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RAW MATERIAL RESOURCE MANAGEMENT DURING THE EPIPALAEOLITHIC IN NORTH-EASTERN IBERIA
The site of Gai Rockshelter (Moià, Barcelona): a case study

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Abstract. From a general point of view, the management of lithic raw materials used during the Epipalaeolithic seems to show a distance reduction within the catchment areas of lithics raw materials, and an obvious decrease in the frequency and importance of intergroupal exchange processes. Indeed, this is also indicated by the management of biotic resources. In comparison with the previous Upper Palaeolithic period, this fact cannot be explained as the consequence of an impoverishment or a cultural crisis, but rather as a new adaptative behaviour adjusting to general environmental change. At the beginning of the Holocene, economic behaviour included intensive, broad spectrum resource exploitation, and consequently, higher group mobility, especially in geographic areas where several biotopes were available. This paper presents the petrographic characterisation of lithics and geological samples collected from raw material sources identified during survey of the region around the site of Balma del Gai. We shall attempt to define the relationship between the geographic location of raw material sources and the activities that took place on the site, as a case of study of the Epipalaeolithic in North-Eastern Iberia and other nearest regions.

Résumé. D'un point de vue général, l'approvisionnement en matières premières lithiques pendant l'Epipaléolithique montre une réduction de la distance parcourue par les groupes humains pour s'approvisionner en ressources lithiques. Cette réduction s'accompagne, simultanément, d'une réduction de la fréquence et de l'importance des processus d'échange. Ce fait a pu être aussi observé dans le domaine de l'approvisionnement en ressources biotiques. En comparaison avec la période précédente du Paléolithique supérieur, ce fait ne peut pas être expliqué comme la conséquence d'un apauvrissement, ou d'une situation de crise culturelle, mais plutôt comme un nouveau comportement adaptatif face à des changements environnementaux généraux. Au début de l'Holocène, les comportements économiques se manifestent par l'exploitation intensive d'un vaste spectre de ressources, ça veut dire aussi une mobilité plus importante des groupes humains, spécialement sur des secteurs géographiques dans lesquels on trouve la coexistence de plusieurs biotopes. Le but de ce travail est de montrer la caractérisation pétrographique des silex du site de la Balma del Gai (Moià, Barcelone), et aussi de leurs sources d'approvisionnement repérées sur le terrain après nos travaux de prospection. Nous essayerons de définir par la suite, les relations entre les aires d'approvisionnement en matières premières des groupes épipaléolithiques de la Balma del Gai et les activités portées sur le site archéologique, comme un cas d'étude de l'Épipaléolithique du Nord-Est de la Péninsule Ibérique et des régions voisines.

Introduction

The archaeological site of Balma del Gai is in a small rockshelter (10.5 metres long and 5.5 metres wide) located in the council of Moià, near the city of Barcelona (2º08'19,5''E 41º49' 00''N) in the North-East of the Iberian Peninsula (fig. 1). From a geographical point of view, the site is about 50 kilometres inland from the coast at 760 metres above sea level on the Moià plateau. The site was discovered in 1975 by Joan Surroca. The first excavations took place during the late seventies under the supervision of Prof. Michel Barbaza, Miquel Llongueras and Prof. Jean Guilaine (García-Argüelles *et al.* 1997). After the initial excavations the archaeological site was almost completely forgotten; new excavations began in 1994, as a new project related to the study of the transition between the end of the Upper Palaeolithic and the beginning of the Epipalaeolithic in North-Eastern Spain, under the supervision of Prof. J.M. Fullola, from the Department of Prehistory, Ancient History, and Archaeology, University of Barcelona (García-Argüelles *et al.* 2001).

The stratigraphy

The stratigraphic sequence of the site is divided into three levels (fig. 2).

The first level called "superficial", presents mixed archaeological remains from prehistoric (mainly Neolithic and Bronze Age pottery) to modern occupations (some coins and pottery dated to the XVIIth century). A few epipalaeolithic remains have been identified in this level, but they had not been taken into account because they are not in their original strata.

The second stratigraphic level, "level I", contains the well-preserved remains of an epipaleolithic occupation and is

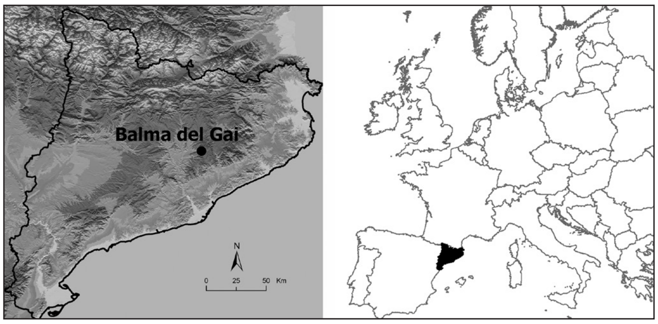

Figure 1. Geographical location of the site.

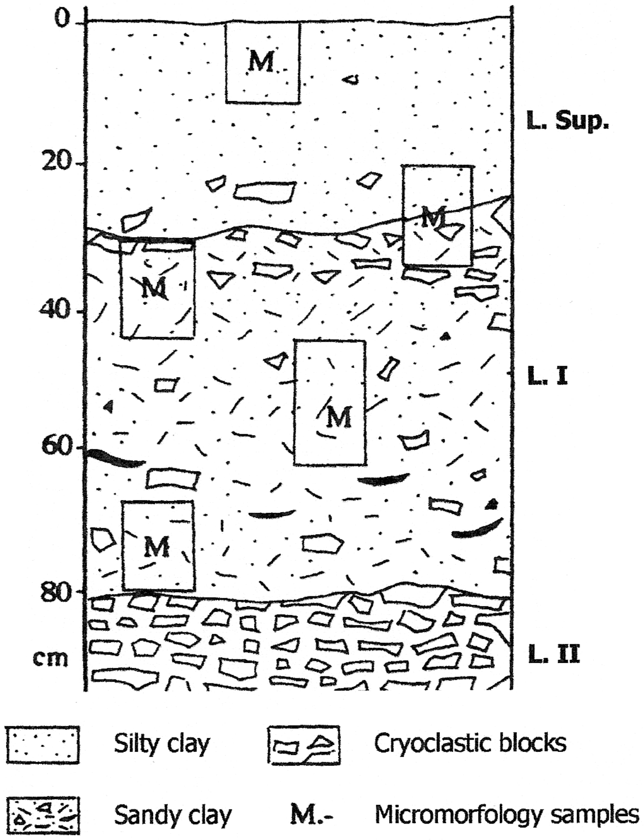

Figure 2. Stratigraphy.

therefore of particular interest to us. Level "I" is 50-60 cm thick and has already yielded several radiocarbon dates (Petit 1998): Gif-10028 (depth below datum (dbd): 126-131 cm) 8.930±140 BP. One range (68% probability) 8.085-7.717 (cal) BC. Two ranges (95% probability) 8.327-7583 (cal) BC; Gif-95617 (dbd: 136 cm) 10.260±90 BP. One range (68% probability) 10.327-9.848 (cal) BC. Two ranges (95% probability) 10.452-9.473 (cal) BC; Gif-95630 (dbd: 146 cm) 12.240±110 BP. One range (68% probability) 12.543-12.153 (cal) BC. Two ranges (95% probability) 12.758-11.987 (cal) BC.

The third stratigraphic level, "level II", is formed by cryoclasts falling down from the roof of the rockshelter, indicating a very cold phase during the late glacial period. Charcoal found in level II yielded the following radiocarbon date: Gif-10029: 11.170±160 BP. One range (68% probability) 11.300-10.969(cal) BC. Two ranges (95% probability) 11.490-10.808 (cal) BC. Artifacts and ecofacts found among cryoclasts in this level, show that they could not possibly be from that level, but originated from the upper level, namely level I. This points to the fact that there is no human occupation in level II.

Chronological analysis and environmental reconstruction

Level I covers a large chronological period relating to the beginning of the Epipaleolithic. This period is known in the Spanish Mediterranean Basin as the "Microlaminar" complex. The Microlaminar complex was well-defined in the thesis of Prof. J. Fortea in 1973, wherein he established the chronological frame for the Epipaleolithic in this part of Iberia. From a chronological point of view, the "Microlaminar" complex is contemporaneous to Azilian complexes in France as well as in the Cantabrian Basin. Nevertheless there are some differences in artifacts and subsistence strategies.

In the upper layer of level I, a scarce occupation related to the "Geométrico" complex, the second Epipaleolithic period, has been identified due to the presence of some geometric (triangular) arrow points.

As far as environmental reconstruction is concerned, preliminary information from charcoal and phytolith analyses is available. The surrounding landscape during the epipaleolithic period was dominated by *Pinus sylvestris, Juniperus* ,with *Acer* sp and *Betula* sp as minor species. The landscape may have been more open and the climate colder than today (Allué 2002).

Lithics

From a general point of view, the lithic industry of Gai Rockshelter is basically composed of flint (Mangado 2002); other raw materials have also been identified, including: calcareous rocks, quartz, hyalin quartz, lydian stone, and foraneous rocks such as rhyolite and jasper. Technological study of the production of stone tools enables us to define Gai's industry as microlithic. All the steps of chipped stone production, such as core preparation, striking platform reparation, core exploitation, tool production, use and repair, have been found and identified on the site. The knapping process basically shows a flake technology related to the exploitation of polygonal cores, but blade technology has also been identified (fig. 3).

Raw material characterization

Gai Rockshelter is located in the Moià plateau, an Eocene calcareous table-land formed by sandstones and calcareous rocks that forms the SE border of Ebro Basin. There are no flint sources documented in geological maps of the region (IGME 1985). Nevertheless, as mentioned above, flint is the main raw material used in the manufacture of lithic industry. Surveys were therefore carried out during the course of this research to identify potential raw material sources. The method used to identify raw materials exploited in stone tool production and to determine their source included two steps:

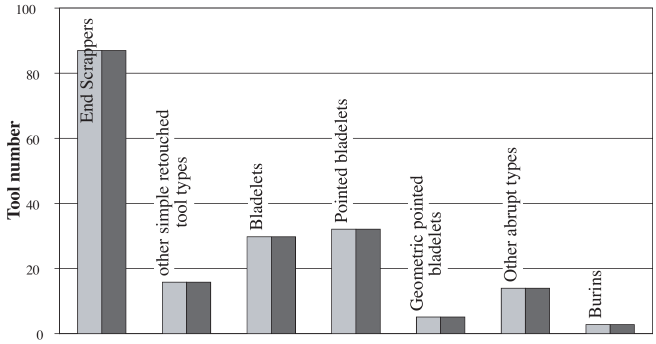

Figure 3. Distribution of tool types.

1. Field surveys: the aim of the surveys was to locate and describe flint outcrops from a geographic and geological point of view. The outcrops (primary or secondary position) were sampled and these samples were described macroscopically. The sampling was done in such a way as to reflect all flint variability in an attempt to refine comparisons with macroscopic descriptions of archaeological raw materials. As a result of this field work several outcrops were discovered (fig. 4).
2. Petrographic identification and characterisation of both geological and archaeological samples: mineralogical and petrological criteria (texture, structure, relics) geared towards the definition of several depositional environments allow us to correlate geological and archaeological samples. The most important type of archaeological flint is related to Lower Muschelkalk. These deposits were sedimented in resticted and hypersaline tidal flats (sebkha type) in the proximal area of a lagoon (Calvet & Ramon 1987) (fig. 5).

Other archaeological types of flint have been described, but their geological origin is still unknown. Examples are the "Gasteropoda-dolomite type" and the "Oolithic type", the latter is known to be related to a Carbonate platform in a high energy environment.

Summary

The scientific study of flint using petrological criteria allows us to relate the silicifications used in the Balma del Gai Rockshelter to Lower Muschelkalk formations. The field work revealed different types of outcrop (primary and secondary) containing different quantities and quality of flint. Taking these differences into account, we assume that the collection of flint comes from secondary outcrops of Lower Muschelkalk into Tertiary clays, where the flint is easily obtained and shows a good quality for knapping (Mangado & Nadal 2001). We consider that flint from primary outcrops was scarcely used due to its bad quality for knapping and to the hardness of the host rock. The characterisation of lithic raw materials enables us to establish that there is little evidence for the exchange of raw materials, basically in the form of tools such as end-scrappers, on jasper and charophyta flint.

Faunal remains

Faunal remains are diverse, but rabbits (*Oryctolagus cuniculus*) are the main species that are well documented. They represent 95% of faunal remains, and of the minimum number of individuals. However, it is difficult to establish whether this species should be considered the most important prey species in the subsistence economy of epipalaeolithic group occupying Gai rockshelter. In fact, there is evidence for large game hunting (deer - *Cervus elaphus*-, wild goat - *Capra pyrenaica*-, wild boar - *Sus scrofa*-, chamois - *Rupicapra rupicapra*-, etc.). We have also documented a large number of land snail shells (*Cepaea nemoralis*) that proves the consumption of small land invertebrates. The quantity of *Cepaea nemoralis* found at Gai is typical of epipalaeolithic sites in the Mediterranean Basin of Spain, France and Italy (see, for example, André 1987).

In any case, the large amount of rabbit remains shows the existence of economic use of this ressource. The stone-tool types (basically microlithic end-scrappers) and micro-usewear analysis support this argument. Taking this information into account we are able to establish that the process of transformation of rabbit carcasses, after hunting, occurs in three steps (fig. 6):
1. Skinning. The most important evidence for skinning is the presence of cut-marks on specific parts of the skeleton, such as on metapodials (metacarpus and metatarsus, and on some bones of tarsus, especially on calcaneus). There are also cut-marks related to the skinning on jaws (mandible). If these cuts are indeed related to skinning, we can suppose that this activity was done in the same manner as it is done today: first, cutting the skin at the autopodia, then, peeling it off up to the head and finally, cutting the whole skin around the eyes and nose areas. This kind of cut-mark represents about 35% of all cut-marks that we have inventoried on rabbit bones.
2. Dismembering. Some parts of the rabbit carcass were dismembered to be consumed, as evidenced by the presence of cut-marks (*e.g.*, on the *collum* of the *scapula*, and at the proximal end of the humerus, perhaps to dislocate those bones, at the distal end of humerus, and at proximal ends of the *radius* and the *ulna*, and on the *acetabulum* of pelvis, and at the proximal end of the femur). This kind of mark is not frequent, and represent less than 25% of all cut-marks observed. Moreover, it is not certain that they are exclusively due to dismembering as they could result from the removal of meat, as we will show later. In fact, disarticulation of small mammals is commonly done by hands during consumption, resulting in few traces of dismemberment.
3. Removing meat off the rest of the skeleton. Meat stripping would be undertaken when delayed consumption occurred. There exist ethnographical references explaining such behaviour (Bean 1972:66; Spier 1978:66), which is a common practice where hunting and consumption of rabbits is seasonal and important, and also when it is necessary to preserve meat for days, weeks or even months. We think that cut-marks along, or through, some bones (such as the scapula, humerus, radius, ulna, pelvis, femur and tibia) could be related to the removal of meat and its preservation by a process of either smoking or drying. As has been stated previously, some of these marks may also be considered disarticulation marks. For this reason cut-marks related to meat preservation are the most abundant (over 55%).

Name of the outcrop	Type of outcrop	Original Geological Age Formation	Secondary Position Geological Age	Main description elements
Torrent de la Frau	Primary	Lower Muschelkalk Middle Triassic Colldejou Unity		**Macroscopic characterisation.** Rounded nodules (15 cm).- Host Rock: Dolomite.-Patinated.-Carbonate relicts.- Banded aspect (agate). **Microscopic characterisation.** Microquartz texture. Fibrous quartz mainly lenght-slow chalcedony.- Anhydrite phantoms & anhydrite relicts.- Micritic mud, sparite crystals, dolomite phantoms. **Depositional environment.** Shallow waters, tidal flat environments, semi-enclosed and hypersalines (type sebkha) situated in the proximal part of a lagoon.
Carrer de 7 Cases	Primary	Lower Muschelkalk Middle Triassic Colldejou Unity		**Macroscopic characterisation.** Subrounded nodules (10 cm).- Host Rock: Dolomite.- Patinated.- Carbonate relicts.- Banded aspect (agate). **Microscopic characterisation.** Microquartz texture. Fibrous quartz mainly length-slow chalcedony.- Anhydrite phantoms & anhydrite relicts.- Micritic mud, sparite crystals, dolomite phantoms. **Depositional environment.** Shallow waters, tidal flat environments, semi-enclosed and hypersalines (type sebkha) situated in the proximal part of a lagoon.
Can Oller	Primary / Secondary	Lower Muschelkallk Middle Triassic	Quaternary deposits	**Macroscopic characterisation.** Tabular fragments (10 cm long x 2 cm wid).- Host Rock: dolomite.- joint.- Carbonate relicts. **Microscopic characterisation.** Microquartz texture. Fibrous quartz mainly length-slow chalcedony.- Anhydrite phantoms.- Micritic mud, sparite crystals, dolomite phantoms. **Depositional environment.** Shallow waters, tidal flat environments, semi-enclosed and hypersalines (type sebkha) situated in the proximal part of a lagoon.
Cami de l'Avenço	Primary	Lower Muschelkalk Middle Triassic		**Macroscopic characterisation.** Tabular fragment & rounded nodule (<6 cm).- Host Rock: Dolomite.- joint.- Patinated.- Carbonate relicts. **Microscopic characterisation.** It has not been done. **Depositional environment.** Shallow waters tidal flat environments, semi-enclosed and hypersalines (type sebkha) situated in the proximal part of a lagoon.
Figuero-Montmany	Primary	Lower Muschelkalk Middle Triassic		**Macroscopic characterisation.-** subangular nodules (6 to 10 cm) & tabular fragments (10 cm long x 2 cm wide).- Host Rock: Dolomite.-joint.- Patinated.- Carbonate relicts. **Microscopic characterisation.** Microquartz texture. Fibrous quartz length-slow chalcedony.- Iron oxides.- Micritic mud, sparite crystals, dolomite phantoms. Terrigenous **Depositional environment.** Shallow waters, tidal flat environments, semi-enclosed and hypersalines (type sebkha) situated in the proximal of a lagoon.

Figure 4a. Description of outcrops.

Cami de can Pollancre	Primary	Lower Muschelkalk Middle Triassic		**Macroscopic characterisation.** subangular nodules (<4 cm).- Host Rock: Dolomite.- joint.- Patinated.- Carbonate relicts. **Microscopic characterisation.** It has not been done. **Depositional environment.** Shallow waters, tidal flat environments, semi-enclosed and hypersalines (type sebkha) situated in the proximal of a lagoon.
Coll de can Tripeta	Secondary	Colldejou Unity Lower Muschelkalk Middle Triassic	Paleocene	**Macroscopic characterisation.** Rounded nodules (High variability sizes). No Host Rock.- Not Patinated.- Different kind of relicts (Iron oxides, carbonated mud, lenticular crystals, siliceous spicules).- several aspects (agate, jasperated, opaline). **Microscopic characterisation.** Microquartz texture. Some Macroquartz mosaic infilling porosity.- Fibrous quartz both length-fast & length-slow chalcedony.- Iron oxides.- Siliceous spicules. Lenticular phantoms of gypsum.- Micritic mud & dolomite phantoms. **Depositional environment.** Shallow waters, tidal flat environments, semi-enclosed and hypersalines (type sebkha) situated in the proximal part of a lagoon.
Can Rovira del Brull	Secondary	Colldejou Unity Lower Muschelkalk Middle Triassic	Paleocene	**Macroscopic characterisation.** Rounded nodules (High variability sizes). No Host Rock.- Not Patinated.- Different kind of relicts (Iron oxides, carbonated mud, lenticular crystals, siliceous spicules).- several aspects (agate, jasperated, opaline). **Microscopic characterisation.** Microquartz texture. Some Macroquartz mosaic infilling porosity.- Fibrous quartz both length-fast & length-slow chalcedony.- Iron oxides.- No micropalaentological remains. Lenticular phantoms of gypsum.- Micritic mud & dolomite phantoms. **Depositional environment.** Shallow waters, tidal flat environments, semi-enclosed and hypersalines (type sebkha) situated in the proximal part of a lagoon.
Torrent del Quirze	Secondary	Colldejou Unity Lower Muschelkalk Middle Triassic	Quaternary deposits	**Macroscopic characterisation.** Rounded nodule fragment (<6 cm). No Host Rock.- Not Patinated.- Different kind of relicts (Iron oxides).- Carbonate relicts.- Opaline aspect. **Microscopic characterisation.** Microquartz texture.- Fibrous quartz lenght-fast chalcedony.- Iron oxides.- No micropalaentological remains. Micritic mud & Terrigenous. **Depositional environment.** Shallow waters, tidal flat environments, semi-enclosed and hypersalines (type sebkha) situated in the proximal part of a lagoon.
Riera de Gallifa	Secondary	Lower Muschelkalk Middle Triassic	Quaternary deposits	**Macroscopic characterisation.** Subangular nodule (16 cm).- No Host Rock.- No relicts.- No patinated. **Microscopic characterisation.** It has not been done. **Depositional environment.** Unknown

Figure 4b. Description of outcrops.

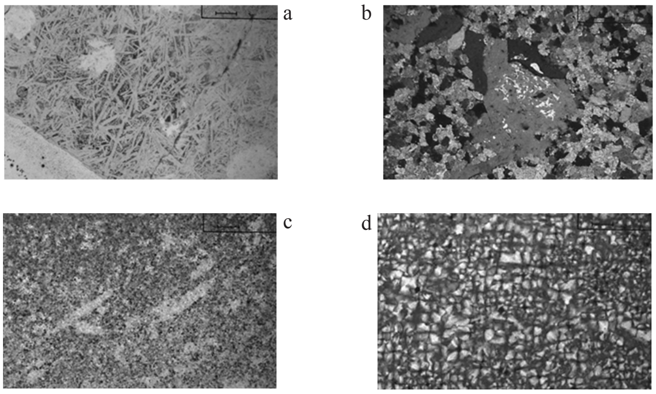

Figure 5. a: acicular anhydrite crystals, b: anhydrite crystals in autigenic quartz, c: lenticular gypsum, d: length-slow chalcedony.

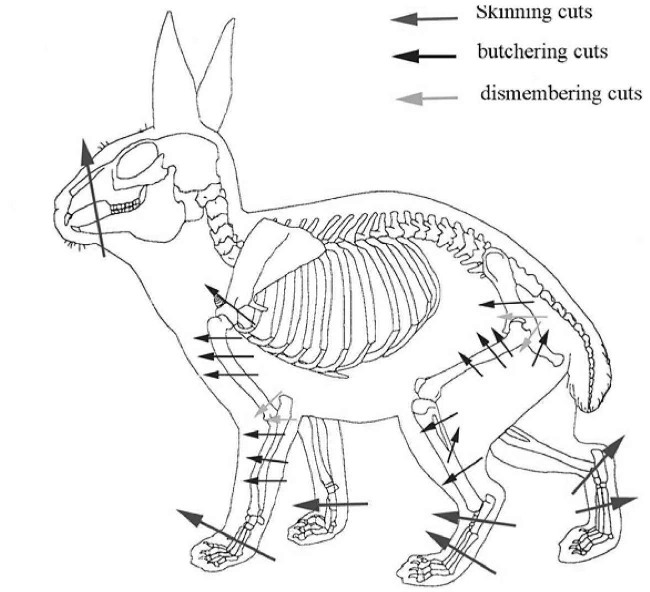

Figure 6. Cut marks in rabbit's carcasses.

Summary

We consider that the consumption of fresh rabbit meat was an important activity, as indicated by representation patterns in bone. If we divide the rabbit's body into four different parts: cranium, trunk (including ribs and pelvis), limbs (minus podial elements, but including the scapula), and autopodia (hands and feet), we observe that there are fewer trunk bones than expected (less than 20% of all the rabbit bones analysed), but more cranium fragments or limb bones (more than 28% in each case).

Why do we observe this pattern? We think that this distribution is a result of human behaviour, which consists of eating the soft bones of the trunk (vertebra and ribs), as some people still do nowadays, and crushing other, stronger bones to consume the brain and tongue (in the case of the skull) or marrow (in the case of long bones). The autopodia (25% of the total rabbit's remains) are perhaps not misrepresented because they were probably not consumed or systematically broken.

We believe that rabbit hunting was the main seasonal activity (maybe during autumn) at Gai rockshelter to obtain not only fresh and dried meat but also skins (García-Argüelles *et al.* 2004). It is difficult to estimate the importance of this behaviour among all the other activities carried out on the site, but it seems very clear that most of the remains recovered are related to rabbit hunting and to the processing of their carcasses.

Sea Shells

We have recovered more than 30 marine shells (well preserved or fragments). They represent a great variety of species: *Glycymeris glycymeris, Glycymeris violascens, Pecten jacobaeus, Collumbella rustica, Hinia reticulata, Hinia costulata, Cyclope* sp.*, Mytilus galloprovicialis, Dentalium vulgare and Dentalium dentale*. All were imported from the Mediterranean coast probably as exchange products. Some of them were used as pendants, and we can clearly observe anthropic holes made in order to suspend them (Estrada *et al.* 2004).

Usewear analysis

Generally, flint artifacts are well preserved with no post-depositional alteration or patina affecting the usewear analysis. The analysis was carried out on 62 lithic remains, mainly tools, and more specifically end-scrapers, in an attempt to explain the results obtained from zooarchaeological analysis.

Unretouched lithic elements constitute the second main group of analysed elements. Gai rockshelter is located in a geographic area where flint outcrops are poorly represented, and this fact could explain why flint is so intensively exploited. The lithics of Gai Rockshelter are clearly microlithic; only unretouched elements that are long enough, with sufficiently large edges, are useful for cutting activities.

Utilisation and identification indices

The utilisation index is around 40.9% while the identification index is quite low, around 33.3%. Only three worked materials could be identified: skin, meat and bone (fig. 7). 10 out of 12 lithics showing utilisation are artifacts. This fact must be seen, in part, as a consequence of analysed sample since end-scrapers were dominant. Only one case of meat work and one case of bone work have been identified microscopically, the remainder of the tools were used on skin (fig. 7).

Micro-usewear analysis of end-scrapers

This group of 30 pieces shows homogeneity of technique: flake technology (80%), microlithic size, and a high degree of standardisation (60% G11 & 20% G12). Micro-usewear analysis shows a relatively low utilisation index (40%) in comparison with common utilisation indices for this type of tool (Jardón Giner & Sacchi 1994; Calvo Trias 2002, 2004). On the other hand, the identification index shows very similar results with other archaeological sites.

The kinetics of end-scrapers shows that the active zone is the frontal (distal) edge of the scrapers (100%); no lateral edges have been used in skin working. The angle of attack,

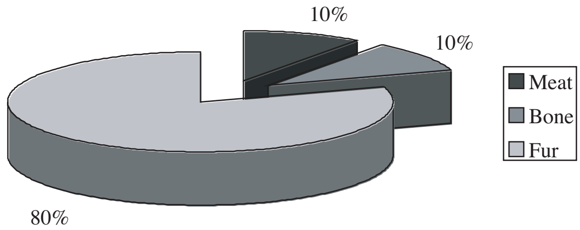

***Figure** 7*. Micro-usewear identification in relation to material worked.

calculated by taking into account the usewear on both faces of the end-scraper is basically high (54.5%) or medium (45.5%) probably due to the kinetic limitations of this kind of work with microlithic tools (Jardón & Sacchi 1994; Calvo Trias 2004). In all cases a transverse motion identified, enabling us to suggest similar working technique.

21 unretouched lithics were analysed microscopically. The utilisation index is very low (9%) and, contrary to the situation commonly found in other archaeological sites, the use of these unretouched lithic remains could not be related to cutting activities. All of the usewear observed microscopically on these unretouched pieces was related to skin work.

Summary

The micro-usewear analysis enables us to confirm that end-scrapers and unretouched lithics were used for working skin. Micropolish analysis of the end-scrapers makes it possible to differentiate various phases of the skin working process. 55.6% of micropolish traces were identified as resulting from the working of dry skins and 22.2% result from working fresh skins. Most of the end-scrapers analysed were used during late phases of skin working. Chronologically and typologically speaking, this situation is similar to the one encountered at the site of Balma Margineda (Andorra) (Philibert 1993).

General conclusions

Rabbit hunting was the main seasonal activity at Gai rockshelter (possibly during autumn) and rabbits were exploited not only for fresh and dried meat, but also for their skins. We cannot establish with certainty the importance of these activities relative to all the other activities carried out by this group within their territory, but it seems very clear that most of the remains recovered at Gai are related to rabbit hunting and to the processing of their carcasses, as is also confirmed by micro-usewear analyses. Lithic raw materials were collected from the local (non siliceous), and regional (siliceous) area, within a relatively large territory (500 sq. km). The Congost river seems to be the main axe of mobility between the Moia plateau (760 meters asl) and the nearest plains in the south (200 meters asl) where many biotopes were available.

Lithic characterisation and technology show that there has been a selection of flint from clays (secondary position outcrops), even if these are located much further than primary outcrops (maybe due to the difficulties of extracting flint from primary outcrops, and to their poor knapping quality). This shows that economic behaviour related to the knowledge of a wide territory, likely suggesting high group mobility, especially in the geographic areas where several biotopes were available, offersing the possibility of seasonal activities. This mobility would have included social interactions with other populations as indicated by exchanges of "exotic" lithic raw materials and marine shells.

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