of recycling, which has been inferred from spatial and

refitting data. Besides a secondary use, artefact movement is the main criterion used to recognize these recycling events. This data has allowed the following kinds of recycling to be identified:

- a) Fragments of broken limestone hammerstones that were reused as percussors.
- b) Sequences that show different and spatially-segregated reduction stages, suggesting the exploitation of previously discarded blanks or cores.
- c) Flakes scavenged from older lithic scatters and transported to other activity areas.

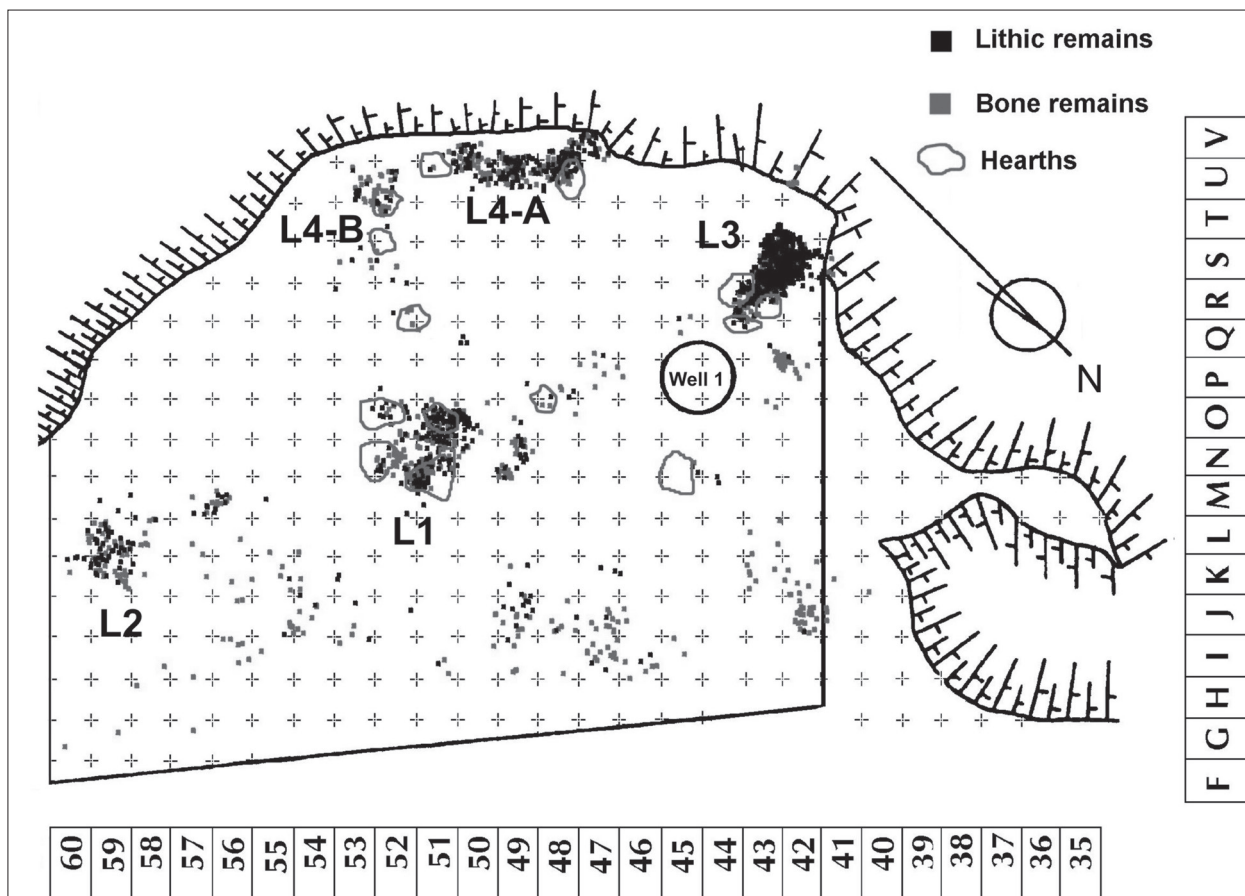


Fig. 2. Spatial distribution of lithic and bone remains in level L of Abric Romani, indicating the main accumulations discussed in the text.

Abb. 2. Räumliche Verteilung von Steinartefakten und Knochen in Schicht L des Abric Romani, mit den im Text besprochenen großen Fundstreuungen.

These recycling events will be illustrated through the data from two archaeological layers, levels L (ca. 52 kyr BP) and J (ca. 50 kyr BP). These units show different spatial distribution patterns. Level L exhibits a discrete pattern, characterized by well-defined hearth-related accumulations, while the remains are more continuously distributed in level J due to the overlapping of different activity areas. Two main archaeological horizons (sublevels Ja and Jb) separated by a sterile layer were distinguished in some areas of level J.

Four main clusters of remains have been differentiated in level L (Fig. 2): L1 (squares N-O/50-51), located in the middle of the rock-shelter and associated with a complex combustion area; L2 (squares K-L/59), which is the smallest cluster; L3 (squares R-T/42-44), which is located close to the shelter wall and yielded the largest archaeological assemblage, especially as far as lithic remains are concerned (48% of all lithic remains found in level L were concentrated in this accumulation); and L4, also located near the rock-shelter wall and showing two subclusters, the largest one (L4-A) in squares U-V/48-51 and the other (L4-B) in squares T-U/52-53 (Vaquero 2005 & 2008). The characteristics of the lithic assemblages from each of these clusters have interesting differences, especially comparing L3

with the other accumulations. In L3, the introduction of unworked flint nodules played an important role in the formation of the lithic assemblage and all the stages of the reduction sequences are therefore well represented. On the other hand, the other accumulations tend to be associated with resources introduced at an advanced stage in the *chaîne opératoire*. The introduction of partially reduced flint cores is well documented and several Raw Material Units (RMUs) correspond to very short sequences that only yielded a few flakes.

Understanding the temporal relationship between these accumulations is fundamental in ascertaining the recycling processes of lithic resources. The refitting pattern is presented in Figure 3. Most refits are inside the clusters and are particularly abundant in L3. However, there are also some inter-cluster connections that can be used to discuss temporal patterns. We have found seven inter-cluster refits, three of which connect accumulations L3 and L4-A. There are also links between L3 and L4-B, L2 and L4-A, L1 and L2, and L1 and L3. The refit between L2 and L4-A features the longest connection line (1219 cm). All the inter-cluster connections can be attributed to the intentional transport of artefacts, since there is not a generalized dispersion of the lithic

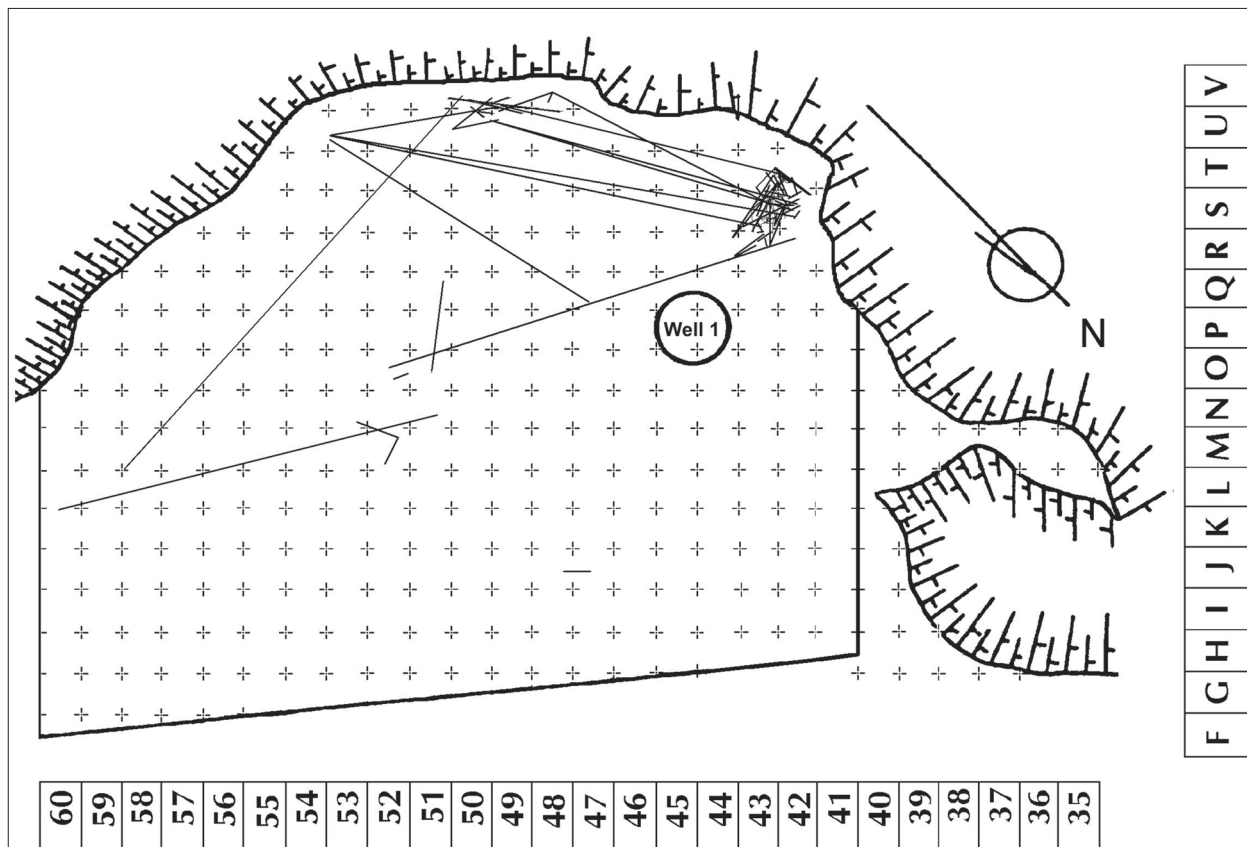


Fig. 3. Spatial distribution of connection lines in level L.

Abb. 3. Räumliche Verteilung der Verbindungslinien in Schicht L.

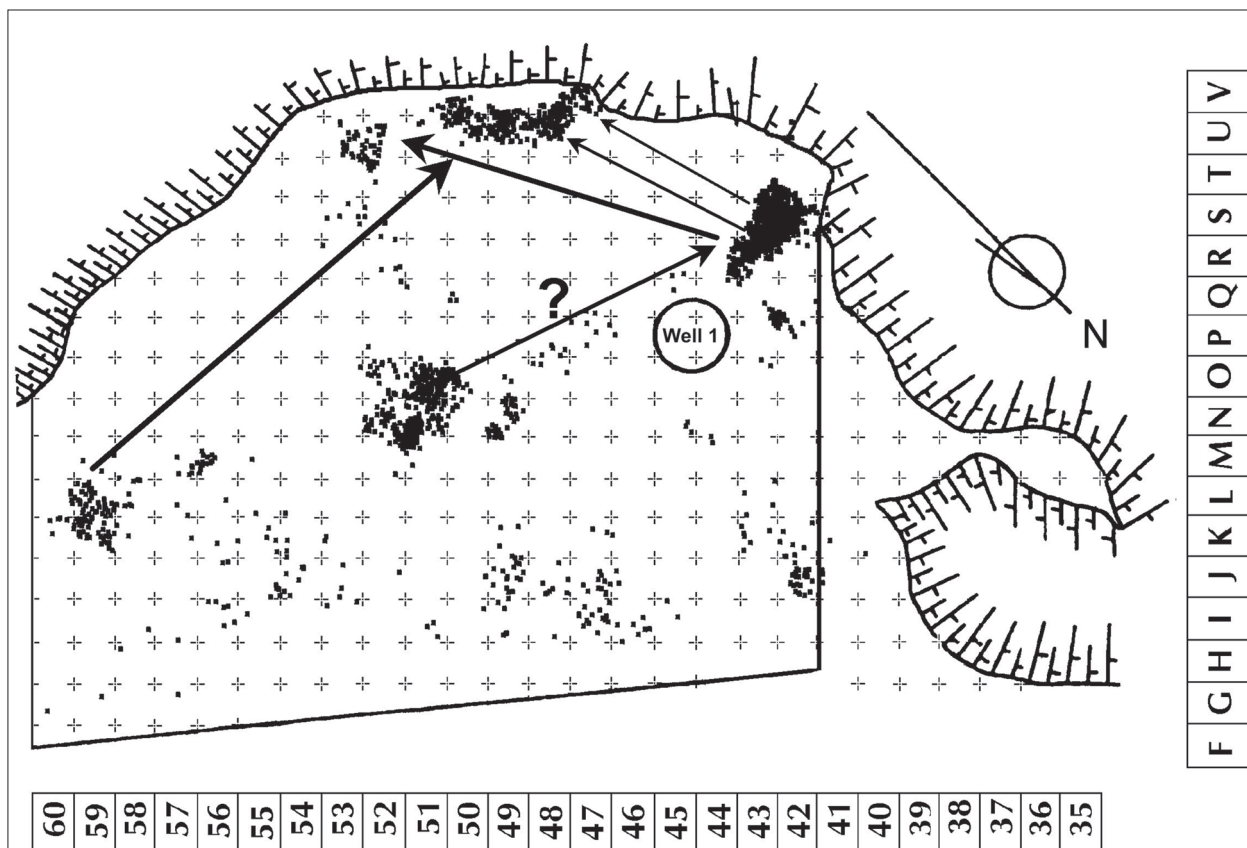


Fig. 4. Direction of the transport events documented between the different accumulations of level L.

Abb. 4. Die Richtung der Transportvorgänge zwischen den verschiedenen Fundstreuungen der Schicht L.

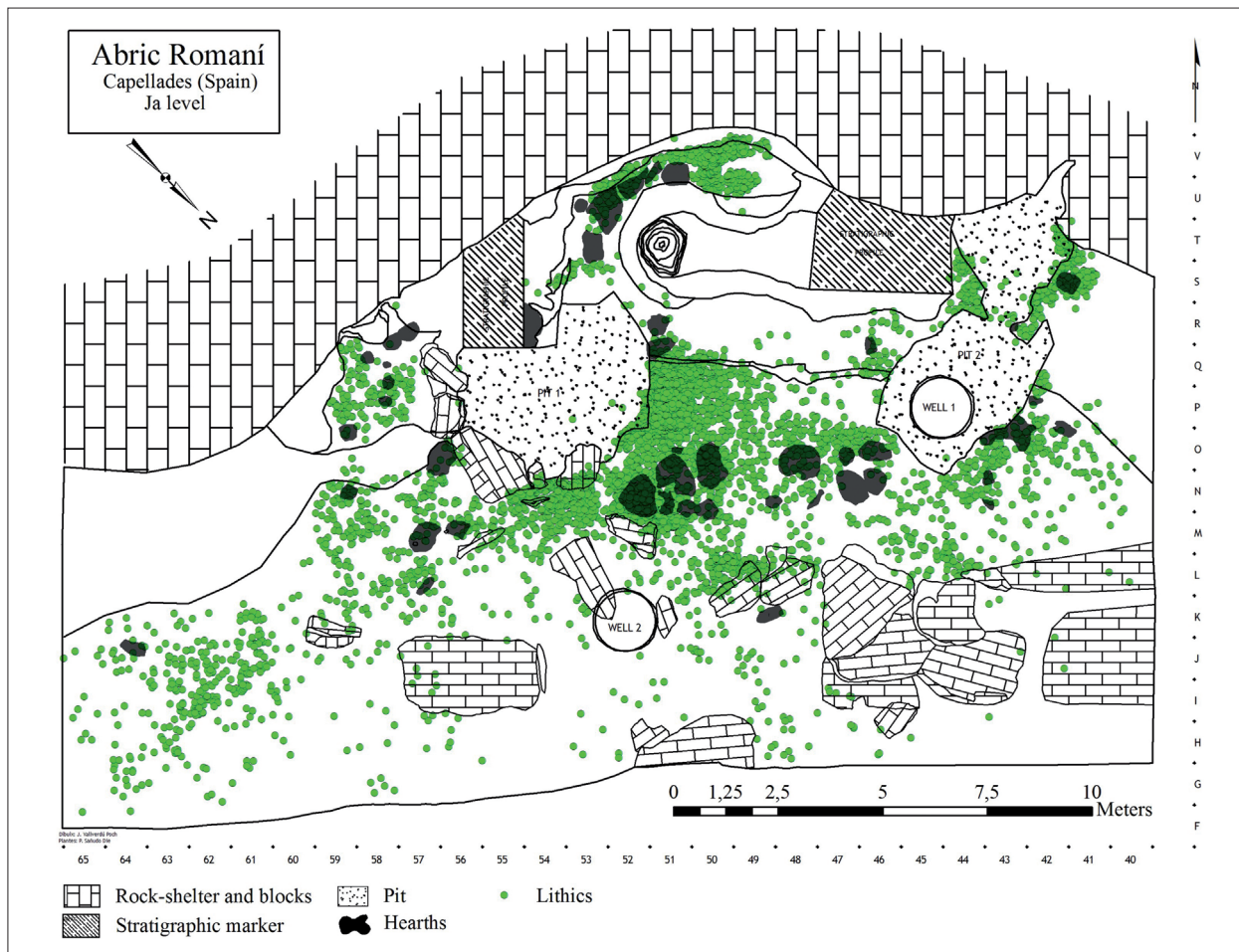


Fig. 5. Spatial distribution of lithic remains in sublevel Ja. The pits and wells from the old excavations are indicated. Only Well 1 reached the archaeological horizons underlying level J.

Abb. 5. Räumliche Verteilung der Steinartefakte in Schicht Ja. Die Gruben und Brunnen der alten Ausgrabungen sind eingezeichnet. Nur der Brunnen 1 erreicht die archäologischen Horizonte unter Schicht J.

scatters and some refits correspond to counter-slope movements. The intra-cluster distribution of the lithics from the same reduction sequence indicates that these accumulations have been little affected by post-depositional movements.

We established the direction of five inter-cluster movements (Fig. 4). The most robust pattern corresponds to the connection between L3 and L4A, since all the transported artefacts belong to the same RMU and were moved from L3 to L4A. The direction of the other displacements was from L3 to L4B and from L2 to L4B. These refits therefore indicate a unidirectional pattern connecting L4 with the rest of the shelter, but especially with L3. There are no movements in the opposite direction, that is, from L4 to other clusters, which would support the contemporaneity of the different accumulations. Three connections correspond to cores that were first exploited in L3 and later transported to L4-A, where the reduction sequence was completed and the core discarded. The cores were moved at a late stage in the knapping sequence, when they were almost exhausted; therefore, the reduction carried out at L4-A produced

only small and medium-sized flakes. The displacement from L2 to L4-A corresponds to the movement of a medium-sized (33x34x13 mm) flake produced in L2, as well as the connection between L3 and L4-B which concerns a flake of a similar size (34x27x12 mm) detached in L3 and moved to L4-B.

The temporal pattern that emerges from these connections indicates that the activities carried out in L4 occurred after those in L2 and L3. The lithic provisioning strategy behind the formation of the L4 assemblage was partly based on the scavenging of artefacts previously discarded in other areas, either practically exhausted cores or small-medium flakes. Therefore, the core reduction activities carried out in L4 produced only small and medium-sized flakes. During the last phases of the formation of level L, the rock-shelter was well-stocked with lithic materials, especially after the introduction of bulk resources documented in accumulation L3, and the last occupants made use of that abundance.

At first, the spatial dynamics in level J seemed to be very different from those observed in level L. Discrete accumulations were barely visible in sublevel Ja, in

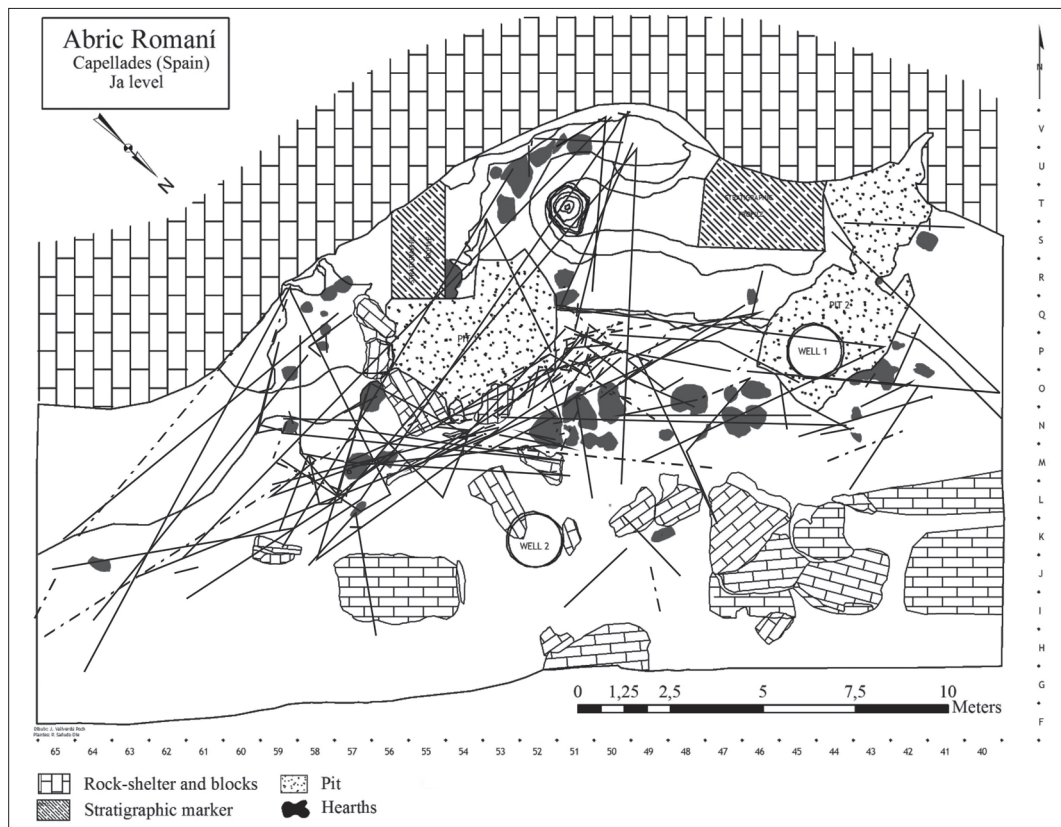


Fig. 6. Refitting map of sublevel Ja.

Abb. 6. Zusammenpassungen der Schicht Ja.

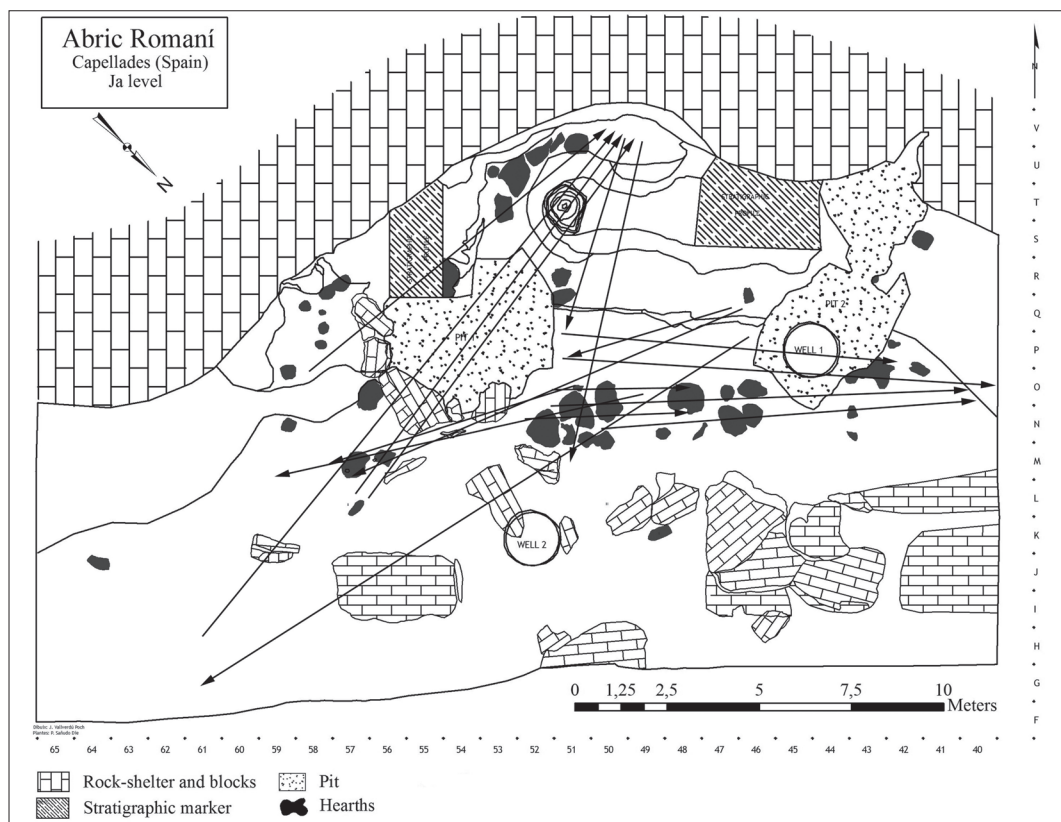


Fig. 7. Directionality of the connection-lines from sublevel Ja corresponding to intentional movements. A dominant unidirectional pattern can be observed.

Abb. 7. Richtung der Verbindungslinien aus Schicht Ja die intentionellen Materialtransport belegen. Das Verteilungsmuster ist vor allem unidirektional.

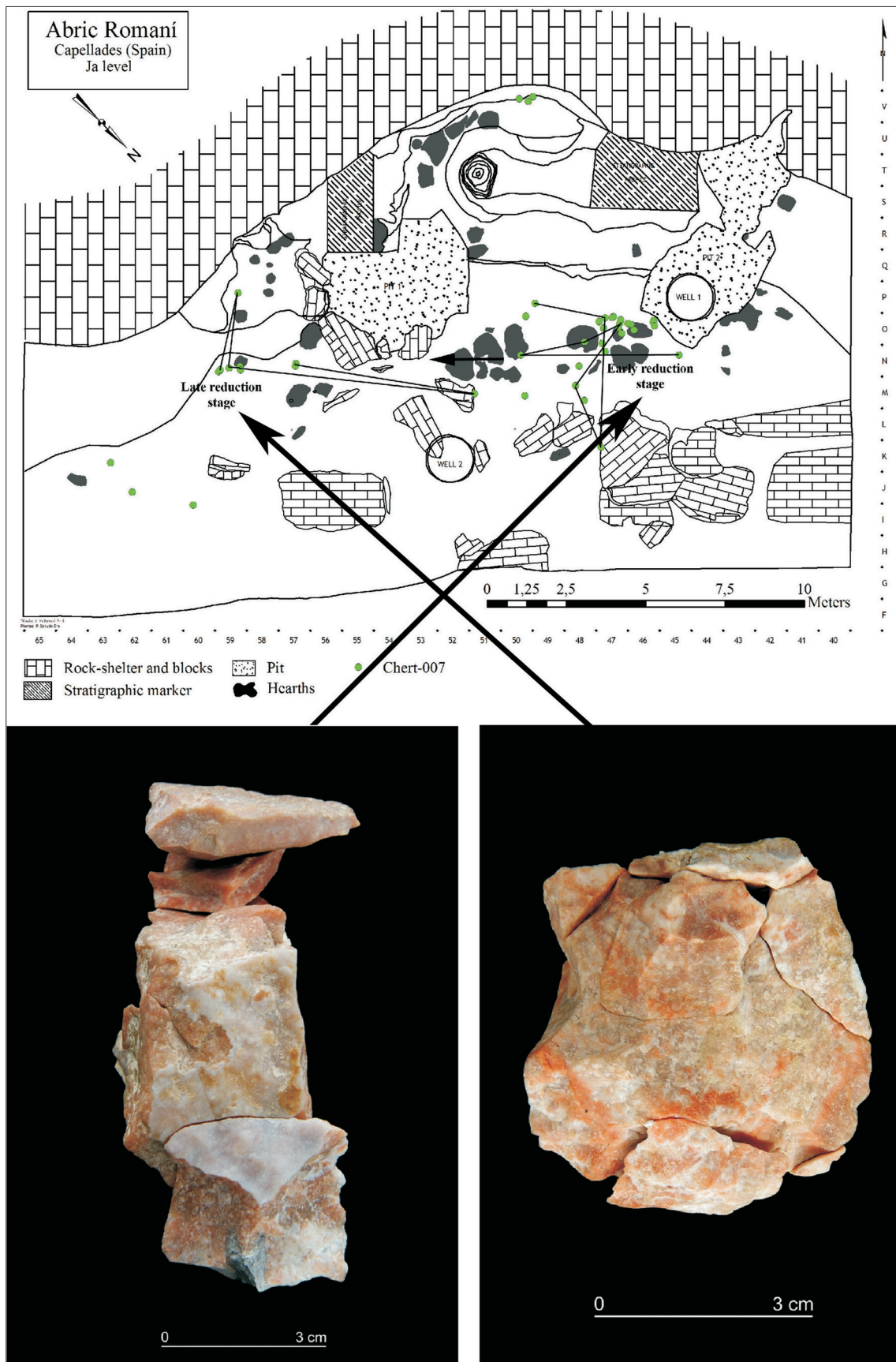


Fig. 8. Refitting and spatial distribution of two reduction stages identified for a single RMU from sublevel Ja.

Abb. 8. Zusammenpassungen und räumliche Verteilung von zwei Abbaustadien die zu einer Rohmaterialeinheit in Schicht Ja gehören.

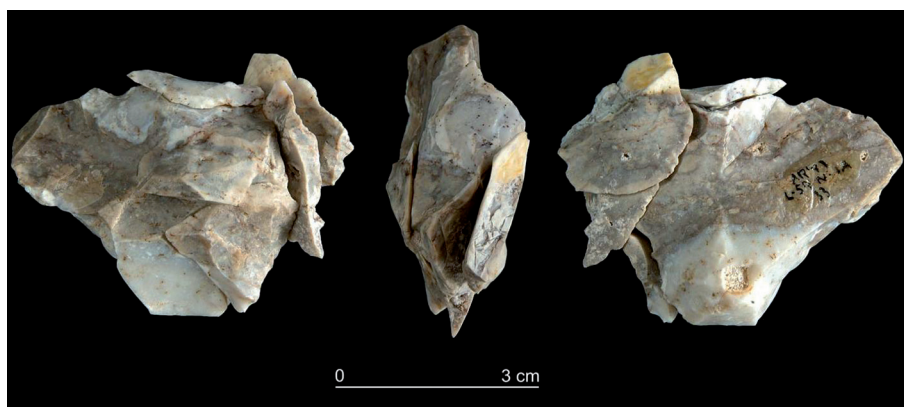


Fig. 9. Refitting of a reduction sequence on a core-on-flake from sublevel Ja. The artefacts forming this refit were clustered in square L57.

Abb. 9. Zusammenpassung der Abbausequenz eines Kernes an Abschlag aus der Schicht Ja. Die Artefakte dieser Zusammenpassung lagen zusammen in Quadrat L 57.

which the archaeological remains were more or less continuously distributed throughout most of the rock-shelter (Fig. 5). Most remains were concentrated in the inner part of the shelter, where the hearth-related activity areas were located (Vaquero et al. in press). Meanwhile, the exterior zone beyond the line of blocks yielded very low artefact densities. In addition, the refitting pattern showed a highly connected space (Fig. 6), including many long connections that could be attributed to the intentional transport of artefacts. Although short connections are dominant (42% of all connection-lines are less than 1 m in length), 11% of refits exceed 5 m. Just as in level L, the temporal relationships between the different activity events forming the lithic assemblage must be analyzed. In spite of the interconnected picture offered by the refit lines, the direction of the intentional transports again displays a basically unidirectional pattern (Fig. 7). Although the direction of the movements is quite variable, bidirectional connections are virtually absent, which supports the proposal that the different activity areas were not contemporaneous.

In addition to the refit data, for level J we have the information provided by the RMU scatters. The dispersion of the artefacts from the same reduction sequence varies considerably. Some RMUs are highly clustered, forming small scatters that suggest minimal post-depositional movements. Meanwhile, other RMUs are scattered over large areas and indicate that the original knapping accumulations were significantly disturbed. The coexistence of these different situations in the archaeological level suggests that not all the lithic scatters were subjected to the same post-depositional disturbances. This is another difference to the spatial pattern observed in level L, in which lithic scatters were little disturbed. This distinction between levels L and J may be explained by the differences in the degree of reoccupation of the activity areas and the incidence of human-induced post-depositional processes. Consequently, RMU

scatters may be considered as a measure of the location of the knapping events in the formation sequence of the archaeological assemblage. The following section describes the best examples of recycling identified in level J through the combination of refits and RMU dispersion data.

Some recycling events are related to the scavenging of artefacts for flake production. Figure 8 presents one of the widest scattered RMUs in sublevel Ja. It features two spatially separated reduction stages, which are characterized by very different dispersion radii. This RMU was introduced as a complete or nearly complete nodule and the first stages of the reduction sequence show the widest scatter. The artefacts from this stage were clustered around O48, which seems to correspond to the focus of the knapping episode, but some remains were dispersed throughout most of the central zone of the site. Nevertheless, the end of the reduction sequence, aimed at producing very small flakes, showed a marked cluster in N59. Five of the six very small flakes detached in this terminal stage were recovered in N59 and the sixth in P59. This indicates a temporal gap between the two reduction stages, which suggests that the second knapping event corresponds to the recycling of the core discarded after the first event.

A similar case is the RMU that appears in Figure 9, which also shows a differential dispersion according to reduction stage. The remains from the first stages are widely scattered, while the last production event corresponds to the exploitation of a very large flake for producing small blanks. Unlike the initial stage, the items from this last event were clearly focused around square L57.

Figure 10 shows one of the most notable recycling events, which was also identified by two spatially separated reduction stages. The first was widely scattered throughout the central area of sublevel Jb. This stage, including the decortication of the nodule, provided a wide array of products that were very

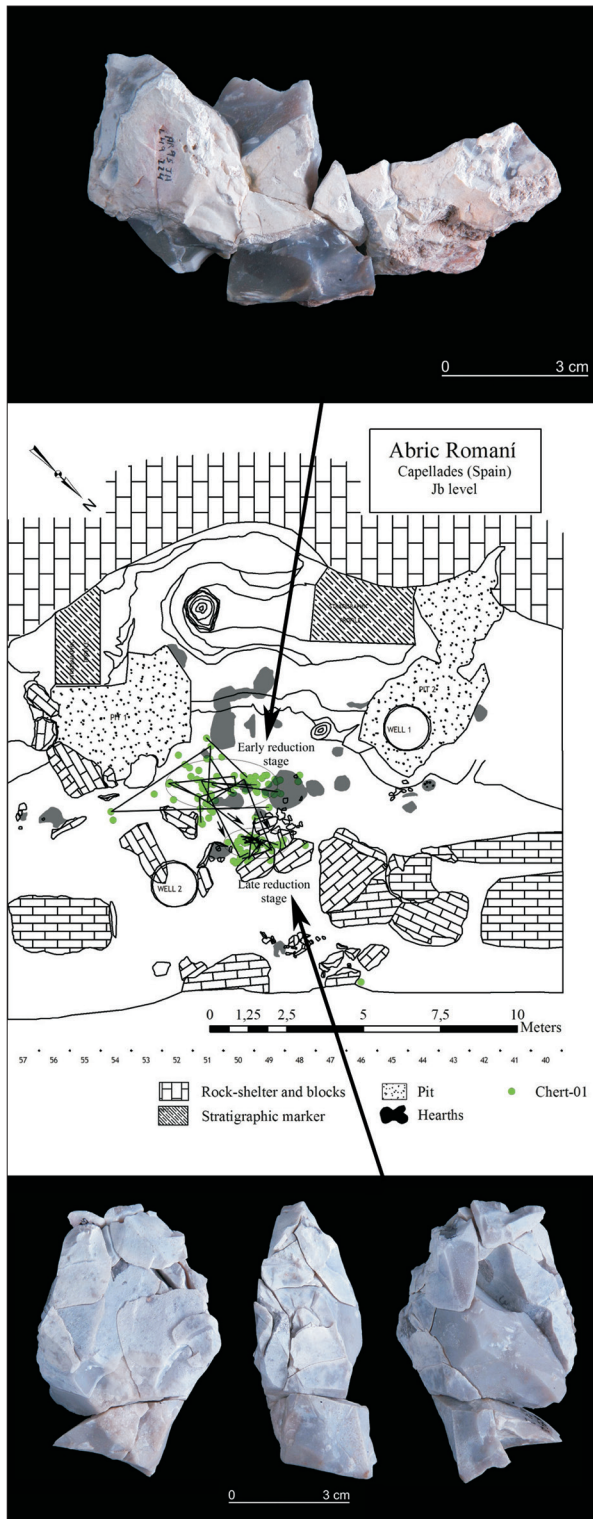


Fig. 10. Spatial distribution of a RMU from sublevel Jb, showing the location of the two reduction stages.

Abb. 10. Räumliche Verteilung einer Rohmaterialeinheit aus Schicht Jb, die den Ort zweier Abbauphasen markiert.

widely scattered. The mean length of the connection lines from this first knapping was 154 cm. The second stage was clustered in L49-50, showing a principal accumulation of only 50 cm in diameter. The mean length of the connection lines from this last stage was 33 cm. This final stage was exclusively aimed at

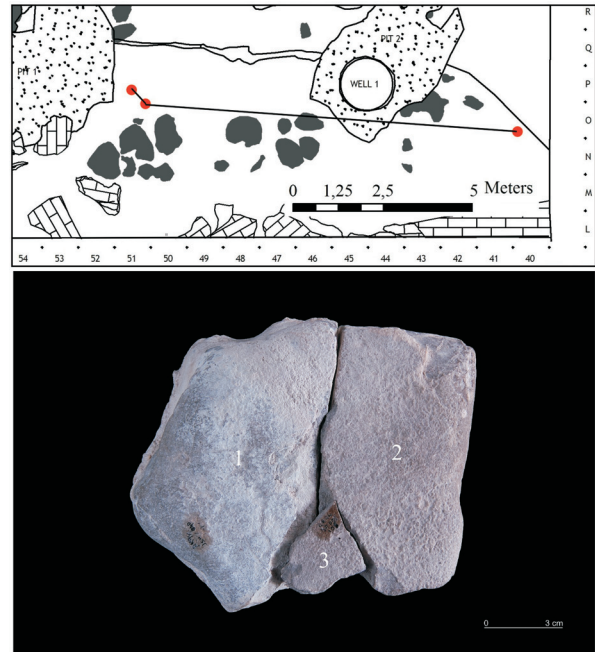


Fig. 11. Refitting formed by three fragments of a cobble that shows an intentional transport of one of the fragments. Fragment number 1 was found in O40, fragments 2 and 3 were found in P51.

Abb. 11. Zusammenpassung aus drei Fragmenten eines Gerölls von denen ein Fragment intentionell transportiert wurde. Fragment 1 wurde in O 40 gefunden. Die Fragmente 2 und 3 stammen aus P 51.

producing small and very small flakes, as is especially evident in one of the refits made up of 17 very small and two small flakes that were conjoined on the core. This lithic assemblage was produced by knapping events carried out from artefacts produced during the first knapping event, including a cortical product and a previously discarded core.

Other examples correspond to the recycling of limestone fragments from cobbles that were used as hammerstones. Figure 11 shows a broken limestone cobble presenting two fragments conjoined by an 1125-cm connection line between P51 and O40. A third fragment, detached at the time of the breakage, was also recovered in P51, which suggests that this was the breakage locus. The direction of movement was therefore from P51 to O40, a counter-slope movement that indicates intentional transport. The two pieces located in P51 were burned, but the fragment from O40 was not burned and showed percussion marks made posterior to the fracture. This pattern indicates that the fragment from O40 was moved before the burning episode and used again as a hammerstone. There are other refits that also indicate the movement of large artefacts from the central area of the shelter to the area of squares O40-42. A very large quartz fragment recovered in O42 was transported from a lithic scatter clustered around N51-52 and P51 (Figure 12). Another refit was formed by two fragments of a broken cobble, one of them found in N50 and the other in O41. These refits indicate a recycling event in which



Fig. 12. Refitting of a quartz nodule from sublevel Ja. Fragment number 1 was found in square O42. The other fragments were scattered throughout the middle of the rock-shelter (squares N51-52 and P51).

Abb. 12. Zusammenpassung einer Quarzknolle aus Schicht Ja. Fragment 1 stammt aus Quadrat O42. Die anderen Fragmente waren über den mittleren Bereich des Abris (Quadrate N51-52 und P51) verteilt.

large items were scavenged from the central area of the site and transported to the area of O40-42, where at least one of them was used as percussor.

Figure 13 also shows the secondary use of cobble fragments. This RMU was made up of 16 elements widely distributed throughout the rock-shelter. It includes a refit that clearly expresses the dispersion pattern of this unit, as it conjoins artefacts located in J62, K58, K61, M59 and P52. One of these fragments presented percussion marks that extended over the fracture plane, which indicates that its use as a percussor was subsequent to the breakage event. Another two artefacts of this refit were burnt, while the rest of the set did not show any evidence of fire damage. This also indicates a temporal succession of at least three different events: the cobble breakage, the spatial dispersion of the fragments derived from that breakage and the exposure to fire of some fragments. During this process, one of the fragments was used as a hammerstone.

Discussion

The evidence found at Abric Romaní underscores the potential of a spatio-temporal approach for extracting information about recycling behaviors. However, the examples presented above should be considered as a minimum number of recycling events.

For instance, from 562 RMUs identified in level J, only seven (1.2%) show evidence of recycling according to the refitting and spatial data. It is very likely that many recycling events will never be identifiable using our current methods. Those recycling episodes that were not associated to a significant movement or scattering of remains can not be identified by these criteria. Moreover, in order to identify a recycling event some very specific conditions related to surface damage or spatial patterns must be in place. Recycling may go unnoticed in assemblages formed by artefacts that have not undergone any type of surface alteration. Likewise, the use of refitting and spatial data is only possible in relatively well-preserved assemblages that have been excavated over large areas. It is clear that many sites do not meet these requirements. Although the panorama is not as pessimistic as that outlined by Odell, our methodological approaches need improving in order to add to the current body of data about recycling.

As noted earlier, recycling tends to be explained by factors related to access to raw material resources. Scarcity of raw material sources in the vicinity of the sites would be a favorable context for high indices of recycling. In keeping with this hypothesis, recycling would be more common in situations characterized by a limited access to lithic sources. As Amick (2007) has pointed out, multiple and even contradictory factors

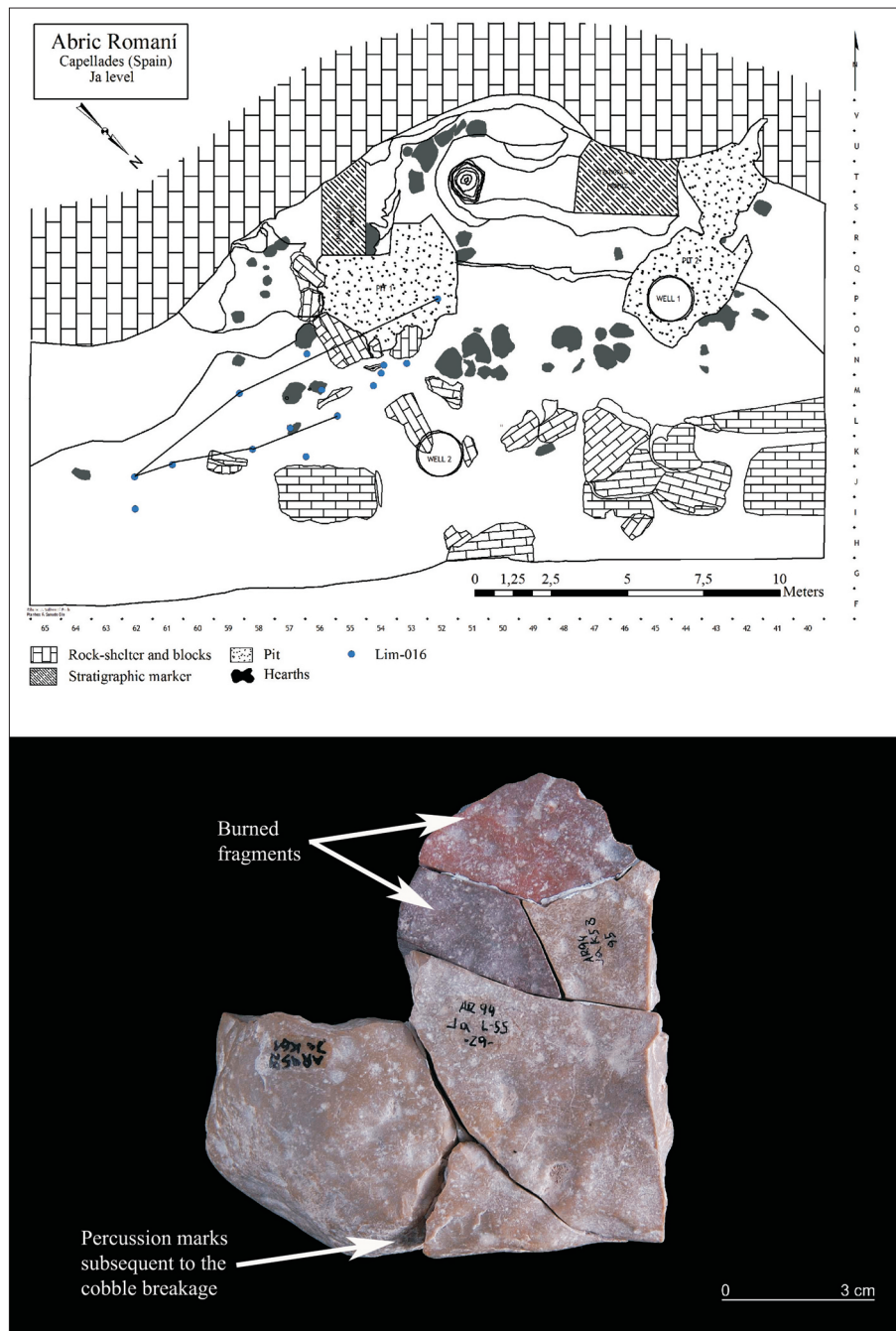


Fig. 13. Refitting and spatial distribution of a limestone cobble from sublevel Ja that shows a temporal succession of different use events.

Abb. 13. Zusammenpassung und räumliche Verteilung eines Kalkgeröls aus Schicht Ja, das eine Abfolge verschiedener Nutzungsereignisse zeigt.

can restrain raw material availability. For example, both high and low levels of residential mobility can limit access to stone resources. Temporal trends in the frequency of recycling would therefore indicate changes in settlement patterns. Hiscock (2009) suggested that the shift to sedentary strategies among Late Holocene hunter-gatherers of Arnhem Land was associated with increasing frequencies of bipolar reduction, which he considered evidence of recycling. On the other hand, high levels of residential mobility would explain systematic recycling among Palaeoindian groups

(Amick 2007). Debates on Middle Palaeolithic assemblage variability also show this contradictory character of recycling. According to Dibble and Rolland (1992), we should expect to see more recycling as occupation intensity increases, as lithic resources would have been more intensively used in prolonged occupations. Meanwhile, Kuhn (1995) argues that brief occupations would provide few opportunities to collect raw materials in the surroundings, making previously discarded artefacts more attractive during these short stays.

The Abric Romaní layers are difficult to interpret in terms of occupation length, but evidence from both levels J and L indicate that recycling took place in residential hearth-related occupations. Although limited access to raw materials should be considered as a primary cause of recycling, we should also recognize that other factors, some of them situational in nature, may be involved. For example, flint recycling can be explained in the Romaní levels by the scarcity of flint sources in the immediate surroundings of the site. However, this is not the case for limestone and quartz, since these raw materials are available in the alluvial and slope formations located at the foot of the rock-shelter. Therefore, merely opportunistic recycling events cannot be excluded for these materials. Perhaps flint recycling was also opportunistic. Maybe each specific recycling event had an opportunistic component and was motivated by immediate circumstances, but we can not discard in this case that the **possibility of recycling** was anticipated prior to the arrival of humans to the rock-shelter. Moreover, two additional issues must be taken into account to evaluate the incidence of recycling: the technological characteristics of knapping activities and the temporal variability of recycling throughout the formation of the archaeological assemblages.

On the one hand, the frequency with which recycling occurs may also depend on the aims of the technical activities. As far as the recycling of artefacts as cores is concerned, the suitability of the available remains for recycling will be determined by the characteristics of the products sought. The recycling behavior identified in levels L and Ja make sense in a technical context defined by the production of small flakes. Most recycling events documented in these levels are exclusively oriented to the production of this kind of flake. This microlithic production is not exclusively associated with recycling events, but it is a general feature of the technical system and characterizes most reduction sequences carried out in these levels. Increasing evidence has been coming to light in recent years concerning the deliberate production of small flakes in Middle Palaeolithic industries (Dibble & McPherron 2006), defining a technological context particularly suitable for recycling. Moreover, reduction strategies in these Romaní layers were particularly expedient, since they involved minimal predetermination of the products. The main goal was to produce the highest number of blanks per core, with little concern for the shape or size of the flakes. In such a context, a large array of artefacts would have been acceptable for recycling. It would be interesting to compare whether recycling occurs as frequently in a more demanding technical context in terms of desired end-products, raw material or technological knowledge – like a Levallois context.

On the other hand, recycling emphasizes the dynamic nature of archaeological assemblages. Far from being a negligible fossil record, the material

remnants of the past play a role in the behavioral strategies of the present. In addition, recycling is an example of the behavioral variability present throughout the formation of an archaeological assemblage. The importance of recycling in understanding Mousterian technical behavior has been documented in levels J and L of Abric Romaní, in which we have documented three kinds of recycling: recycling of cores or blanks for producing small flakes, recycling of cobble fragments for their use as hammerstones, and scavenging of flakes from previous reduction sequences. The scatter of remains produced in most recycling events, together with the stratigraphical location of some of them, suggests that this behavior was more common in the later phases of occupation. Recycling therefore exemplifies the temporal dimension of behavioral variability and marks a difference between early and late stages of lithic assemblage formation. Provisioning choices varied throughout the sequence of events that formed the archaeological assemblage. The first occupants of the rock-shelter had no other choice than to carry the lithic resources that they needed to the site. Transport of bulk resources would be more likely and mobility strategies would be more constrained by decisions concerning lithic provisioning. As the volume of lithic materials discarded in the site increased, the succession of introduction events transformed the site into a lithic provisioning area, and the occupants had the opportunity to use the lithics previously discarded by prior visitors. At the same time, the mobility of the groups occupying the shelter would be less conditioned by the need to access the original raw material sources. As lithic resources were available in the site, hunter-gatherers did not have to include those primary sources in their regular trips through the landscape.

The incidence of recycling in the formation of lithic assemblages forces us to reconsider the relationships between sites and lithic provisioning areas. Provisioning strategies were constrained by raw material availability in the surroundings of the site. The distance between raw material sources and the site is a key factor in characterizing these strategies. Local raw materials tend to be dominant, especially in Lower and Middle Palaeolithic assemblages, and the percentage of remains decreases as their origin becomes more distant. Moreover, resource management also varies according to distance. Complex reduction methods and elaborate tools are more common in materials of distant origin, while the processing of local resources tends to be more expedient. However, distance-induced constraints are modified as a consequence of recycling. Once at the site, exogenous materials became local and therefore the treatment of these materials by humans would have changed accordingly. Artefact management may therefore change between different use events. A previously discarded curated artefact may be considered an expedient tool when recycled.

Recycling not only depends on the regional distribution of raw material sources, but also on the amount of lithic materials available at the site. The accumulation rate of lithic materials in archaeological sites is determined by several causes, but reoccupation is one of the most significant. In addition to the natural features that may lead to the reoccupation of a place (e.g., topography, access to critical resources, location in geographic corridors, sun exposure, dwelling conditions, etc.) raw material provisioning may also be a factor, especially when activities requiring lithic tools were anticipated. Lithic provisioning may have even driven some visits to the sites, as they were transformed into a supply location (Camilli & Ebert 1992). Therefore, recycling is dependent on previous provisioning events. This introduces a historical factor in the formation of the lithic assemblages, since provisioning is not only conditioned by structural factors like the location of raw material sources, but also by the contingent decisions made by previous dwellers.

A potentially interesting issue that has not been addressed in this paper is that concerning the social actors responsible for the recycling events. In fact, we may wonder if this question is out of the scope of the archaeological inquiry, at least in a technical context like that represented in the Abric Romaní. Only in some very specific cases it has been possible to identify the social status of knappers. For example, the technical skills inferred from different blade production sequences was used by Pigeot (1990) to distinguish between expert and novice knappers. In the Abric Romaní, the recycled events do not exhibit lesser degrees of technical dexterity. In fact, this approach does not seem very suitable in technologies that are characterized by the expedient production of flakes and do not need high levels of technical skill.

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