

Neolithic flint mines and quarries from Vaucluse (France): Assessment and review

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Abstract

Neolithic mines and quarries from Murs and Malaucène have been known since the beginning of the 20th century, mainly because hundreds of grooved mallets were discovered on these sites. These two mines are extremely important, on the one hand because of the size of the exploited areas (more than 250 ha each) and on the other because of the high quality of the remains which are preserved. Moreover during the Chassean period (4500-3500 BC) the raw material extracted in Murs and Malaucène was distributed all over the northwestern Mediterranean seashore and along the Rhone Valley. However, despite an early discovery, information available about flint extraction methods is still incomplete.

We will assess existing data, present the first results of our own work started in 2015 and outline the goals of the programme we aim to pursue.

Keywords: Mines, quarries, bladelets, grooved mallets, pits, shafts, workshops.

Résumé

Les mines et carrières de Murs et Malaucène sont connues depuis le début du XX^{ème} siècle, essentiellement pour les centaines de maillets à gorge découverts sur ces sites. Ces deux sites sont extrêmement importants, d'une part par l'étendue des exploitations reconnues (plus de 250 ha chacune) et d'autre part, par l'ampleur des vestiges qui y sont conservés. De plus, pendant le Chasséen, la matière première exploitée à Murs et Malaucène sera diffusée sur l'ensemble du pourtour de la Méditerranée nord-occidentale et le long de la vallée du Rhône. Toutefois, malgré une identification précoce, les données disponibles sur les modalités d'extraction pratiquées sur ces deux sites sont encore lacunaires.

Nous ferons un bilan des données existantes, présenterons les premiers résultats des recherches que nous avons entamées en 2015 et les objectifs du programme que nous entendons poursuivre.

Mots-clés : mines, carrières, lamelles, maillets à gorge, fosses, puits, ateliers de taille

1. INTRODUCTION

The lower Rhone Valley is the source of much flint used since the Palaeolithic, and intensively exploited during the Neolithic period by mines and quarries (Fig. 1). The Lower Cretaceous levels (Bedoulian stage, part of the Aptian stage) from the Vaucluse contain high quality flint frequently called 'blonde flint'. It was extensively used in prehistoric times especially during the Middle Neolithic (Chassean period), and reused in Modern Times to make gunflints. At least four extraction areas are known in Vaucluse: Châteauneuf-du-Pape /Orange, Monieux /Sault, Murs and Malaucène (Fig. 1).

Flint outcrops located in Murs and Malaucène are known to have been exploited by mines or quarries since the end of the 19th century. The two others were identified more recently. Murs and Malaucène are considered to be the most important of the Vaucluse. To date, we still do not know much about these sites. Consequently we felt it was pertinent to restart research activities to try to better characterise them.

We shall begin by drawing together the current state of knowledge from an analysis of previous research combined with the results of our preliminary investigations. We shall also

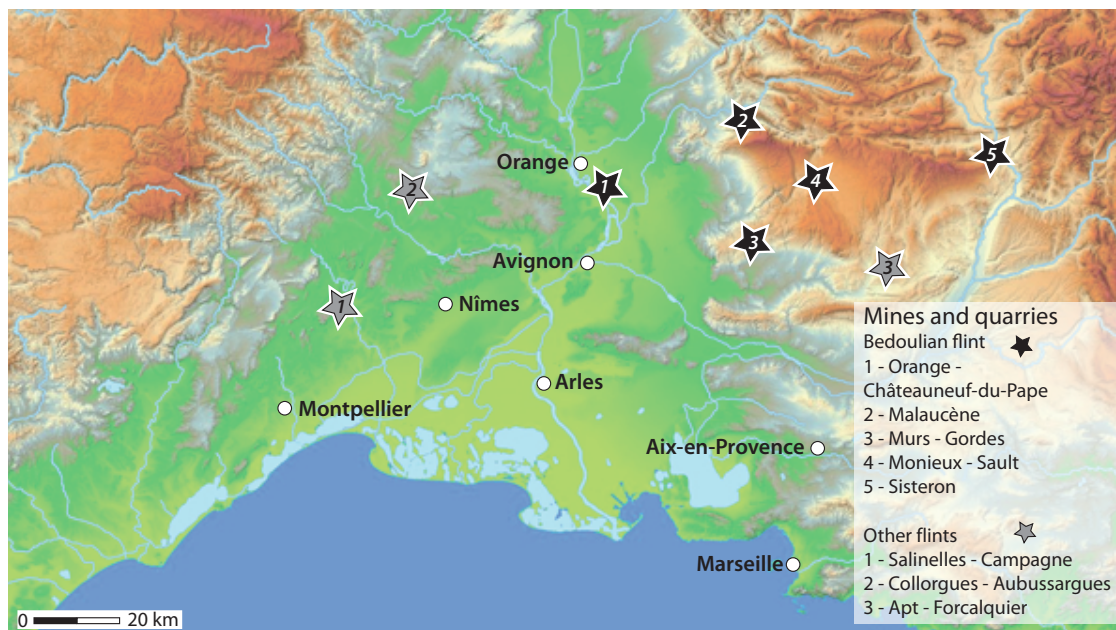


Fig. 1 – Maps of the flint mines and quarries from lower Rhone Valley and Provence.

develop proposals regarding the areas of future research which we would like to be able to develop within the framework of the programme which we have already begun.

2. LOCATION OF THE SITES, THE GEOGRAPHIC AND GEOLOGICAL CONTEXTS

2.1. Murs

The municipality of Murs is situated on the south side of the Vaucluse Mountains between 400 and 650 m in height, approximately 35 km east of Avignon. The territory presents contrasting landscapes of fields, orchards and wooded spaces. The mines and quarries that have so far been discovered are distributed on an arc about 7 km long, situated on the western side of the municipality (Fig. 2). They overflow slightly into the nearby municipality of Gordes to the South. The zones of extraction do not exceed 400 m in width, they are intermittent and cover a total area estimated at approximately 250 ha (Fig. 2). They are located on small plateaux, generally forested but sometimes cultivated, which overlook generally dry valleys.

2.2. Malaucène

The municipality of Malaucène is located on the northwestern slope of Mount Ventoux, around 30 km east of Orange. The main extraction zone is in the north-east of the municipality of Malaucène, near the hamlet of Veaux. This sector, called 'Plateau of Rissas', covers 1.5 km from east to west and also from north to south, providing a surface area of between 200 and 300 ha (Fig. 3). It is restricted to the north by the gorges of the River Toulourenc which has a steep south/north slope (height between 500 to 300 m). It is cut by about ten dry coombes, known as the 'Coombes of Veaux', between 30 m and 50 m deep. They are very narrow at their base, and open up to 200 m wide at their summit. Their slopes are often very steep or even vertical. It is in these coombes, on the

bottom, along the slopes and at the summit, that evidence of flint exploitation is most important.

There are also zones of extraction beyond the Plateau of Rissas, in particular in some coombes on the right bank of the Toulourenc River. They are located within the municipality of Mollans-sur-Ouvèze (Drôme) and in the 'Grande Combe', in the municipality of Malaucène, east of Rissas (Fig. 3). This whole zone, between the Drôme and Vaucluse, forms the Veaux Basin which covers approximately 1000 ha. Today the vegetation consists mainly of scrub which is difficult to penetrate. There are also numerous scree slopes where the vegetation is absent.

The geology in the Veaux coombes is restricted to a single layer of Urgonian limestone (n5U3). In the Veaux basin, on both banks of the Toulourenc River, this unit is overlain by the Burdigalian limestone.

3. HISTORY OF RESEARCH

3.1. Early 20th century grooved mallet 'hunting'

From the end of the 19th, and more particularly at the beginning of the 20th century, numerous amateur prehistorians explored the quarries of Murs and Malaucène, their main interest being the acquisition of grooved mallets. These were collected by the hundreds (Fig. 11-13). Their discovery generated a plentiful literature peppered with intense debate about the age of these objects.

However, these pioneers of prehistory quickly made the connection between the tools, the vast workshops in the middle of which they were found, and the acquisition of flint. After a visit to Malaucène, Dr. Paul Raymond gave one of the first descriptions of the mining evidence. He describes *'important open-cast mining or in the form of shafts. There is not only a workshop, but still quarries where the raw material was extracted, rough-hewed and partially shaped (...). We meet there (...) colossal accumulations of fragments of flint, flint flakes, mixed with fragments of the calcareous rock (...). To give an idea of the importance of these cuttings (...) A coombe (...)*

showed two banks of fragments covering its natural hillsides and having not less than about thirty metres in height and about twenty wide at the base. These banks (...) consist only of flint debris, flakes, more or less finished tools, hammerstones, and lastly mallets. (...) This important exploitation of flint occupies a considerable area (...)' (RAYMOND, 1905, p. 18). He does not hesitate to compare this site to Spiennes but also to several other mines in the North of France.

In his article of the 1930s summarising his work on the municipality of Murs, André Vayson-de-Pradenne gives a very edifying description of what he saw in the first years of the 20th century: *'a visit to the sites was then really striking; we saw at the same time at the scene the enormous mass of the waste from flint knapping and the number of extraction tools proportionate to this mass, still in place, as if the old quarrymen had left the work a few years previously'*. He adds that *'the fragments of split and partially crushed limestone mixed with the waste of the flint reaching in places a thickness of about two metres'* (VAYSON-DE-PRADENNE, 1933-1934, p. 147).

All the researchers of this time were impressed by the extent of the quarries which they investigated and by the mass of evidence. A. Vayson-de-Pradenne summarises things well by evoking *'[the] first signs of the modern industrial spirit'* (VAYSON-DE-PRADENNE, 1933-1934, p. 178). This intense pioneering research ended with World War I.

3.2. 1920-1970, the search for the settlements of the quarrymen

After this pioneering craze, interest in these sites becomes blurred. Between the 1920s and the beginning of the 1970s there was nevertheless some work on the quarries of Malaucène. The research question then was to establish where the settlements of the quarrymen were and what they were like. To try to answer this, limited excavations were carried out in the 'Grotte du Levant de Leunier' and in 'Abri Grangeon', both found in the heart of the extraction zone.

The 'Grotte du Levant' opens into the coombe of Leunier, half way up the slope. It is a

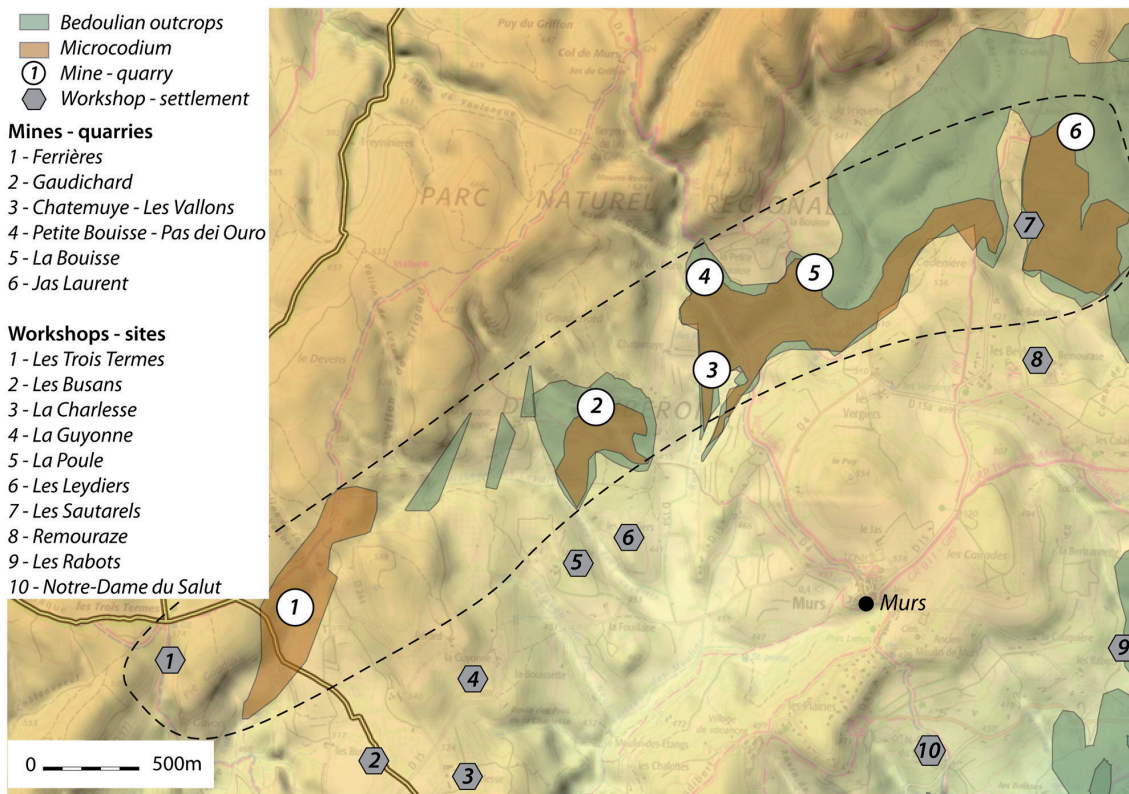


Fig. 2 – Murs, location of the sites.

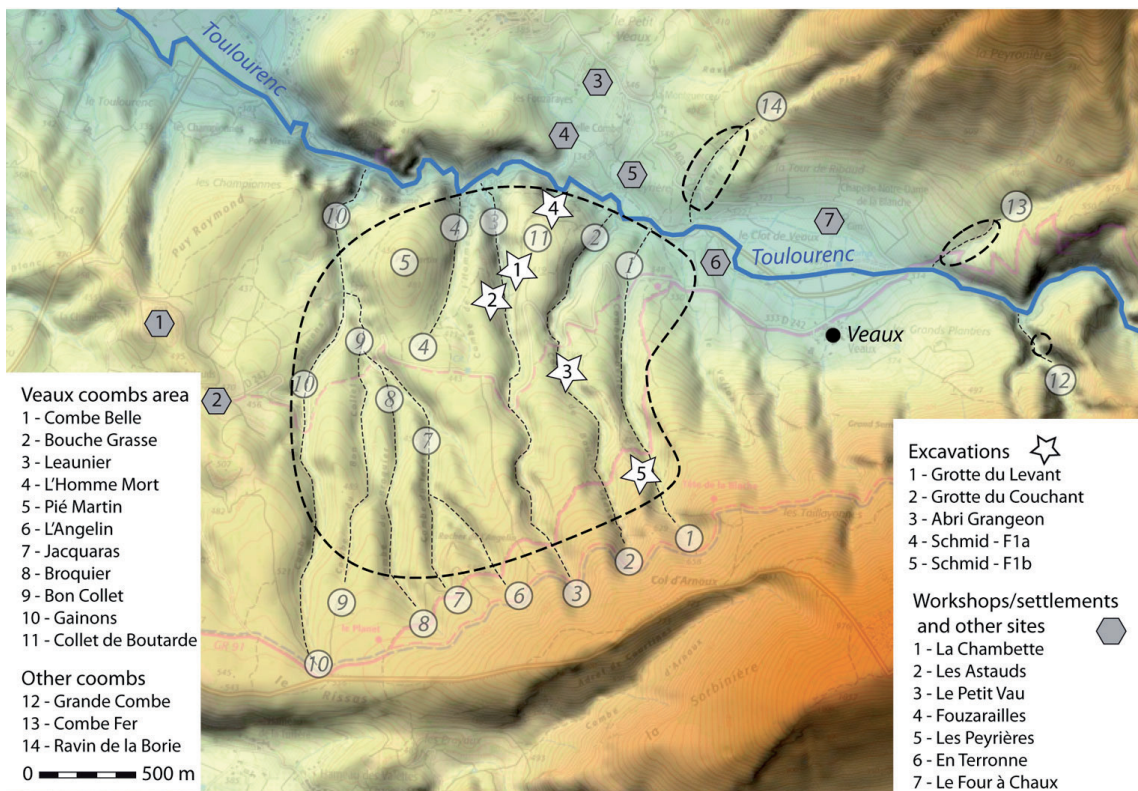


Fig. 3 – Malaucène, location of the sites.

cavity of 13 m x 7 m, with a maximum height of 2 m. It was excavated by the brothers Louis and Auguste Catelan between 1920 and 1922 (CATELAN & CATELAN, 1921, 1922), by Louis Gauthier in 1953 (GAUTHIER, 1953) and Albert Barthélémy between 1956 and 1959 (BARTHÉLÉMY, 1952-1956, 1955). The substratum was never reached in spite of archaeological probings 3.8 m deep. Seven stratigraphic levels were identified by A. Barthélémy (Fig. 4). They were an alternation of layers containing vestiges of extraction with other layers showing signs of apparent domestic use. They revealed occupation spanning the Middle Neolithic to the Final Bronze Age (BARTHÉLÉMY, 1952-1956; BUISSON-CATIL & VITAL, 2002, p. 213). The Chassean culture was very strongly represented.

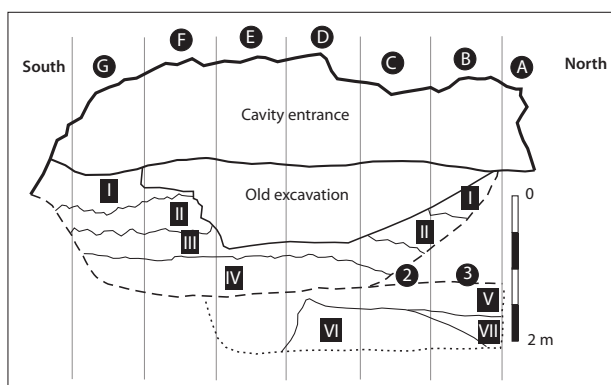


Fig. 4 – Malaucène 'Grotte du Levant de Leunier', cross-section. After BARTHÉLÉMY, 1952-1956.

- Layer I: Modern use of the cave (sheepfold; gunflint workshop);
 Layer II: Dispersed limestone and flint nodule fragments;
 Layer III: Black sediments (probable hearths) and archaeological material (ceramics, blades and bladelets);
 Layer IV: Extraction and knapping activities, presence of 'knapping waste concentrations', but 'without nice blades, pottery, fireplaces, bones';
 Layer V: Black unconsolidated sediment (ashes and charcoal indicating possible hearths, ceramic sherds and bone fragments);
 Layer VI: Extraction and knapping activities, 'cemented deposit with dust made from flint and limestone', flakes;
 Layer VII: Extraction and knapping activities, 'unconsolidated deposit', 'rubbles, mixed with yellowish clay', numerous flakes, tools and bones.

The 'Abri Grangeon' (7 m x 3 m, with a maximum height of 2 m) is located in the base of 'Bouche Grasse' coombe. It was almost totally excavated by Jean Vincent between 1966 and 1970 (VINCENT, 1966; VINCENT & DUBOIS, 1972). Its spoil heap has been re-excavated and sifted recently (ANDRÉ, 2013; ANDRÉ & LÉA, 2013). In spite of excavations to 1.8 m deep the substratum was not reached. The stratigraphical sequence contains eight layers, some consisting of blocks of limestone, sometimes compacted, corresponding extraction waste, and others containing quantities of ash or with clay deposits dominant (Fig. 5).

At both sites an important number of artefacts were collected.

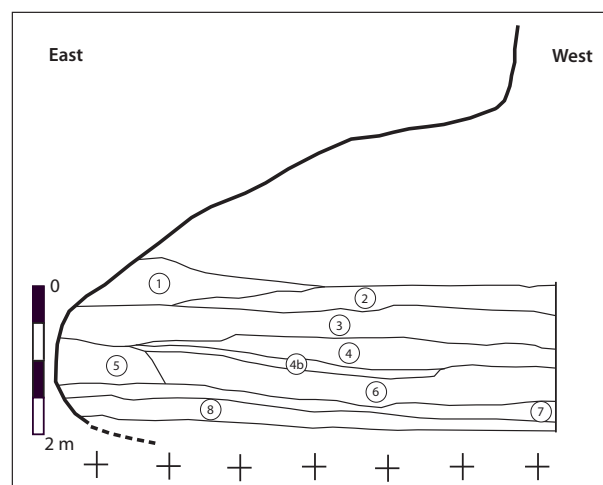


Fig. 5 – Malaucène 'Abri Grangeon', cross-section. After VINCENT & DUBOIS, 1972.

- Layer 1: Rubbles originating from the walls;
 Layer 2: Limestone nodules and brown sediment;
 Layer 3: Limestone blocks (8-4 cm) and numerous large black flint flakes;
 Layer 4: Ash rich deposit (hearth), small burnt limestone blocks and numerous artefacts (struck flint, ceramic, bones);
 Layer 4b: Layer of brown compacted sediment with only few artefacts and stones;
 Layer 5: Limestone blocks from the vault or from the outside, partly cemented;
 Layer 6: Same as layer 5 but less consolidated and with some artefacts;
 Layer 7: Layer with ashes and burnt limestone blocks, few flint flakes;
 Layer 8: Clayey compacted sediment.

3.3. 1950-1960, mines and quarries, the rebirth of interest

In 1959, then again in 1962, Elisabeth Schmid undertook two excavations at Malaucène on the vestigial remains of the mining features. She published two articles (SCHMID, 1960, 1963) and a synthesis (SCHMID, 1980). Published in German, these works were not influential in France, although Jean Courtin mentioned them because of his appointment to oversee her excavations (COURTIN, 1974, p. 187-188).

The excavation F1a was opened in 1959 at the foot of the plateau of 'Collet de Boutarde'. E. Schmid had initially planned to dig out a trench of 9 m in length and 1.5 m in width. Facing technical difficulties, she finally limited her trench to two test pits. The stratigraphy was divided into two main phases: in the first metre is evidence of gunflint production, below which is up to 3 m of waste produced by Neolithic extraction. The substratum was not reached. The Neolithic layers consisted of limestone rubble mixed with flint flakes.

The excavation F1b was opened in 1962, in the high part of 'Combe Belle', perpendicular to the valley. It is a trench of about 15 m in length

and 7 m of maximum width, and 6 m deep. 170 m³ of material was removed during the excavation consisting solely of waste produced by Neolithic extraction. This contained a large number of flint flakes, no tools, but a half-dozen broken mallets. At the base of the trench a small part of the calcareous substratum was revealed.

It is from these two limited excavations that E. Schmid proposed the reconstructions that she published in the Bochum catalogue (SCHMID, 1980, fig. 152, fig. 158). These plans were well received and sparked interest amongst the community of mining archaeologists (Fig. 6).

3.4. 1980-2000, the *chaînes opératoires*

From the middle of the 1980s Didier Binder, and then Vanessa Léa, proposed the first typo-technological analysis of Bedoulian blonde flint industries (BINDER, 1984; LÉA, 2004a). They highlighted complex *chaînes opératoires* which include the heat treatment of the flint, an identification of blade and bladelet debitage by indirect percussion or by pressure flaking. The whole mining operation appeared to facilitate a large scale production of standardised blades and bladelets during the Chassean period (4500-3500 BC).

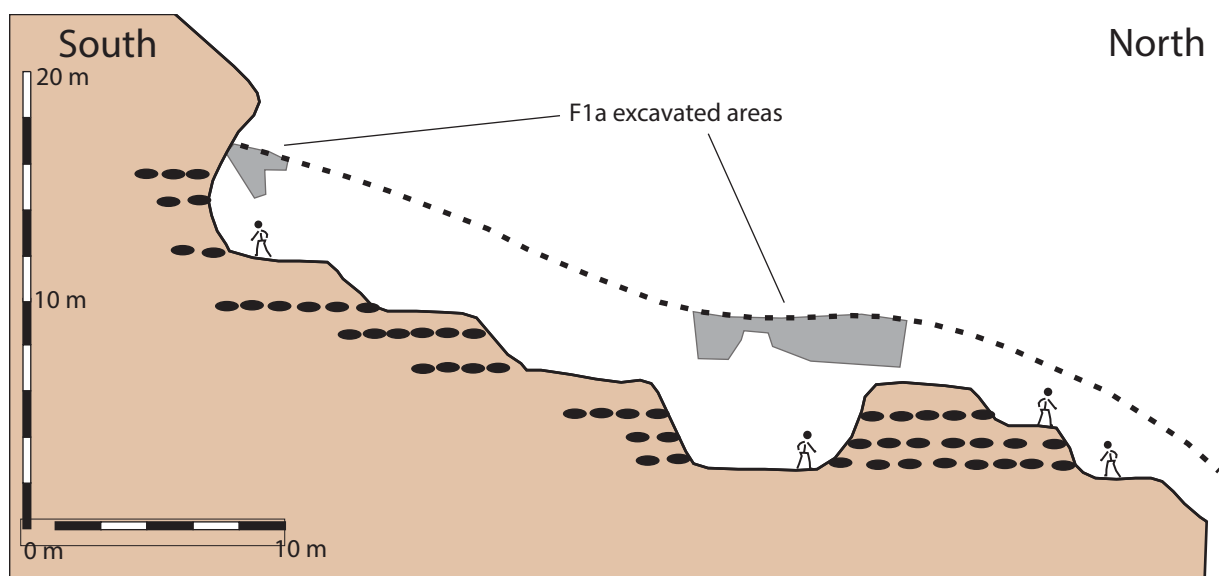


Fig. 6 – Malaucène, extraction diagram. After SCHMID, 1980.

3.5. From 1990s, raw material and lithothecas

Several researchers and teams now study the raw materials of Murs and Malaucène (AFFOLTER, 2002; BARBIER, 1996; BINDER & GUILBERT, 1996; FERNANDES, 2013; WILSON, 2017). There are a number of samples kept in different lithothecas. It is important to mention that there have been two attempts at characterisation by chemical methods (ASPINAL *et al.*, 1976, 1979; BLET *et al.*, 2000). In both cases it has proven the difficulties to differentiate between the Bedoulian flints of Murs and Malaucène.

3.6. Turn of the millennium, networks and diffusion

Following the analysis of the *chaînes opératoires* and the raw material, the distribution networks were then analysed. These studies, led by Didier Binder and Vanessa Léa, showed

that bladelets made from the Bedoulian flint of Vaucluse were distributed by networks extending for several hundred kilometres. They are found in Liguria, in Catalonia and in the Toulouse area (BINDER, 1998; LÉA *et al.*, 2004; VAQUER, 2012) and as far as the Valais region of Switzerland (HONEGGER, 2011).

In the Toulouse hinterland and in Languedoc, both finished products and cores were distributed, some not heat-treated, whereas in the most distant regions, such as Liguria and Catalonia, it is the finished products which are more often present including unheated blades, heated bladelets and arrowheads.

3.7. Today, a return to the processes of acquisition of raw material

In recent decades and in spite of the interest in the production of Bedoulian flint from Vaucluse, the extraction sites, the procurement

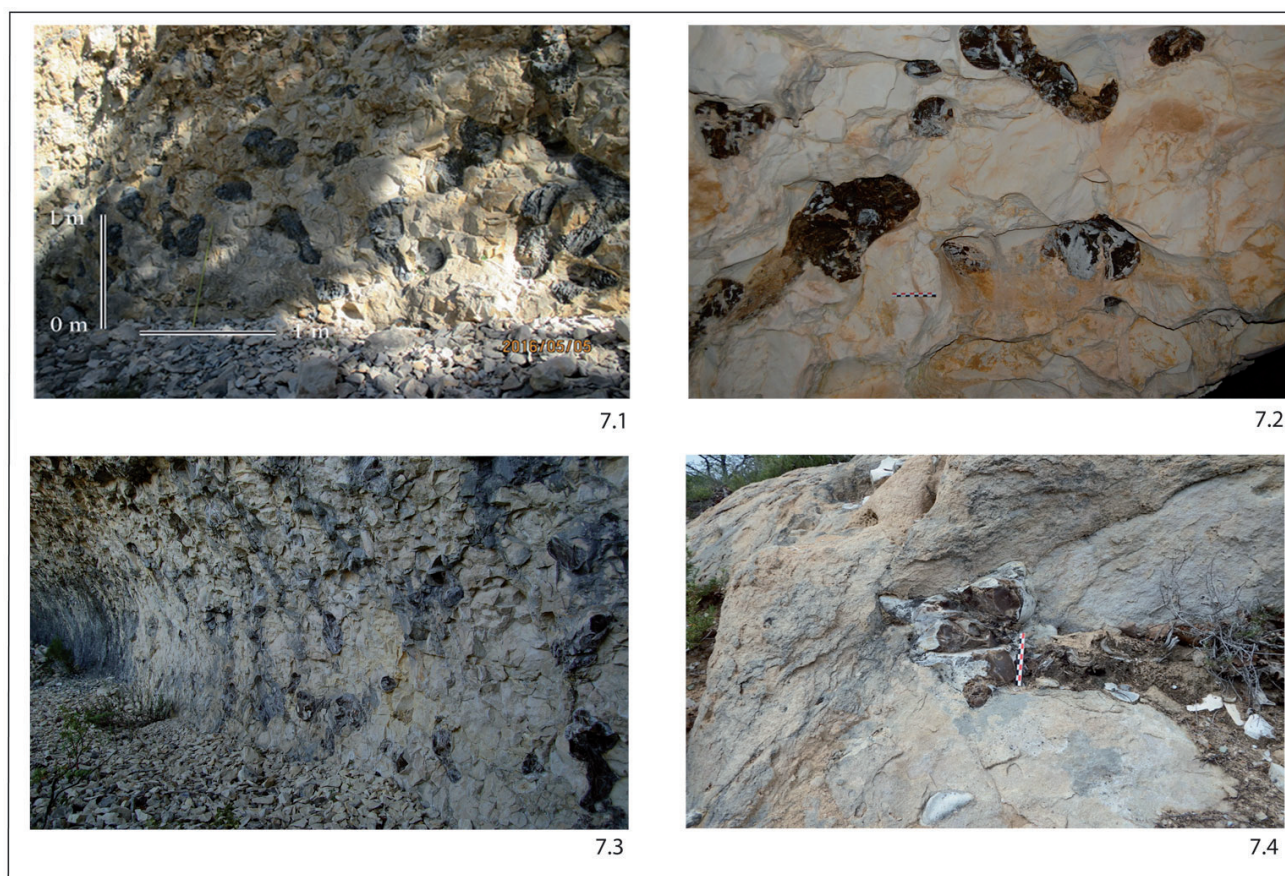


Fig. 7 – Primary flint nodule deposits. 1. Malaucène 'Grande Combe'; 2. Malaucène 'Grotte du Levant'; 3. Malaucène 'Combe de Leunier', face; 4. Murs 'Chatemuye/Les Vallons'.

and the preparation of the raw material have not been studied extensively. Schmid's work still remains the most important reference.

All available documentation, including articles, reports and archives, were first gathered and analysed during the course of 2014. The first field work began in the summer of 2015. Our goal was to rediscover the sites and evidence mentioned by our predecessors and to establish an overview of these settlements and their main characteristics, the outcome of which was to

define a set of research questions and to plan further investigations.

4. ACCUMULATED KNOWLEDGE

4.1. Raw material and bedrock

4.1.1. Bedrock

The bedrock consists of bioclastic limestone with flint of Lower Cretaceous. This

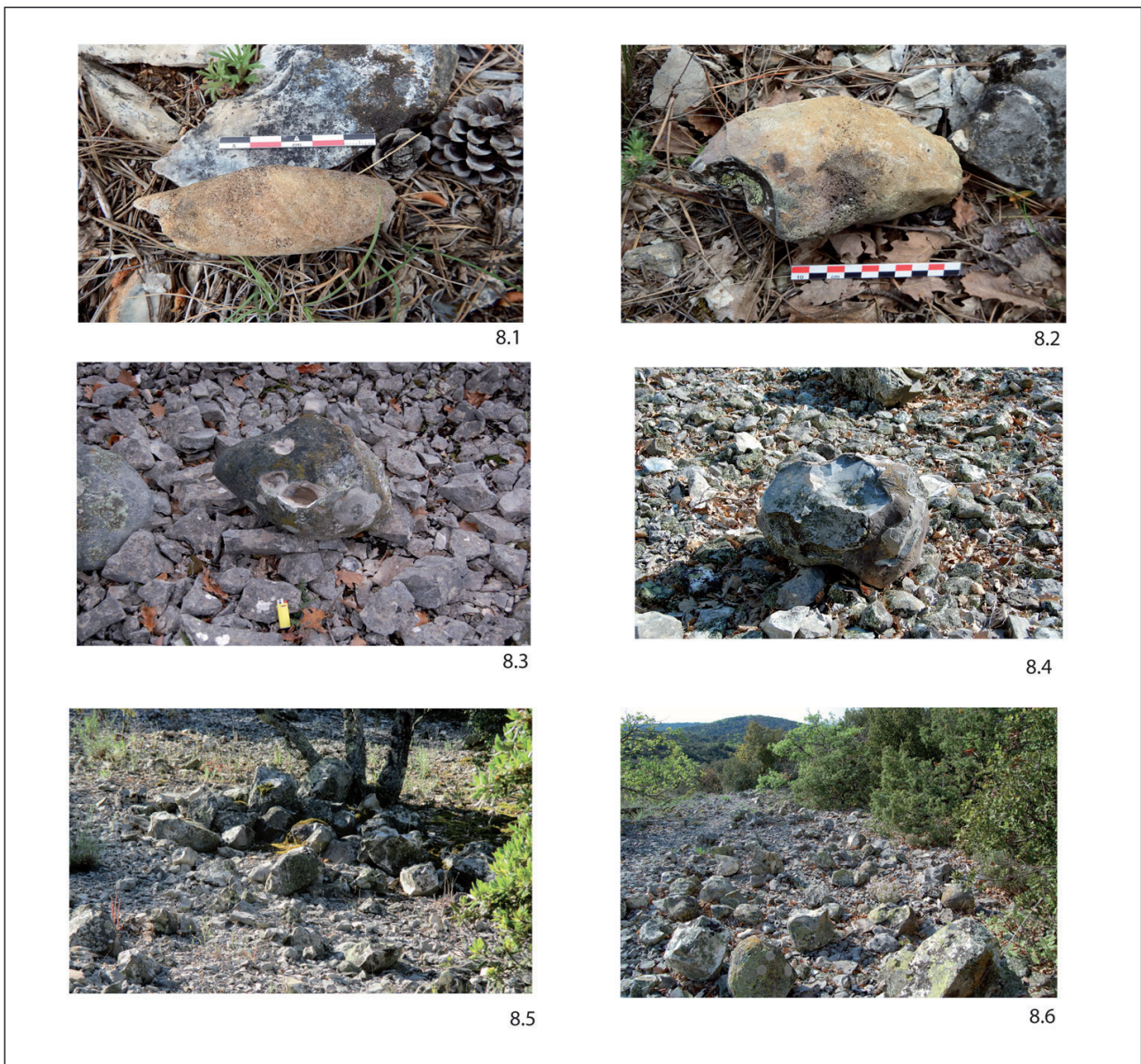


Fig. 8 – Morphology of the flint nodules. 1. Murs 'Le Vallon'; 2. Murs 'Jas Laurent'; 3-4. Malaucène 'Bouche Grasse'; 5. 'l'Angelin'; 6. 'Bouche Grasse'.

limestone belongs to the base of the Bedoulian (sub-floor of the Aptian). They are of similar facies to that of the Urgonian. We noted strong variations in the consistency of the rock, which is sometimes very compact, sometimes faulted and jointed. In Murs we noticed that there is a narrow correlation between limestone with microcodia and the quarries. Indeed, microcodium aggregates loosen the limestone and make it easier to break which favours the extraction of the flint nodules.

4.1.2. Arrangement of the raw material

In Murs as in Malaucène, the siliceous horizons are irregular and complex. In Malaucène, there are tabular formations situated at the top of the limestone pavement on the Rissas plateau which dominate several metres of the underlying rocky spurs. These formations provide outcrops of poor quality material, very often faulted and inconvenient for knapping.

We identified outcrops which could qualify as 'pockets' of flint. They consist of a multitude of flint nodules sometimes arranged up to several metres in height. They can be very compact as in the 'Grande Combe' at Malaucène (Fig. 7: 1) or, in contrast, much wider as on the right bank of the coombe of Leunier at Malaucène (Fig. 7: 2-3) or on 'Chatemuye/ Les Vallons' at Murs (Fig. 7: 4). These areas were generally intensively exploited.

4.1.3. Size and morphology of the flint nodules

The geological layers of Malaucène frequently contain spherical flint nodules about 40 cm in diameter and sometimes more (Fig. 8: 3-4). In contrast, on the right bank of the Toulourenc River, the flints are pebbles about 10 cm long. In Malaucène River, there are also some flints with quirky shapes, as evidenced by broken protuberances found on site.

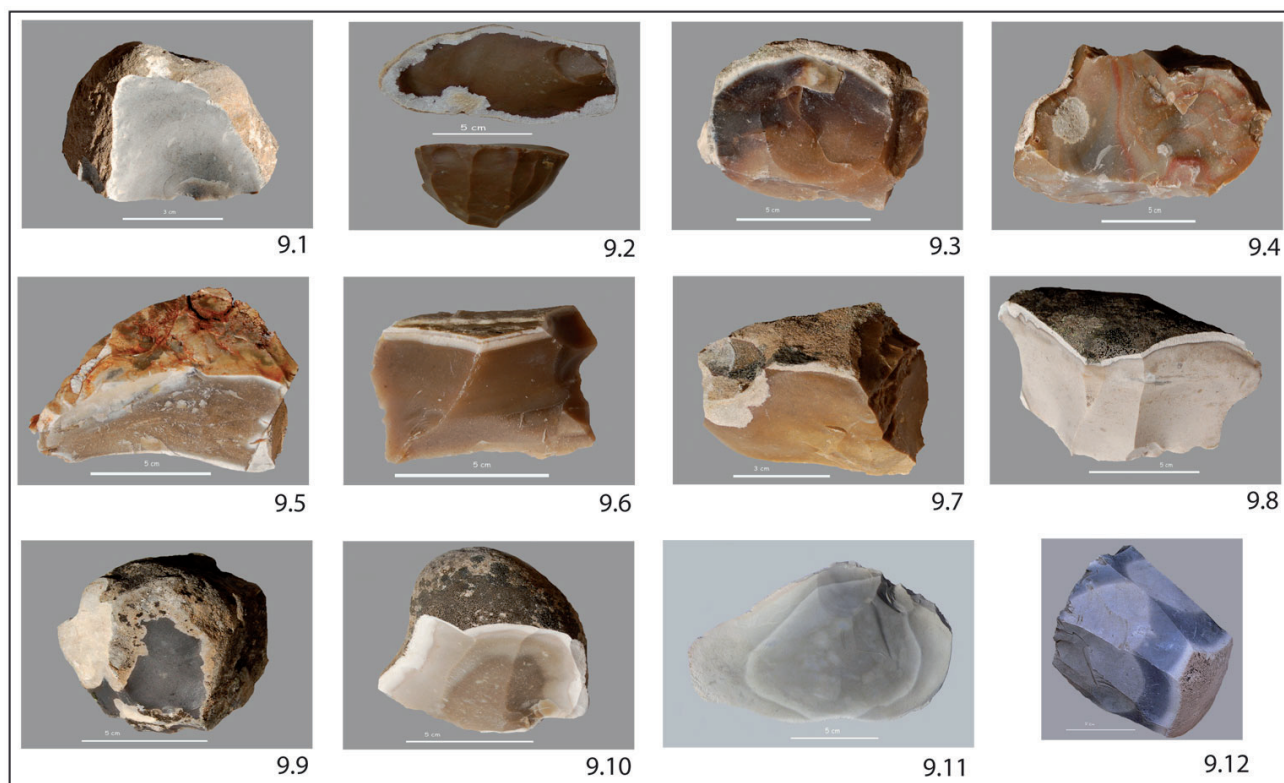


Fig. 9 – Variability of Malaucène's raw material. 1. 'Bouche Grasse'; 2. 'Combe des Gainons'; 3-4. 'Combe de l'Homme mort'; 5. 'Dessus de Leunier'; 6-9. 'Leunier'; 10. 'Vallon de la Borie' (Mollans-sur-Ouvèze); 11. 'Combe de Jacquaras'; 12. 'Combe de Bouche Grasse'.

In Murs, nodules are usually ellipsoid but there are also some which are spherical (Fig. 8: 1-2). They are present in different sizes. The largest can reach up to 30-40 cm in diameter, the smallest being 5 cm in diameter.

The majority of the flints that are still visible today are roughly between approximately 20 and 30 cm. Some Bedoulian flints occur in tabular layers, but it is of rather mediocre quality, being very faulted and jointed.

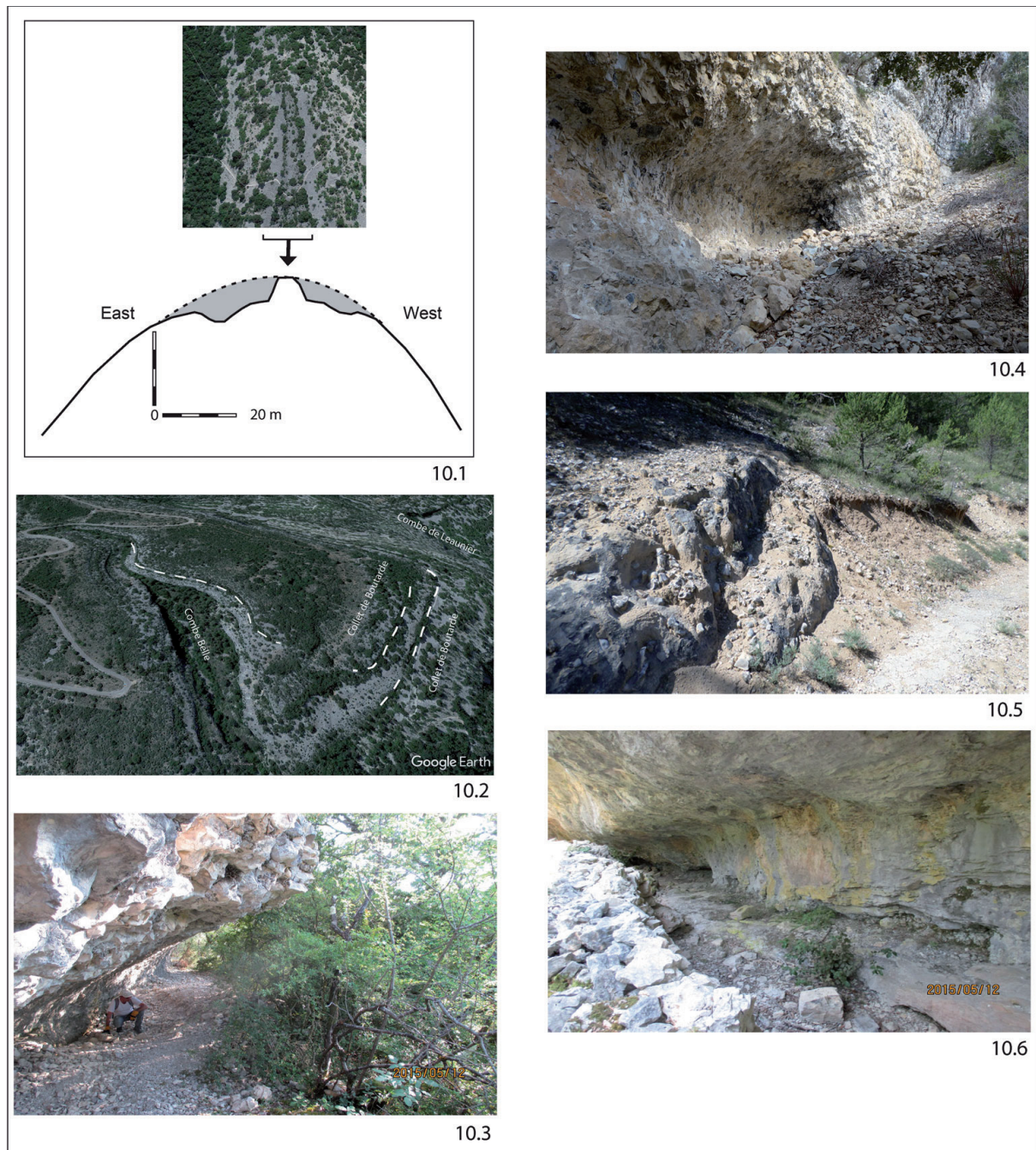


Fig. 10 – Extraction remains and techniques.

1. Malaucène, between 'Combe Belle' and 'Bouche Grasse', residual ridge of rock. After SCHMID, 1980;
2. Malaucène 'Collet de Boutarde': working face showing steps; 3. Malaucène 'Combe de Leauvier', undercut quarry; 4. Malaucène 'Grande Combe', big extraction niche; 5. Murs 'les Vergiers', steps; 6. Malaucène 'Abri Gangeon II', undercut quarry.

4.1.4. Nature of the flint

The Bedoulian flint of Vaucluse shows a great variety of colours, textures and cortices (Fig. 9). The observations recorded in the coombe of 'Leaunier' show that there is a blonde flint, similar to the one that served to make the Chassean bladelets. There are also banded materials, and flint of other colours ranging from white to dark grey. In Malaucène, in the upstream parts of the coombes of 'Combe Belle', 'Bouche Grasse' and 'Leaunier', the flint is grey or blue-grey, sometimes with clearer spots. In other coombes, the flint ranges from dark brown to red and from honey coloured to deep burgundy, sometimes in zones and often with inclusions of quartz. In the right bank of the Toulourenc River the flint is speckled beige. The flint of the 'Grande Combe' is grey-black to black. The colours of the flint from Murs are also varied. They range from light brown to dark brown and to almost black.

4.2. Extraction techniques

The quality of preservation of the sites of Murs and even more so at Malaucène, is in every respect exceptional. We can still see today numerous examples of evidence of Neolithic activity, virtually in the state in which sites were abandoned by Neolithic people. This is because the area has never been cultivated, for the most part, and has been little frequented since the end of prehistory. This state of preservation still allows us to visualise the work of the miners. The work was so intensive in many places that they totally remodelled the landscape. On both sites we were able to note the implementation of several different techniques of extraction.

4.2.1. Quarry

Flint exploitation was frequently undertaken by quarrying vertical faces which cut the exposed rock. These faces could develop concave walls and significant overhangs. The most spectacular are in the 'Collet de Boutarde' and at its meeting point with the 'Combe de Leaunier' (Fig. 10:3). The 'Abri Grangeon', in the coombe of 'Bouche Grasse', is also a good example of an overhanging face (Fig. 10:6). In certain parts, as in 'Collet de Boutarde' the succession of vertical

faces of different heights forms a series of terraces several metres high (Fig. 10:2).

On the crest separating 'Combe Belle' from 'Bouche Grasse' close to the trench (F1b) made by E. Schmid, there is a small ridge of rock of some metres in width and height that can be followed for more than 100 m. This is the last evidence of the Neolithic exploitation of a much wider cliff (Fig. 10:1). Those features can be compared to the Lousberg quarry in Aachen (WEINER & WEISGERBER, 1980, fig. 69).

The horizontal or dipping limestone layers which contain good quality material were exploited from the top. This technique was implemented in Murs (Fig. 10:5) and in a less obvious way in the coombes of the right bank of the Toulourenc River. This type of exploitation also creates terraces of modest size compared with those of the 'Collet de Boutarde'. These remnants are very similar to those documented and published by Gerd Weisgerber in Oman (WEISGERBER, 1997).

4.2.2. Pits or shafts?

Depressions were identified by several of our predecessors. Francki Moulin writes: '*a demonstration is especially remarkable at Malaucène [it is] these depressions, [which are] regularly circular, are generally outlined in the mass of waste (...). These adjacent depressions, like a set of basins are each 8 to 10 m in diameter, of variable depth, but generally small, appearing in series, arranged longitudinally in the base of the plateaux itself, which they partially follow*' (MOULIN, 1905, p. 74-75). Dr Raymond also comments on them: '*Some places intrigued [us] initially. They are depressions in the form of cupules, regularly circular, some of them are hardly 2 to 3 m in diameter and their depth is insignificant; but there are others which measure 8 to 15 m in diameter with a depth of 3 to 5 m*' (RAYMOND, 1905, p. 21).

We easily identified these depressions. They are more numerous than was formerly estimated. In the coombes of Veaux, these depressions are distributed in several zones which cover vast areas. We also located them in the quarries of Murs, in 'Jas Laurent', 'Ferrières', 'Bouisse' and in

'Petit Chatemuye'. In Murs they are apparently less numerous and harder to discover because they are situated under forest cover. It is still difficult today to know if they are big pits, as envisaged by E. Schmid (SCHMID, 1980, fig. 152, and Fig. 6 in this paper) or the entrance to shafts.

4.2.3. Subterranean extraction

Two cavities have been known for a long time in the quarries of Malaucène: the 'Grotte du Levant' and the 'Grotte du Couchant', both located in the coombe of Leunier, inside the Rissas plateau. The first comprises only a single chamber today. The second consists of a small network of chambers. In each of these 'caves' the walls are dotted with big flint nodules and with numerous alveoli having previously contained flint.

The investigation and recording of the underground network of the 'Grotte du Couchant' was made in 2016. The accessible network consists of three chambers: the first one opens into the quarry whilst the other two descend inside the calcareous plateau. The first chamber is 13 m by 9 m and approximately 2.5 m in height at its highest point. Midway up the wall is an excavation rather similar to the niches found in flint mining shafts. Chamber three, the deepest, is more than 20 m long with a width between 3 m and 5.5 m. This chamber has a surface area of more than 80 m², and a height of more than 2 m. Both the walls and ceiling retain numerous flints as well as many cavities and hollows which demonstrate that raw materials were taken.

The 'Grotte du Levant' is part of the continuation of one of the faces of the 'Collet de Boutarde', where the face is particularly concave. The limestone walls outside the 'cave', as well as those of the 'cave' itself, abound in flint. The digs revealed that several of the layers of infill consisted of mining waste (limestone rubble, fragments of nodules, flint flakes).

Both of these cavities may be partially or even totally artificial, and may represent large extraction chambers. It should be recalled that it is around these caves, in this sector of the Rissas plateau, that the flint used extensively during the Chassean period was most probably extracted.

4.2.4 Firesetting

In Murs, Neolithic people deliberately chose to exploit flints which were in limestone loosened by the presence of microcodium. At Malaucène the limestone is very compact, so the bedrock could have been purposefully weakened by firesetting to allow easier fracturing and the recovery of flint nodules. This technique has been identified at other flint extraction sites, in particular in Kleinkems (WILLIES & WEISGERBER, 2000).

There are certain evidences for the existence of firesetting in Malaucène. E. Schmid claims to have observed in the F1b excavation burnt blocks of limestone surrounded by copious quantities of charcoal (SCHMID, 1963, 1980). Her observations were echoed by J. Courtin (1974, p. 189-191) and L. Willies and G. Weisgerber (2000, p. 143). For our part, we also noticed that certain faces, in particular that of the 'Grande Combe' in Malaucène, showed traces of fire or signs suggesting thermal cupules (Fig. 10:4).

4.3. Extraction tools

The extraction tools identified consist mainly of mallets or hammers (Fig. 11). Several hundreds of these objects were previously collected both in Murs and in Malaucène. They are mainly made from pebbles of quartzite collected from the former Pliocene terraces of the Rhone or the Durance rivers, tens of kilometres away. There are also some limestone mallets (Fig. 11:5) and more rarely mallets in diorite (Fig. 11:4), serpentine or eclogite and even sandstone (D'AGNEL, 1902; CARIAS, 1920; Fig. 11:7).

Their weight can vary from some hundreds of grams to more than 12 kg, with the average weight between 3.8 kg and 5.3 kg (RAYMOND, 1905; COURTIN, 1974, p. 188). They are mainly grooved, more rarely with two grooves, parallel or crossed. Rather than grooves the mallets sometimes feature lateral notches. We noticed a large variation in the finish of these tools, some being particularly well shaped, while other pebbles were almost untouched.

There are also other types of extraction tools, far more rare made of flint. E. Schmid

collected some during her excavations (SCHMID, 1960, 1963), as did Jürgen Weiner on the occasion of his visit to the coombes of Veaux in 1999 (WEINER, 2003, fig. 4).

4.4. Elements of flint production at the extraction sites

The preparation and the fracturing of the flints were made directly in the quarries. We

noticed that in some places there were piles of flint nodules left as if they were about to be transported, worked on or knapped (Fig. 8:5-6). The artefacts visible on the surface consist mainly of cortical flakes, sometimes quite large. But there are also some finished products and exhausted cores. We envisage that certain parts of the *chaînes opératoires* were conducted on the spot. In particular, the long unheated blades may well have been manufactured on site, because

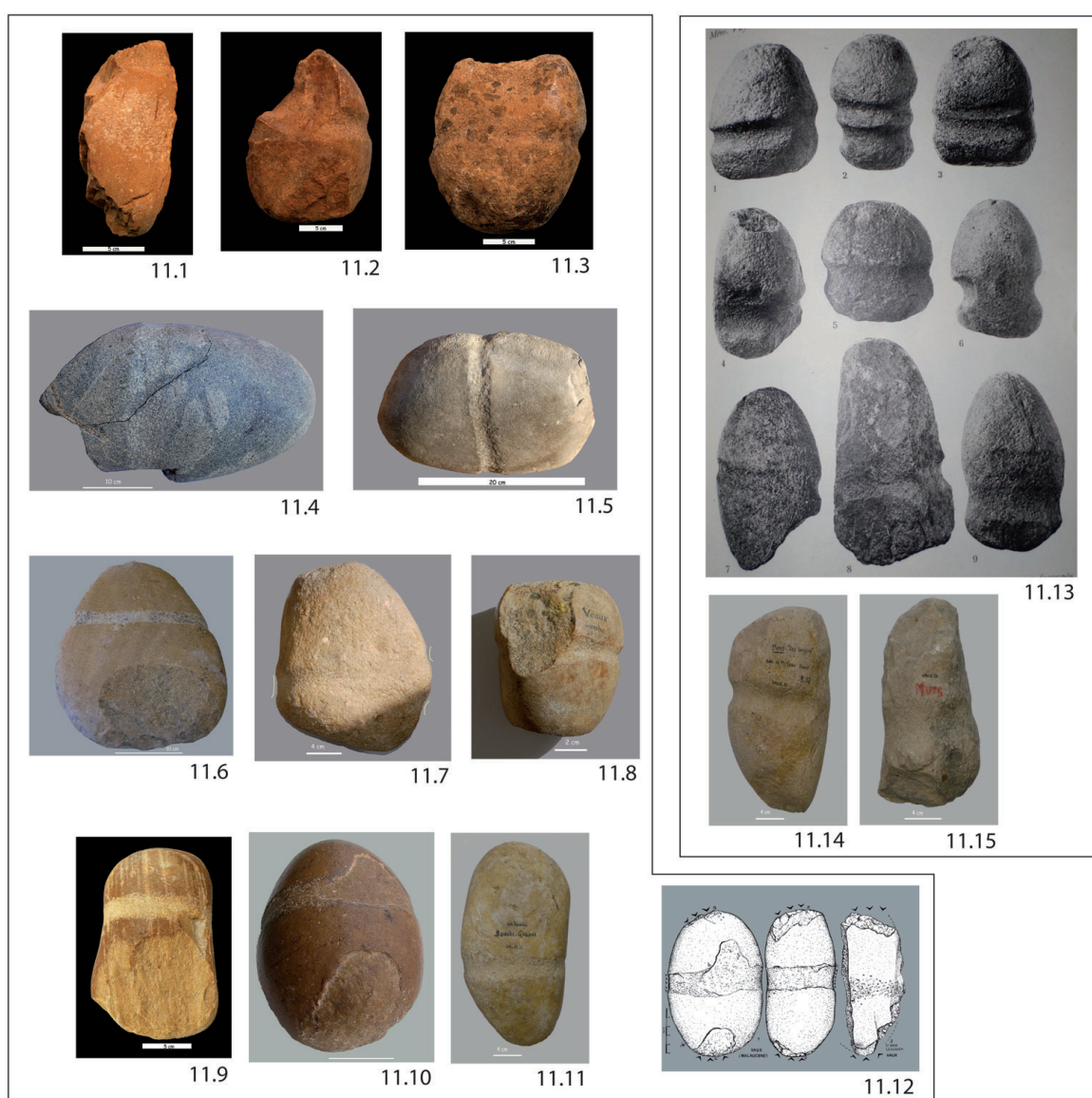


Fig. 11 – Mallets, extraction tools.

- 1-3. 'Grotte du Levant de Leauvier', Barthélémy collection; 4. 'La Chambette', diorite, private collection; 5. 'Combe Belle', limestone, private collection; 6. 'Bouche Grasse', Monge collection; 7. Sandstone, Guerold collection; 8. 'Combe de Leauvier', Guerold collection; 9-12. Veaux and Veaux Combes, Corbeille, Tournière, Gauthier, and Barthélémy collections. 13. After VAYSON-DE-PRADENNE, 1933-1934; 14-15. Gauthier collection; 1-12. Malaucène; 13. Murs

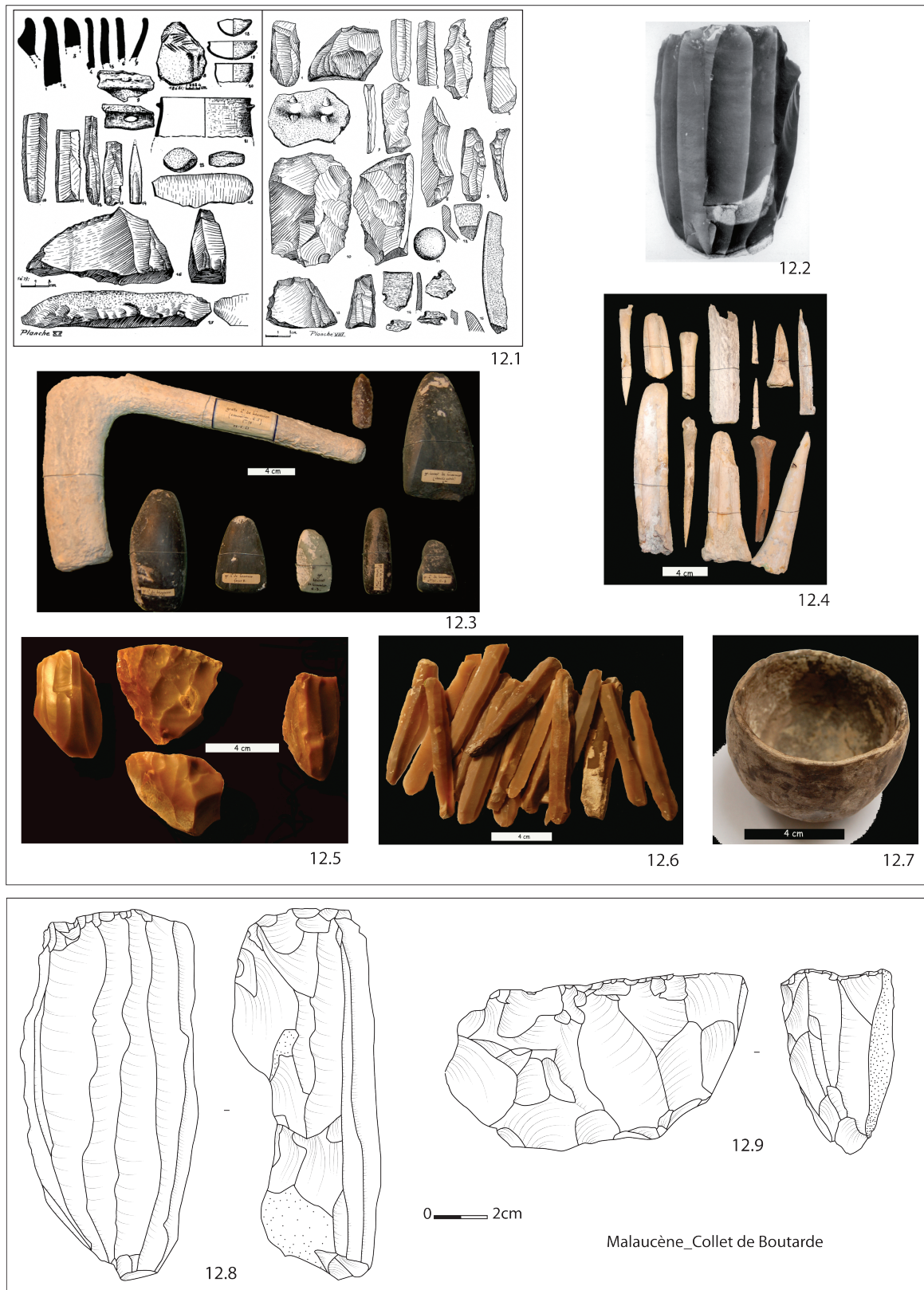


Fig. 12 – Artefacts.

1-7. Malaucène 'Grotte du Levant'. 1. After BARTHÉLÉMY, 1955, 1960; 2. Gauthier collection; 3-7. Barthélémy collection. 8. Blade core collected at Ferrières Quarry, Gauthier collection; 9. Preheated bladelet precore Malaucène 'Collet de Boutarde'.

we found some blade cores at both Malaucène and Murs. Heat treatment was also conducted on site as shown by the presence of some cores and flakes with mat and brilliant surfaces. Some of the finds made in the 'Grotte du Levant' and the 'Abri Grangeon', clearly show there was flint knapping in these locations because many cores, blades and bladelets were found (Fig. 12:2, 5-6).

4.5. Household activities at the mines

At present the extraction sites at Murs only shows evidence related to the activities of procurement and/or to the initial preparation of the raw material. However, located in close proximity is a number of settlements, recognised only by fieldwalking, which produced assemblages of very different artefacts from those usually found in a quarry or a workshop. At these sites there is no evidence of knapping activities but rather artefacts that were related to domestic use. On the site of 'Charlesse', for example, situated approximately 1 km from the quarries, Marc Deydier describes '[A] rich site (...) characterised by polished stones, arrowheads, some willow or laurel leaf points' (DEYDIER, 1904, p. 172). A. Vayson-de-Pradenne records that at 'Mourre de Bérard', a few hundred metres away from the extraction sites, there are '*Polished axes of green rocks, fragments of pottery, cores ..., bladelets ..., scrapers, tranchets, arrowheads (...)*' (VAYSON-DE-PRADENNE, 1933-1934, p. 175).

The excavations in the 'Grotte du Levant' and those of 'Abri Grangeon', in the heart of the extraction zones of the Rissas Plateau, yielded archaeological evidence indicative of activities not directly related to the extraction of flint. In the 'Grotte du Levant', the brothers Catelan and Barthélémy found dozens of cores, hundreds of unworked blades and bladelets, but also stone balls, beads, axes of green rock, fragments of querns, ceramics and animal remains (Fig. 12). In 'Abri Grangeon', J. Vincent collected 68 cores, 200 blades or bladelets, but also tools (scrapers, burins and arrowheads), 150 ceramic sherds and fragments of fauna.

The geographical area surrounding the Veaux coombs, within a radius of approximately 20 km, is dotted with small sandstone eminences

with a high density of sites or indications of sites. There are settlements with workshops for pottery production and the heat treatment of the flint at Saint-Martin in Malaucène, for example, and dwelling sites in 'La Chambette' and 'En Terrone' (Fig. 3). There are also specialised workshops for the production of arrowheads such as those of 'Peyrières' in the municipality of Mollans-sur-Ouvèze (ANDRÉ, 2016).

4.6. Dating

We still do not have any 14C dates. Consequently, typo-chronological analysis is used to attribute date ranges to the items found at the sites of extraction, processing and consumption. In his synthesis on the Neolithic of Provence, J. Courtin envisaged that the quarries of Murs and Malaucène had been exploited since the Middle Neolithic and up to the 'Chalcolithic' (COURTIN, 1974). We think we can now propose a longer period of use.

The mines and quarries exploiting the Bedoulian flint at Murs and Malaucène could have started in the Early Neolithic during the middle of the 6th millennium. Indeed, important evidence of quantities of this raw material has been discovered at several settlements. Examples are the 'Baratin' in Courthézon (Vaucluse), and also in the region of Nice at Castellar 'Pendimoun', in Liguria at 'Arene Candide', and in western Languedoc at Sallèles-Cabardès 'Grotte Gazel' (BINDER, 1998).

During the Chassean period (4500 – 3500 BC), the Bedoulian flint is found in abundance in the archaeological collections of the South of France. This period represents the apogee of the use of Bedoulian flint. Blades, bladelets and cores, as well as the ceramic artefacts found in the 'Grotte du Levant' and in 'Abri Grangeon', point to the fact that this quarry was exploited during this period. The lithics and pottery found at 'Trois Termes' at Gordes, situated a short distance from the Murs quarries, are also typically (LÉA, 2004b).

The end of this period of mining exploitation is poorly documented. From the Late Neolithic (3500 – 3000 BC), bladelets of Bedoulian blonde flint are replaced gradually

by longer blades of grey or grey-blue Bedoulian flint. The origin of this material is traditionally attributed to the deposits of Monieux/Sault. However, the upstream parts of the coombes of Leunier, 'Bouche Grasse' and 'Combe Belle' produce a raw material of the same colour. Therefore we can speculate that the quarries of the Rissas Plateau continued to be exploited until the end of the 4th millennium.

The Murs and Malaucène quarries were exploited for a minimum of 1500 years between the middle of the 5th millennium and the end of the 4th millennium. However it is highly likely that they were exploited for a much longer period, one which could span more than two millennia, or even three, from the mid 6th to the end of 3rd millennium.

5. SYNTHESIS AND PROSPECTS

5.1. Definition of the extraction area

At both sites the extent of the zones of extraction remains to be identified.

The coombes of Veaux undoubtedly constituted the main zone of extraction. 'Combe Belle', 'Bouche Grasse' and 'Leunier' represent the coombes where there is a concentration of the most remarkable evidence connected to the extraction and the preparation of the raw material. However, coombes situated further west ('l'Homme Mort', 'Pié Martin', 'Rocher de l'Angelin', 'Jacquaras') also provide significant evidence of extraction (Fig. 3). The definition of the extraction zones in the most western coombes remains to be done. There are also isolated extraction zones such as that located in the 'Grande Combe', situated more than 2 km east of the hamlet of Veaux. On the right bank of the Toulourenc River, there are also signs of flint extraction in at least two coombes ('Combe Fer', 'Vallon de la Borie'). Finally, there may well be other zones of extraction still to be discovered further west outside the Veaux basin.

In Murs, we have so far identified about ten different zones, distributed on an arc 7 km

long. It is likely that some of these sites, which appear to be separate today, could in fact be parts of a single site (Fig. 2). Put end to end they would cover a surface area close to 250 ha. However, the better definition of these zones and the identification of undiscovered sites still remain to be done.

5.2. The precise characterisation of geological deposits

It is possible that our fieldwalking expeditions failed to identify other important outcrops of raw material. If so, this was probably the consequence of two essential factors: either they are masked by the waste of later exploitation and vegetation, or they were completely removed by extraction. Much work remains to be done to identify flint deposits or layers.

The various sampling campaigns led by several early teams do not bring clarity to these questions. Partly because recording techniques were then less accurate, and partly because it is not clear whether the samples were taken from outcrops which were actually exploited during prehistory. Considering the diversity of the siliceous horizons, the number of samples is insufficient. In addition, the descriptions, the thin section analyses and the other types of analysis undertaken are still not widely available. It is thus necessary to collect and to synthesise all the existing geological data, and perhaps to relaunch a specific program of sampling at the various proven places of extraction.

In parallel, we intend to proceed to a detailed study of the limestone. The particular properties of the bedrock were a fundamental parameter which explains the techniques used by Neolithic miners. At Murs for example, the presence of microcodium was a determining factor in the opening of that extraction site.

5.3. More information about extraction techniques

It is also necessary to document the morphology of the various faces and the terraces and to locate and record all the depressions. A

Lidar survey was undertaken, but still needs to be processed.

During 2017, we have scheduled geophysical surveys in the quarry depressions found at Malaucène. The purpose of this is to determine if these depressions are simple pits or genuine shafts and to estimate their depth. We also hope that geophysics will be able to discriminate between the underlying limestone bedrock and extraction waste.

We also plan to explore the underground extraction networks of the 'Grotte du Levant' and the 'Grotte du Couchant'.

5.4. Extraction tools

Our first investigations revealed that a significant number of grooved hammers are held in several different collections. We have a potential corpus of several hundreds of these tools today. Until now they have neither been described nor analysed. Most of this work thus remains to be done.

5.5. Lithic production

Lithic production is still a significant field of investigation at these sites. Work is needed to determine the precise nature of the activities and to define the *chaînes opératoires*. We know that the testing and the fracturing of flints was carried out *in situ* but, we also discovered that there were other more advanced stages of the *chaînes opératoires* represented too. This is confirmed by the nature of some of the artefacts found in the 'Grotte du Levant' and in 'Abri Grangeon'. A detailed study of these archaeological assemblages remains to be undertaken. We also intend to survey the knapping waste material preserved within the quarries.

5.6. Vaucluse Mining complex

Several years ago the notion of a mining complex was proposed (DE LABRIFFE & THÉBAULT, 1995). In brief, this hypothesis aimed to study the relationships which may well have

existed between contemporary settlements and the raw material procurement sites. It seems that the Vaucluse mines and quarries are particularly adapted to that kind of study because of their size and their environment. Indeed, these mining sites were exploited over a very long period of time. This suggests that the sustainability of these sites was a major consideration of the local Neolithic communities in this region. They were thus naturally at the centre of the territorial organisation of these Neolithic societies, more so than the megaliths, causewayed enclosures or dwelling sites. Indeed, we know of a significant number of contemporaneous sites in close proximity to the mines and quarries at Murs and Malaucène especially specialised workshops, dwelling and funeral sites. Combining this data should turn out to be particularly fruitful and allow us to better understand the nature of the relationships maintained between the various sites within this complex.

6. CONCLUSION

After visiting Malaucène in 1999, J. Weiner asked, provocatively and quite rightly: '*Why French archaeologists never showed any apparent interest in excavating in the flint mining area of Veaux*' (WEINER, 2003, p. 516). In answer to this, it is clear that the scale of the task was enough to scare off more than one researcher. However he was right and the quality, the interest and the importance of these sites certainly deserve attention. The collation of earlier data and our preliminary fieldwork is still a very modest contribution, but a necessary review of these impressive quarries has now begun. At this stage, we have only scratched the surface, as much more remains to be revealed. Many years of research and study are needed to enrich our understanding of these sites. We hope this paper will be the first of many.

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