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Cover figure: Last mining event at Casa Montero, Madrid (c. 5200 cal BC). Illustration by Juan Álvarez-Cebrián

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# The flint mine of Ri «Le Fresne»

**Cyril MARCIGNY, Emmanuel GHESQUIÈRE, David GIAZZON,  
Rodrigue TSOBGOU AHOUBE, François CHARRAUD,  
Laurent JUHEL and Sébastien GIAZZON**

## **Abstract**

The flint mine of Ri is located at +200 to +205m NGF (*Nivellement Général de la France*) on a south-eastward slope, in the north of the Houay's Valley, whose eponym river is a tributary of the Orne. The raw material mined at this site has the shape of spherical mid-grain-sized pebbles, measuring 20cm in diameter and 50cm in length. They outcrop in a powdery limestone layer, 1.2m in depth at the southern end of the excavated area to 4.5m at the northern end. From shallow to deep areas, the infrastructure of the mine varies from incurved holes to 30 square meters pits radiating a network of small galleries and extensions. While some of these galleries remained unfilled, most pits were refilled immediately after the extraction of flint. Their walls contain a great number of digging tool traces. Twenty eight radiocarbon dates have been obtained on deer antlers recovered from the entire surface of the excavation, situating the mine in the second half of the fourth millennium BC.

## **Keywords**

France. Lower Normandy. Neolithic middle II. Flint mine. Flint axes.

## **1. Introduction**

The Neolithic mine of Ri is one of a series of flint mines built in the Plain of Caen, a Jurassic limestone plate. This group of mines is oriented north-southward, along a thirty kilometer long line (Figure 1). Although the archaeological field survey estimated the surface of the mine to be 30 hectares, only two hectares have been excavated. The exact area of excavation measures 22,300 square meters, extending 730m in length and 40 to 50m in width (Figure 2).

During 6 months, from June to November 2007, the excavation made by Inrap has allowed the discovery of five thousand and fifty structures of flint extraction, along the area of extension of the future A88 highway transept (Caen-Sées), cutting a part of the mining complex. Five thousand and ten of these structures have been excavated using a backhoe. Forty were excavated by technicians. A team of 10 persons collected a great quantity of data during the fieldwork at Ri.

Assuming that the nature and the depth of the geological layers containing exploited flint determined different types of extraction structures at Ri, one of the foci of the project has been to improve our understanding of their morpholo-

gy and distribution, correlating the layers to specific microstructures and qualities of the flint (see Tsobgou *et al.* in this volume). We have recorded many geological profiles—15 geological drillings, measuring 3m by 2m, and one 300 meters long stratigraphic transept (Figure 3).

In the course of this study we hope to enrich our knowledge of the economy of siliceous raw materials and their exploitation in European Prehistory, principally in mining activities, while drawing on the existent scholarship on this topic initiated at the end of the 19th century. In France, and principally in Normandy, the excavation of the Neolithic mine of Bretteville-le-Rabet marked the start of this research line (Desloges 1986, 1990).

## **2. The Substratum Characteristics**

The flint extracted from de mine of Ri comes from the Limestone of Caen formation (J3ca), a fine bioclastic limestone located at a depth 10 to 12m. This limestone has white to beige color and is porous and poor in fossils. The age of the limestone formation has been assigned to the Lower and Middle Bathonian (Gigot, *et al.* 1999), but a more recent micro fauna examination has showed the presence of

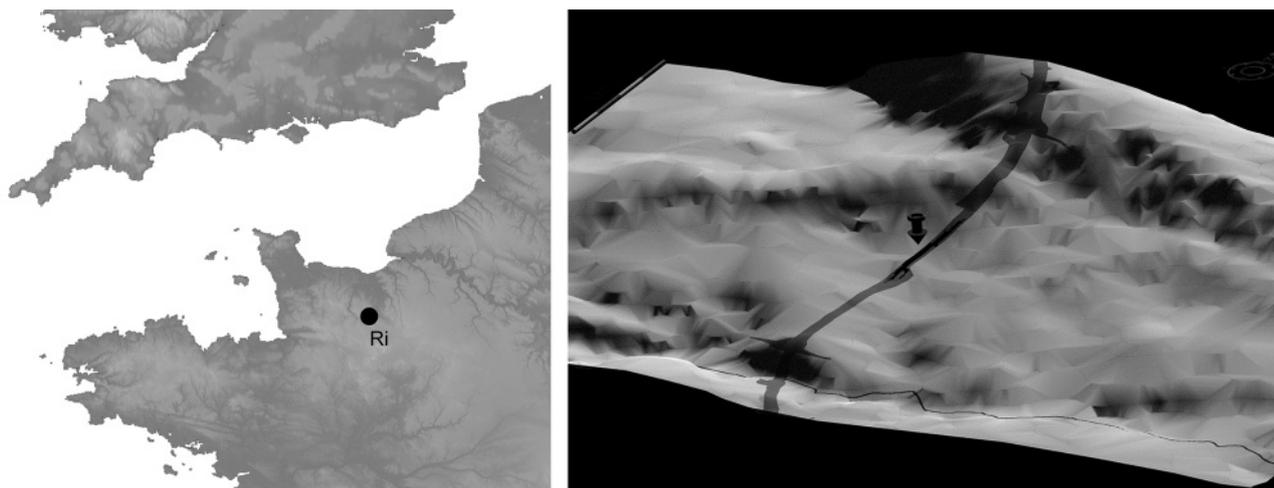


Figure 1. Location map of the road and the area of excavation on a 3D projection of the topography (DAO, L. Vipard, Inrap).

*Rynchonella* which extends its deposition to the upper Jurassic (Oxfordian) (see Tsobgou *et al.* in this volume).

The deposition of carbonaceous sediments occurred during many phases, followed by weathering process. In addition to weathered sediments of the limestones layers, we have also observed brownish-red clay and a sandy loam layer. These weathered layers are covered by silty Holocene colluviums and loess, sometimes mixed with fragments of altered limestones. The thickness of this cover increases from 0.5m in the southern to 3m in the northern parts of the excavation.

The flint extracted in this mine has the shape spherical nodules. It is associated with both a sandy loam layer, called ‘chaussin’ by current miners, and a mixed colluvium in the southern part of the mine. The rarefaction of flint in the surface layers of the northern section of the mine is not only due to a northward thrust, but also to the presence of good quality flint in deeper layers.

In the central area of the mine, where mining structures are more concentrated, flint has a mudstone texture, whether the structure of the limestone is packstone to wackestone. The external areas of the mine are poor in structures of exploitation because there the flint has the texture similar to that of the enclosing bedrock. We have identified three categories of flint nodules at Ri (see Tsobgou *et al.* in this volume). The nodules of category 3 present in the axial area of the excavation possess a double cortex (gritty to chalky) and a double core. Two sub-categories 3a and 3b of these nodules have a less weathered inner core, and are the most exploited. The mechanical properties of flint extracted in the fifty drillings are related to the substratum sedimentological characteristics and their topographic position. The quality of flint for knapping and use decreases from surface to deeper layers (see Tsobgou *et al.* in this volume). Although the best quality flint of the mine of Ri was suitable for the manufacture of tough and resistant axes,

the size and the shape of blocks restricted their production in large volumes.

### 3. Mining Structures

#### Pits or shafts

The 550 excavated extraction pits are concentrated in two areas (Figure 3)—the widest area located in the southern part of the excavation and the narrow area of the northern section. Drawing on Bostyn and Lanchon’s terminology (1992), we have identified five types of extraction structures (Figure 4):

#### Open holes

The first type of structures observed is located in the south end of the mining zone, at an altitude of 197m (NGF). These open holes vary in size and are mainly circular, with diameters ranging from 1.3 to 1.7m. Some of them are oblong or double spherical (‘8’ shaped), reaching 5 meters in length and 2 to 3 meters in width. These open exploitation structures cover an extended surface, forming a network of holes interconnected by thin trenches. The mean depth of open holes is 0.6m, but some reach 1m. The top of the layer which contains flint is at the depth of 0.4m from the surface. The walls of the holes are generally vertical, but sometimes they are bell-shaped.

#### Holes with chambers

The second category of structures is located at an altitude of 198m (NGF). This category is composed by circular holes, with diameter of 2 to 2.8m. The exploitation of these holes is extended in one or many directions by 1.2 meter-deep subsurface cavities. In this type of hole a miner could work on his knees. The mean height of the chambers is

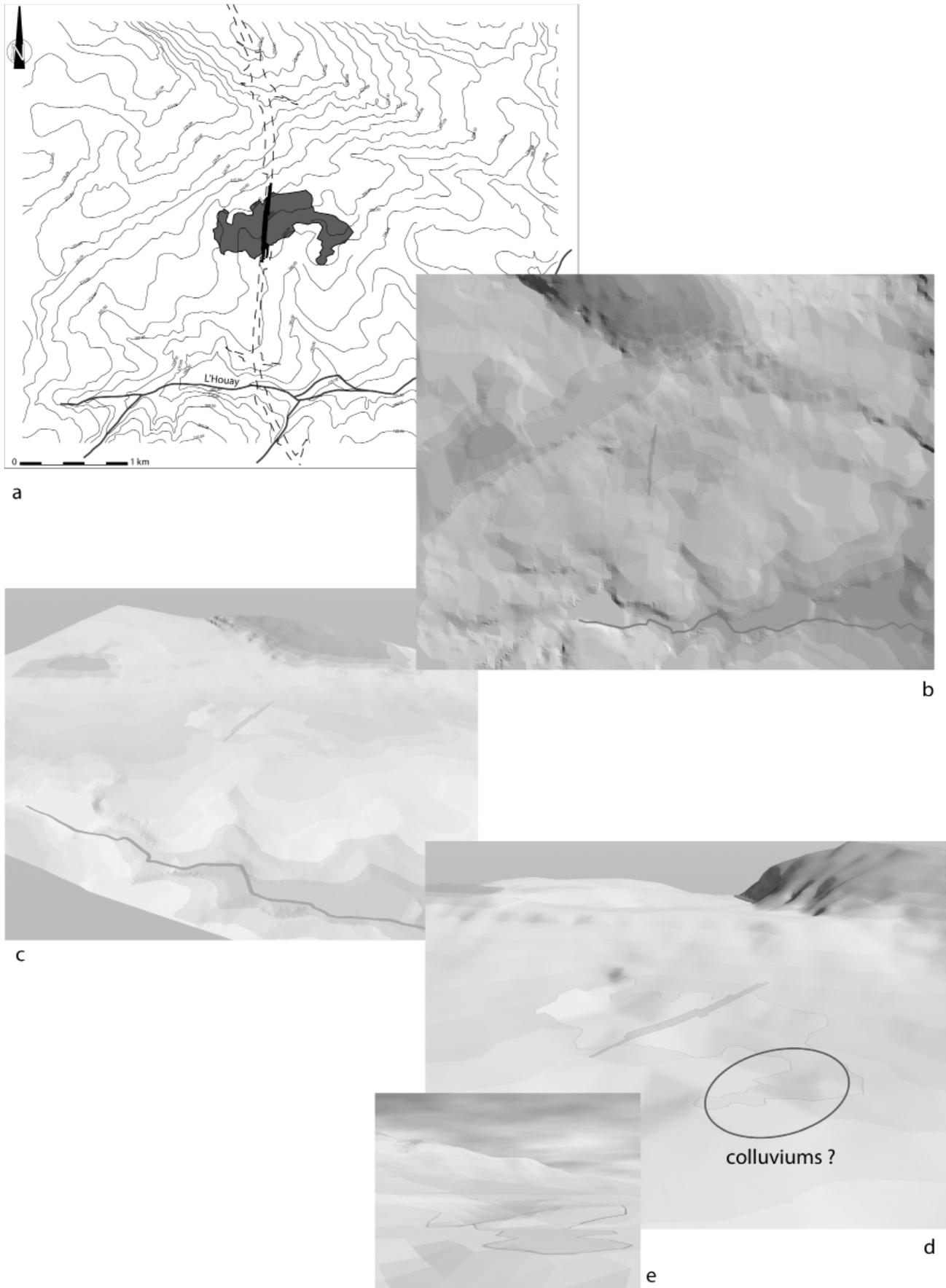


Figure 2. Estimated surface of the mine by land prospection (a and b). The 3D model of the artefacts position shows an area which could be disturbed by colluviums (d and e) (DAO, L. Vipard, Inrap).

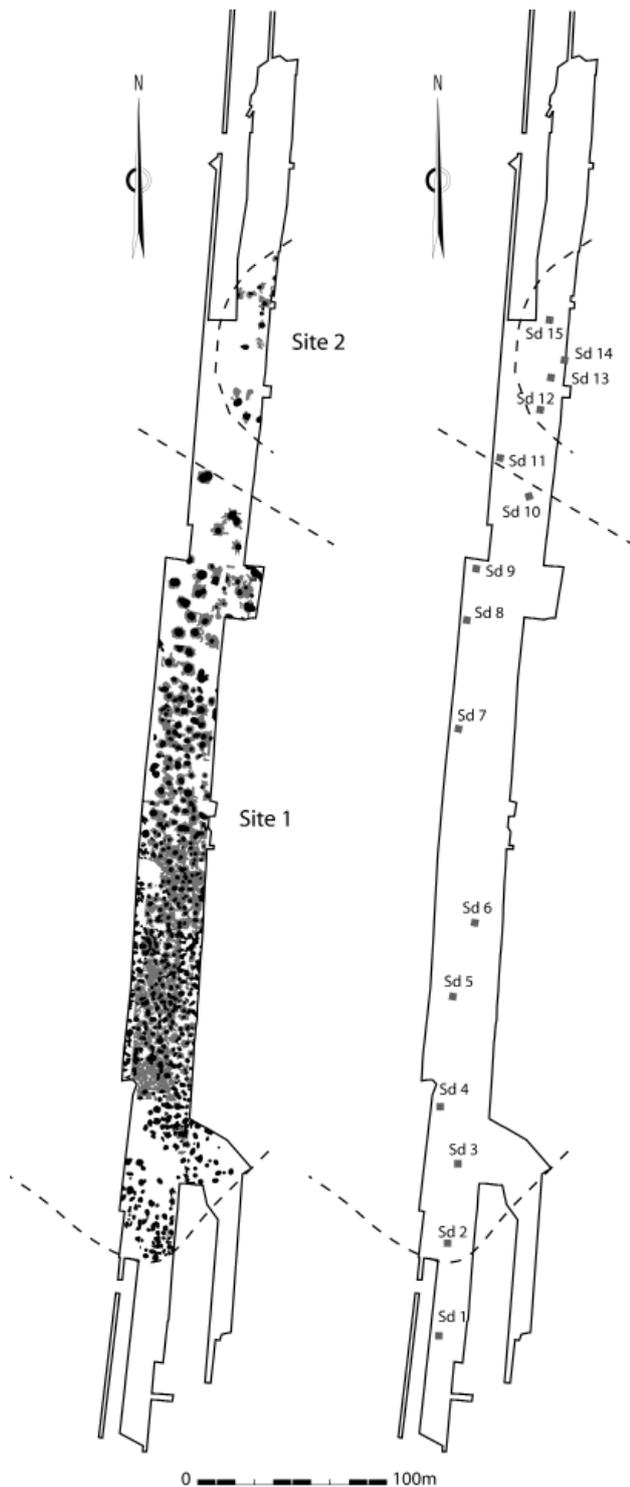


Figure 3. General scheme of the mine showing the two concentrations and the distribution of stratigraphic drillings (DAO, J.M. Palluau, Inrap).

0.8m, with the diameter of vertical access measures less than 0.4m. The layer with flint containing these holes with chambers is located at 0.8m from the surface of the mine.

#### *Pits at medium depth*

The third category corresponds to pits of medium depth, located at a 200 meters altitude (NGF). The pits of this

category are generally situated at a 1.3 to 1.7m depth and are bell-shaped. As in the holes with chambers, the access is vertical, but here, its mean diameter is 2m. The exploited surface is 5m in diameter and 0.5m high (corresponding to the thickness of the layer with flint). At the bottom the pits contain some flint nodules, suggesting that the extraction took place primarily there, and their height simply facilitated miners' activities. Some pits of this type are characterized by a trench. These pits with trenches form a network of open galleries. This configuration of the structures of extraction permitted the optimization of production (Figure 5). This type of pits is dominant in the areas accounting for 90 percent of the exploited bedrock flint.

#### *Deep pits*

Deep pits constitute the fourth category of structures. While some of them are observed at a 200m and 201m NGF, others are situated in the north (200m from the first ones) at a 204m NGF. Their distribution between two different areas marks one of their distinctions. In the north area, the pits are scattered and the flint nodules are very gelifracated. The form of pits is circular to sub-circular, and their diameter and depth vary from 2m to m and 1.7m to 2m respectively. The thickness of the exploited layer of flint ranges from 0.5m to 0.6m. The access of pits is conical and serves as a central space connecting numerous galleries.

#### *Very deep pits*

The last category of pits is observed at considerable depths. These sub-circular structures, located at 201m to 203m (NGF), have a mean diameter of 5m. The mean depth of these pits is 2.3m, but some reach 4m (example of St. 643). The 0.6 meters- thick exploited layer is situated at the depth of 1.6m. The access of the pit is conical because of the instability of the substratum due to weathering. The exploitation of the layer occurred in different chambers connected to large central spaces. Sometimes, two layers of flint have been exploited, and the depth of pits then reaches 4m. To reach this second layer of flint, an access of 2 to 3m in diameter was made following the same axis as the first one.

#### **The network of structures**

The main parts of different structures are connected in a subterranean network. They still, however, have the appearance of separate structures. The design of bell-shaped pits connected to chambers or galleries apparently functioned to maximize the yield of exploitation and allowed the workers to meet during the extraction process. A 3D representation of the network shows a structure with a flat bottom, which corresponds to the exploited flint layer, and many arches working as pillars for the roof support. The management of the mining spoil sometimes consisted in stacking up small limestone plates. This layout has the profile of a dry fortification which may be used to prop up the roof, but most importantly to reduce the quantity of spoil that

has to be removed from the chambers or galleries to the surface of the mine. The pits are systematically filled after their exploitation as represented by the cone of dust visible on the sections of structures. This choice of backfilling the pits seems to be related to the objective of minimizing the amount of dust removed from chambers and galleries.

Small sized pebbles of flint were left on the bottom floor of these structures, probably discarded after the initial selection of bigger size or better quality nodules. Some of these nodules had first been tested before their abandonment.

### The debitage accumulations

The debitage accumulations are abundant surrounding the mouth of pits at Ri. Although they are present in different forms, some rare and small accumulations are found in the loamy upper horizons, situated at 200m to 202m NGF. To understand the conditions of their conservation we selected an area of 1200 square meters for a detailed excavation. The report of this area shows the presence of large heaps and empty areas. These empty areas may be the prints of some accumulations after their disturbance.

One of the thoroughly excavated debitage heaps contained a superposition of layers of flint flakes. Unlike the debitage accumulations present at the pits' bottom and in the spoil heaps, the disposition of accumulations at the top is controlled by the topography of previous heaps (Figure 6). The quality or the type of flakes found here differs from the quality of flakes present in the pit's bottom accumulations.

## 4. The Mining Tools

The ways in which pits were dug are identified through the types of tools left by miners in the mine, but also through the traces documented on the walls of chambers, galleries and pits. The most frequent traces found on the walls are thin grooves, 1 to 2cm wide and less than 40cm long. Their section is sub-circular and their extreme end circular, sometimes dissymmetric. The traces are generally grouped and their features are indicative of the deployment of a pointed tool.

In addition to giving us clues about the model of excavation, these traces allow us to reconstruct or imagine the miners' gestures. At the end of galleries, numerous traces cover the walls of excavations, showing the technique deployed for digging mining pits. The miners used here an angled pick, as evidenced by the short traces around flint pebble prints, and their movements or strokes were downward. Some differences however appear in digging techniques, notably in the pit St. 457, where the gestures alternate first from right to left, and towards the end from left to right (probably traces of a right-handed miner) (Figure 7). The mining tool here could have been a deer antler,

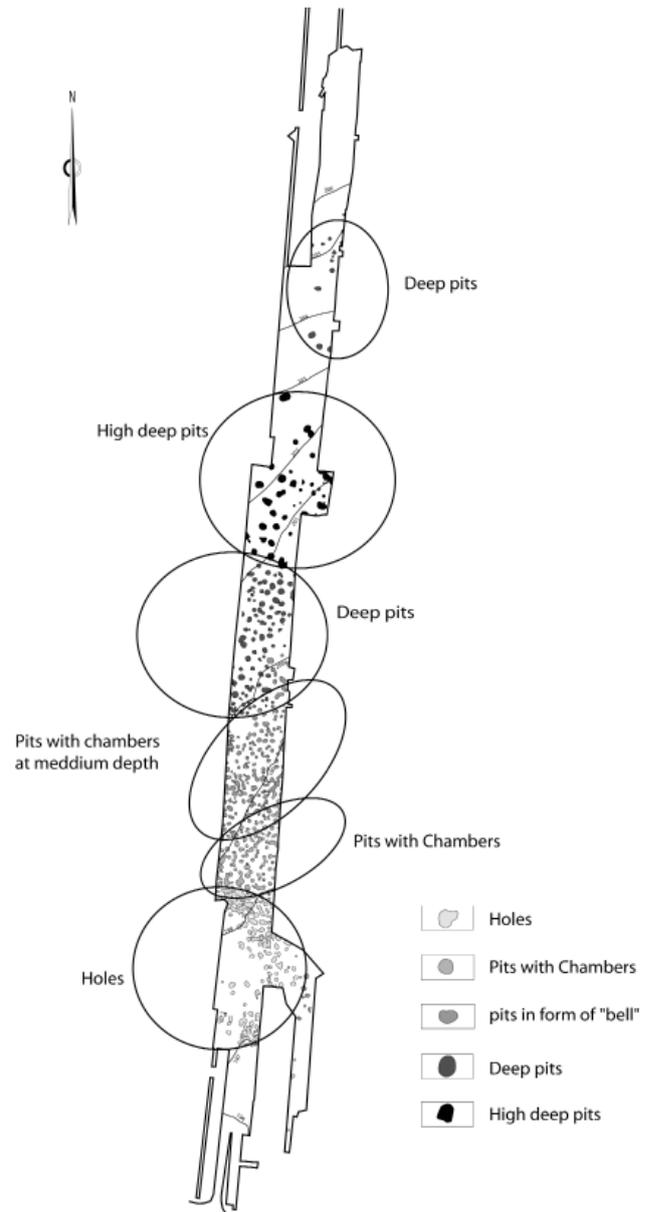


Figure 4. Types of pits or shafts with topographic curves in m; DAO, J.M. Palluau, Inrap).

as confirmed by our experiments and the great quantity of this type of tool in the pits.

Other traces are observed on some walls and flint pebbles in very deep pits. These traces are thinner and shorter (fine grooves) than those described above. They are mostly observed on hard surfaces (flint cortex or hard limestone) that are more resistant for a digging using antler tools. Our experiments have showed that the tool was probably a flint pick. However, the use of this tool is restricted to the bottom of very deep pits and of secondary importance to the mining activity, which is also the case for the use of cortical pieces of flint. At the bottom of very deep pits, two concentrations of charcoal evidence the use of torches for the lighting. However, it is still difficult to confirm this hypothesis or correlate it with the traces of torch flames.

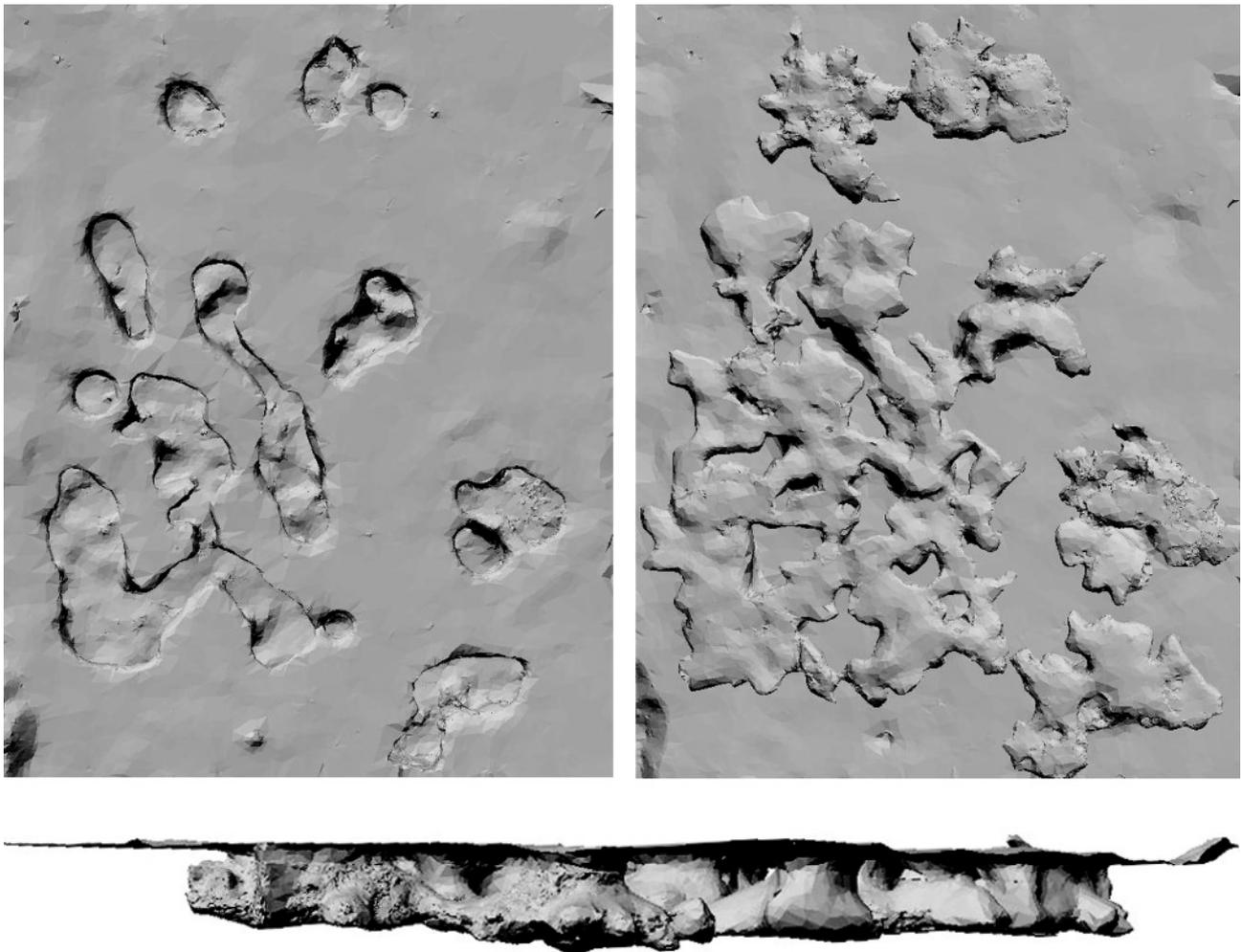


Figure 5. 3D scan of an area of the mine. At the left: view of the opening of pits. At the right, a view of the bottom of structures showing the density of the exploitation surface. Down: side view of the area with pits of 1.6 m depth in the limestone (ATM3D profile).

The hypothesis of the possible use of wooden mining tools is not excluded either. The presence of elongated grooves (more than 50cm length) on the walls of galleries, principally on roofs, may attest to the use of stakes as digging tools. These traces are straighter and wider than the traces left by antler tools. The plaster cast of these traces and the restitution of positive forms using a polyurethane rubber were successful just for two pieces from the structure St. 361. The analysis of the positive shows that the traces are of branches or small tree trunks ranging from 1.3 to 0.5m in length. The extremities of these wood pieces are broken. Whether they were used as stakes or were parts of a ladder still remains an open question.

#### **The main digging tool: red deer antlers**

In the course of the excavation of Ri, the team recovered 427 fragmented red deer antlers, which represents the largest quantity of deer antlers discovered in the flint mining complexes of the north-western Europe to date.

The antlers were well preserved as a consequence of their abandonment in depths of 1.5m to 2.5m. Deer tools have not been recovered in all mining structures: deer antler remains are found in only one third of the pits (with a mean of 10 tools per pit). The analysis of the preservation of these tools and their layout at the bottom of the pits suggests that some tools were lost while others (2 or 3 antler pieces) were probably purposefully discarded.

Twenty-eight percent of the recovered deer antlers have observable traces of cutting using the fire brake technique, currently recorded only at the mining sites of the Durrington Walls and Grimes Graves (Clutton-brock, 1984) and absent in the others contemporaneous sites in France. The typology of tools (Figure 8) gives little new information about the mining activities. Their shapes seem to be strictly related to the structure and characteristics of the substratum layers. Hence, the preferential use of short or very short tools (picks, tips) and the occasional presence of pickaxes and crowbars.

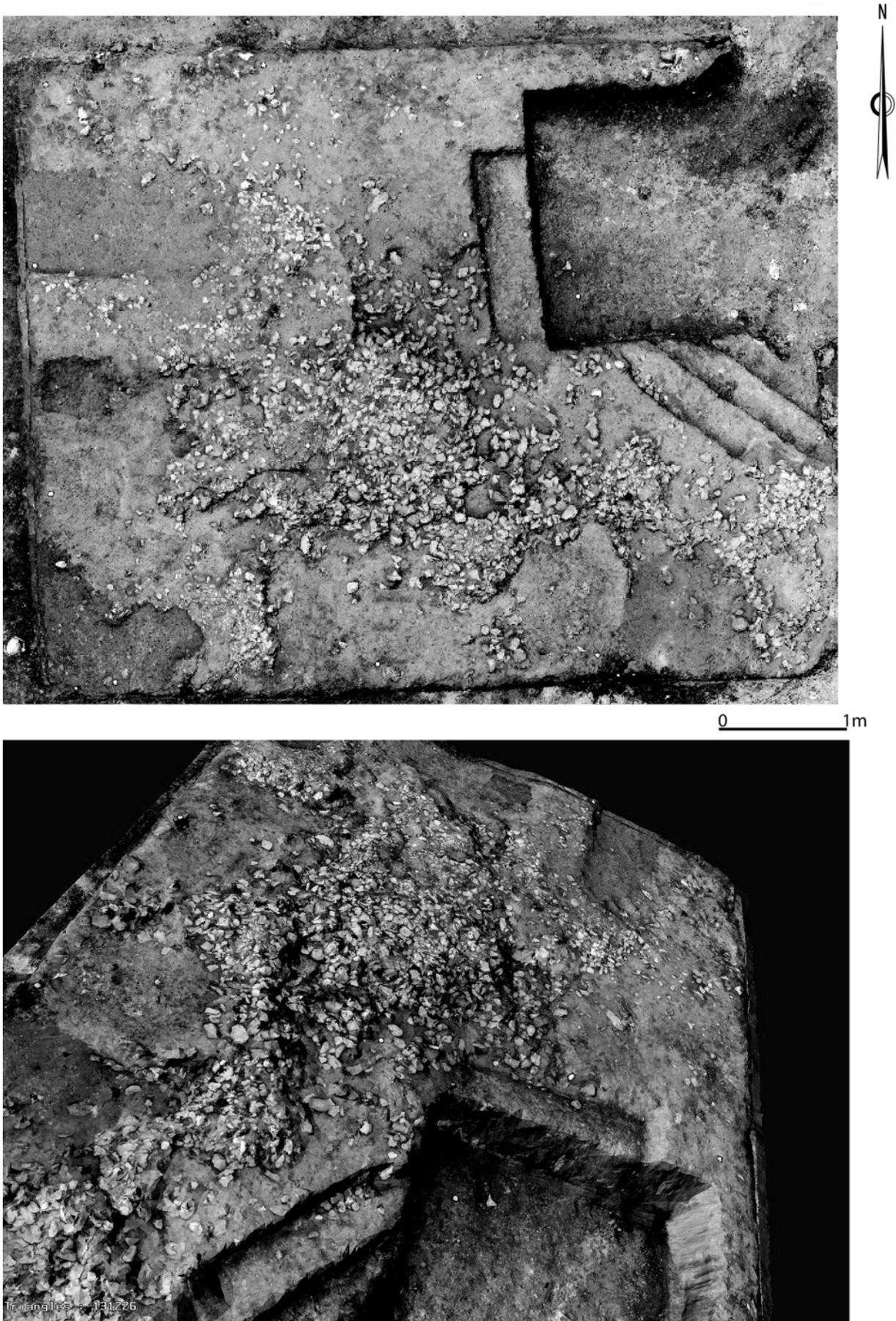


Figure 6. 3D scan of a debitage accumulation (ATM 3D profile) and precise view of its profile.

The use of red deer antlers in the mining activities at Ri constitutes the site's principal similarity with other mining sites. The percentage of deadwood versus killingwood antlers, the ratio between right and left antlers, the weakness of tools and the technique of wood cutting are also statistically similar to those of known flint mining sites. The observable differences among some characteristics such as the shape and the size of tools are closely related to the specificities of each flint mine and bear no cultural significance. The most substantial difference between the tools found at the mining site of Ri and those recorded at other mines in France is the aforementioned use of fire cutting technique, pointing to the possible connection to the English examples.

## 5. The Chronology of Exploitation

The chronology of the exploitation of the mine has been one of the main questions of this project. Since the start of the excavation at Ri, we have been studying the elements characterizing the phases of exploitation of the mine—its initial construction, evolution and abandonment. Although only a small part of the estimated mining complex has been excavated, the recovery of an important number of faunal remains allowed us to address the question of the mine's chronology.

The nature of the recovered artifacts and their stratigraphic significance complicates the task of establishing dates. Some artifacts, such as the ceramic fragments found in one of the pits at Ri, cannot be used for diagnosing the start or the end of the pit's exploitation. In most cases, ceramic fragments are present in trapped soils during the packing down of sediments in partially filled structures or in filling sediments of totally overflowed pits.

For radiocarbon dates, we have chosen to use only deer antler remains deposited at the bottom of pits. This choice is meaningful because the type of material directly bears on the interpretation of the link between the 'radiocarbon event' and the 'human activity event' (i.e. antler decay and antler gathering). Although killingwood is the best type of antler, we have chosen deadwood samples because of their potential to provide us with the data which would allow a more nuanced spatial examination of the evolution of mining activities.

A total of 28 radiocarbon dates were obtained on deadwoods recovered from 7% of pits containing antlers. At Site 1, 27 date measurements were performed on this material (Figure 9, 1 date by AMS: Lyon-4370-OxA), allowing the dating of the entire surface of the excavation, while on Site 2 only one date was obtained, due to lack of good material suitable for analysis.

The dates obtained at Ri reflect the use of two types of mining structures. The date obtained on site 2 is 500 years

(in BP) younger than those of the site 1 (Figure 9). The old part of the mine, on the surface of excavation, appears to have been exploited between 4100 and 3700 cal BC. The exploitation lasted three centuries, excluding the dispersion due to the dates between 5255 and 4985 BP. Although this figure sounds impressive, the number of structures of extraction (more than 5000 pits) could explain the longer time of the mine exploitation (considering that the surface of the excavation is representative of the total surface of the mining complex). This means that 20 to 30 pits were opened every year (2.5 in the area of excavation). The figure falls close to those obtained in others mines such as Jablines (Bostyn and Lanchon 1992). The site 2 is dated to the second half of the 4th millennium—the date obtained from the sample of a deer antler recovered from pit St. 1094. This result has yet to be correlated with the rest of the mine's surface.

## 6. The Production

The analysis of the debitage material from Ri and of the correlation between the limits of technical possibilities (in the production of flint axes) and the results obtained have led us to conclude that the technical system was not specialized. The examination of the technical protocol of axe production shows that such activity does not require specialization (Figure 10 and 11). The extraction and manufacture of flint axes are then characterized by a low level of skills, which each member of the community could obtain and develop. Sometimes the miners had to adjust to environmental changes, but such adaptations were most certainly spontaneous or transmitted to the rest of the group by the more qualified workers. However, these qualifications did not immediately give these individuals the status of specialists. As Augereau and Pelegrin (2005), we argue that the knowledge of mining techniques and practices was transmitted through copying.

Calculation of the mean surface of pits allows us to estimate the quantity of flint extracted in each structure of the mine. Based on this estimation, we have concluded that 200kg of flint can be dug out from small holes, 500kg to 1 ton from pits of medium depth. This quantity could reach 3.5 tons in the deepest pits. The experiments realized to estimate the ratio of flint axe pieces to the weight of material mined at Ri have showed that a total of 15 axes could be produced using 194kg of flint raw material. Taking into account the total number of pits in the mine, it was possible to manufacture 15 flint axes from the material extracted from each small hole, and more than 250 pieces in the case of deeper pits. The time needed to obtain a roughout was experimentally estimated at 30 minutes to one hour, but it is still difficult to estimate the time necessary to transform it into a finished product, especially since there are many techniques of time optimization and improvement of productivity such as the pressure during polishing operations.

The number of flint axes produced at Ri, estimated through our calculations or predictions, cannot be treated as an accurate figure representing the actual volume of production in the mine. There is no guarantee that the all flint extracted from the mine was intended for flint axe production. The percentages of the area of the mine that underwent exploitation vary from 40 % in the south end to 60 % in the north, and to more than 90 % in the central part of the mine. Therefore, our estimations are based on the mean of 70 % of the mine and given that 2010 square meters surface was excavated, resulting in approximately 2000 tons of flint mined and 1.5 million of flint axes produced.

The question of the circulation of products manufactured at Ri cannot be currently addressed. It is bound to be an exciting and ambitious but also very difficult to realize project, considering the difficulties of flint facies identification of all the substrata (limestones with flint) in the Plain of Caen such as those of Bretteville-le-Rabet (Desloges 1986; 1999). Nevertheless, we know that the polished axes in Bathonian flints from the Plain of Caen have been found across Basse-Normandie, in small quantities in Haute-Normandie and Ile de France, and have not been traced in Brittany. On the other hand, in Basse-Normandie, Bathonian flint axes are less frequent than the axes made of tougher raw materials such as dolerite.

A large number of flint workshops were located at a two kilometer distance of the mine, and their number became scarce at a distance greater than five kilometers. This fact suggests that different phases of flint axes production (shaping, polishing) could have been completed by different communities.

## 7. Conclusion

The flint mine of Ri was discovered many years ago by ground survey. Although its total surface was initially estimated at 30 hectares and then adjusted to 25ha (based on taphonomic analysis of remains and dispersion by slope colluviums calculation), the construction of the A88 highway in this area of Normandy enabled us to excavate 2ha of the mine, oriented north-southward in width. In the sampling area, which represents 10 % of the estimated total surface, more than 550 pits have been discovered. Most of these pits have been excavated mechanically or manually. The mining structures are pits, characterized by an open and somewhat deep circular access area branching out into chambers or galleries in the flint layers exploited. These pits are classified according to their morphology and depth into in 4 sub-types –holes, bell-shaped pits or pits with chambers, mid-depth pits, and very deep pits.

Twenty-eight radiocarbon dates have allowed us to identify two phases of exploitation of the mine. The first phase of exploitation is estimated at 4100 and 3700 cal BC, corresponding to the second phase of the middle Neolithic,

and the second begins one and a half millennium later, as observed at Jablines, after the abandonment.

Different experimental approaches applied during this study have allowed us to improve our understanding of the techniques and methods employed by the miner of Ri.

## References

- Augereau, A. 2005. *L'industrie du silex du Ve au IVe millénaire dans le sud-est du Bassin Parisien. Rubané, Villeneuve-Saint-Germain, Cerny et groupe de Noyen*. Paris, Maison des Sciences de l'Homme. Documents d'Archéologie Française, 97.
- Bostyn, F. and Lanchon, Y. 1992. *Jablines, Le Haut Château (Seine-et-Marne): Une Minière de silex au Néolithique*. Paris, Maison des Sciences de l'Homme. Documents d'Archéologie Française, 35.
- Clutton-Brock, J. 1984. Neolithic antler picks from Grimes Graves, Norfolk, and Durrington Walls, Wiltshire : a biometrical analysis. *Excavations at Grimes Graves Norfolk 1972-1976, Fascicule 1, Dorchester* 1984, 55.
- Desloges, J. 1986. Fouilles de mines à silex sur le site néolithique de Bretteville-le-Rabet (Calvados). *Revue Archéologique de l'Ouest*, 1er suppl. Actes du Xème colloque sur le Néolithique 1983, 73-101. Caen, Pôle éditorial de l'Ouest.
- Desloges, J. 1990. L'extraction minière du silex au Néolithique et l'exemple de Bretteville-le-Rabet (Calvados) EHESS. Polycopié.
- Desloges, J. 1999. Une mine de silex au Néolithique, l'exemple de Bretteville-le-Rabet. In *L'exploitation ancienne des roches dans le Calvados, Histoire et Archéologie*. 52-77. Caen, Conseil Général du Calvados.
- Gigot, P., Dupret, L. and Le Gall, J. 1999. Carte géologique de la France 1/50 000, feuille Falaise (176), notice explicative. Editions BRGM, 154.