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Axe heads productions during the Neolithic in France: a state of knowledges

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INTRODUCTION

In France, the discovery of flint mining sites in the Paris Basin begins at the end of the 19th century, and is at the origin of definition of the Campignian (Nougier 1950). However, the first archaeological excavations are not older than the 1970', with C. Guillaume's work at Saint-Mihiel (historical record *in* Bostyn & Lanchon dir. 1992, p. 23-25). Some of this mining sites are devoted to the production of flaked axe heads (intended to be polished). For the tenaceous rocks, the recognition of productions appeared during the 1950' with the creation of a programm of petrographic analyses of the axe heads discovered in Brittany under the direction of P.-R. Giot and J. Cogné (historical record in Le Roux 1999). This work took up the methods previously developped in Great Britain (Grimes 1979). Quickly, it was demonstrated that three main rock families were preferentialy used, but only one, metadolerites called at this time of the "A type", were broadly diffused out of Brittany (Le Roux 1999). The discovery then the excavations of the quarries of Plussulien (*ibid.*) authorized to precise the concept of production: a structured organization of the making of the axe heads (from extraction to final polishing), devoted to more or less important diffusions.

To schematize, since this pioneer works, two main ways of research have been developped in France, wich are seldom associated. The first one is the analysis of the modalities of production: the discovery or the excavation (mostly in emergency conditions) of the great flint mining sites of the Paris Basin and the debitage areas associated allows to understand the modalities of production; for the tenaceous rocks, the discovery of the quarries, excepted Plussulien (in 1964), occured only at the beginning of the 1990' (*cf. infra*). The second way, mostly developped for the tenaceous rocks, consisted in the caracterization of great number of objects coming from receiving sites or from stray finds (especially old collections), in order to define petrographic groups and then discuss the origin of the rocks.

This contribution would like to compere a state of knowledges on the productions of the Neolithic axe heads in France. It takes into account the two ways of research aforesaid. All the rocks identified, all the sites of production are not presented, because of the difficulty to present an exhaustive assessment in few pages, but also because of the lacks of documentation about some of the rocks used. In particular, it is difficult to know at this day if the various tenaceous rocks identified on small series of axe heads correspond to real productions, or if we are face to occasional rock use (for instance, on the eastern border of the Massif Armoricain; Le Roux 1999).

We present below the productions of polished axe heads in tenaceous rocks and flint identified in France, by the way of short notices. If the inventory isn't exhaustive at all, the most important productions are described, as well as most of the less important productions wich

have nevertheless a regional significance (1). As it is, this report reflects the current researches on both questions of the productions and the diffusions. Nevertheless, it doesn't reflects the whole researches about the Neolithic axe heads, wich grow richer with the questioning about the functions, the functionning and the position of this eccentric tool within the Neolithic societies (Pétrequin & Jeunesse dir. 1995; Thirault 2001a; Pétrequin et al. 2002).

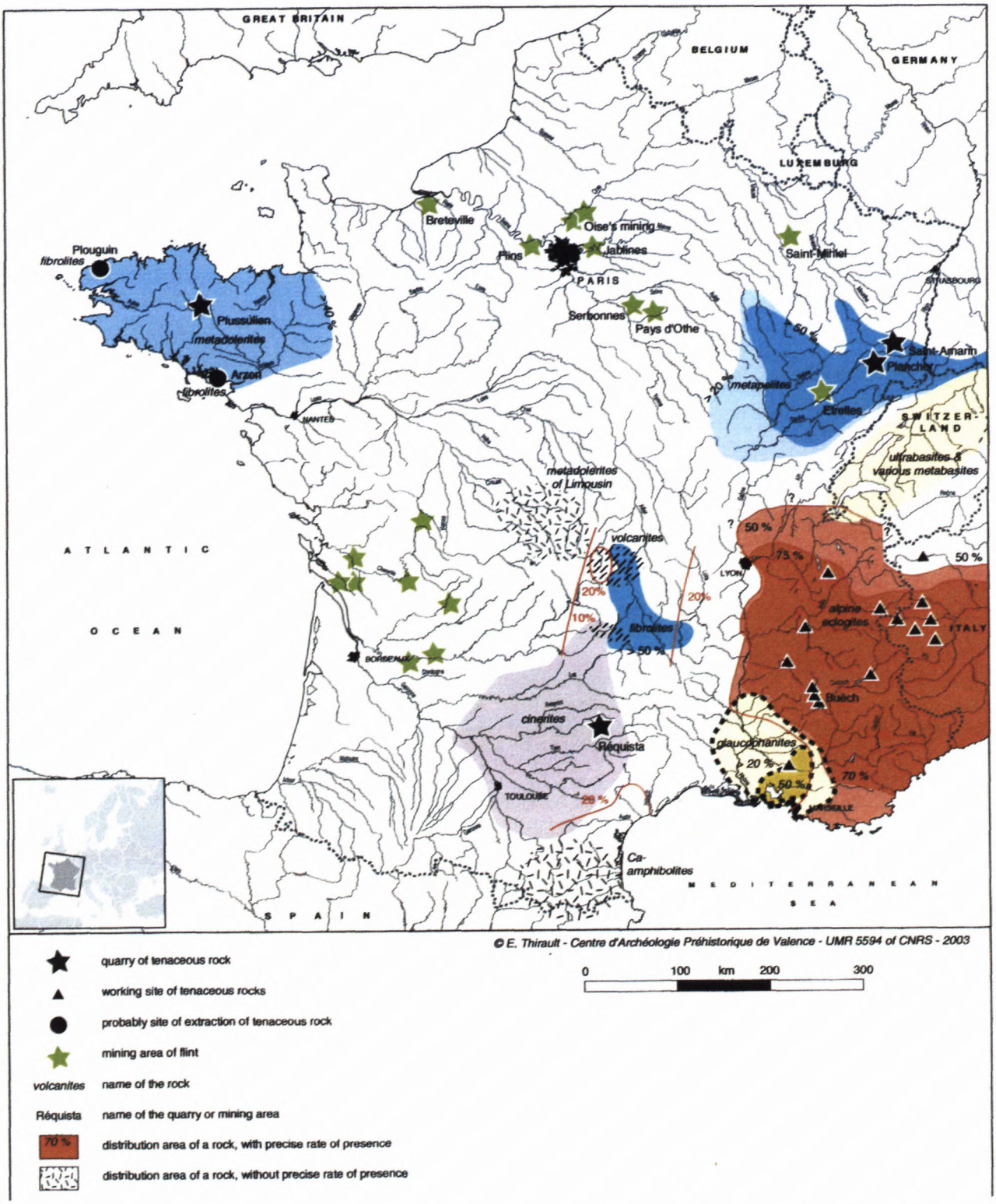

Figure 1. The main centers of productions and the broad diffusions of axe heads in France (map E. Thirault, with the help of F. Bostyn and P. Fouéré).

1. PRODUCTIONS IN TENACEOUS ROCKS

1.1. THE ALPINE WORLD (E. Thirault)

1.1.1. ALPINE ÉCLOGITES WITHIN SOUTH-EASTERN FRANCE

Alpine eclogites gather the metabasites of high pressure and low temperature (eclogitic facies) few of not retrogressed. They include eclogites *stricto sensu* (garnet + omphacite associated) and omphacitites (where omphacite is the only dominant mineral) without or poor garnets (Ricq-de Bouard et al. 1990; Compagnoni et al. 1995; D'Amico et al. 1995; Thirault et al. 1999).

Location of the exploited deposits

None deposit is known within the French Alps. Autochthonous deposits are known in Italy within the Voltri Group (Apennines of Liguria and Piedmont) and within the valleys and alpine reliefs of Piedmont and Val d'Aosta (Mont-Viso's Massif, Sesia-Lanzo Zone, Gran Paradiso). In Switzerland, deposits exists in Valais within the Zermatt's and Saas's valleys (Mont-Rose's Massif). The main allochthonous deposits are the Tertiary conglomerates of the Pô basin in Italy, and the morainic and alluvial deposits of Valais and Swiss Plateau up to the Léman Lake.

Production sites

In Italy, production sites are known:
- within the Apennines of Liguria and Piedmont (Voltri Group): near by the outcrops (Sassello: Garibaldi et al. 1996b) and near by the Tertiary conglomerates (Brignano Frascata: D'Amico & Starnini 1996; D'Amico et al. 1995; Zamagni 1996b; Rivanazzano: Mannoni et al. 1996).
- Alba's sites alongside the Tanaro river (Piedmont): Venturino Gambari & Zamagni 1996; D'Amico et al. 2000.
- within the piedmontese alpine valleys and in the foothills: Rocca di Cavour (Zamagni 1996a), Balm'Chanto at Roreto (Biagi & Isetti 1987), La Maddalena at Chiomonte (Delcaro 2002).

In France, production sites testifying the pecking and the polishing of preformed roughouts are identified:
- within the " Sillon alpin " (Isere valley, Isere): Saint-Loup at Vif (Thirault 2001a et c).
- in the Buëch valley (Hautes-Alpes): at least 16 sites on the communes of Aspres-sur-Buëch, Le Bersac, Chabestan, Lagrand, Orpierre, Sainte-Colombe, Saléon, Savournon and Sigottier (Thirault 2001a et c).
- within the Diois (Drôme valley, Drôme): sites of Les Terres Blanches at Menglon, Les Clapiers and Vallieu at Recoubeau (Thirault 2001a et c).

Diffusion of the products

Alpine eclogites are predominant for the polished tools in a radius of 200 kms at least to the East and the West of the alpine and apennines deposits (D'Amico 2000; Thirault 2001a). They usually form more than the three quarters of the axe heads on the french Rhône right bank, from the Léman Lake (excluded) to the Mediterranean See (Ricq-de Bouard 1996; Thirault et al. 1999; Thirault 2001a et b).

Chronology

The first productions are identified within the Early Neolithic (*Neolitico antico*) of Liguria (*Impressa* of Arene Candide and La Pollera: Garibaldi et al. 1996a) and of Piedmont (Brignano Frascata and maybe Alba). They are scarcely diffused in Provence and within the French Préalpes. During the Middle Neolithic (*Neolitico medio*, Culture of *Vasi a Bocca Quadratta*), production sites appear within the piedmontese alpine foothills (Rocca di Cavour). Then, during the *Chasséen récent* (Néolithique moyen II in France, *Neolitico recente* in Italy), they appear within the Western Alps both of the piedmontese (Chiomonte) and dauphinois side (Sillon alpin, Buëch valley, Diois), i.e. at 100-120 km far from the closest natural deposits. At this time, the diffusions are broad within the South-Eastern part of France. During the end of the Neolithic period (Néolithique final/*Eneolitico/Calcolitico*), some alpine production sites remain active (Balm'Chanto, Dauphiné's sites).

1.1.2. ULTRABASITES, METABASITES AND CATACLASITES WITHIN THE LÉMAN LAKE BASIN

Definition & location of the exploited deposits

This productions are realised on pebbles and rolled blanks of various petrography, coming from moraines. Ultrabasites gather the serpentinites (constituted by antigorite) and the chloritites (constituted by chlorite). Metabasites are metamorphozed under conditions of low to middle pressure and temperature: amphibolites, metadolerites epi- and mesozonals, pyroxenites of middle pressure and temperature and retrogressed eclogites are identified by thin section and X-ray analysis. Cataclasites are formed by grinding of the aforesaid rocks in geological faults, then resilification (Thirault et al. 1999).

According to the location of the sites where the axe heads have been discovered, the used deposits are the moraines of the south bank of the Léman Lake.

Production sites, diffusion of the products and chronology

Roughouts are common on the lakeshore dwellings of the south bank of Léman Lake: Séchex at Anthy-sur-Léman, Beauregard and Tougues at Chens-sur-Léman, Bel-

levue and Eaux Vives at Geneve, Crozette at Messery and Corzent at Thonon-les-Bains (Thirault 2001a). None diffusion can be demonstrated away from the Léman bank.

The lakeshore dwellings of the Léman Lake are occuped from the Middle Neolithic (*Néolithique moyen II Cortaillod*) until the *Néolithique final*, i.e. during the IV° and III° millenium BC calib. (Marguet 1995). The manufacture of the axe heads isn't preciselly dated.

1.1.3. GLAUCOPHANITES IN WESTERN PROVENCE

The glaucophanites and the glaucophanitic metabasites belong to the alpine metamorphism of high pressure and low temperature. They are metabasites of the external piedmontese zone, recrystallized under the blue schist facies, and caracterized by the glaucophane (a sodic amphibole). To the naked eye, the glaucophanites offer a green to blue color, and often whitish veins. The grain of the rock is fine or very fine (Ricq-de Bouard et al. 1990; Ricq-de Bouard 1996).

Location of the exploited deposits

None indication of exploitation as been recognized at this day on the french outcrops within the Queyras and the upper valley of the river Ubaye. In fact, the axe heads are realized on pebbles used entire or flaked. This pebbles comes from the middle and lower valley of the Durance, in western Provence, from the conglomerates of the Plateau de Valensole, et maybe from the Crau and the Côtiere de Nîmes (Lazard 1993; Ricq-de Bouard et al. 1990; Ricq-de Bouard 1996; Thirault 2001a).

Production sites

In the valley of the Durance, two dwellings have given the proof of the fabrication of axe heads in glaucophanites (flakes, roughouts, whetstones). They are located at Forcalquier "La Fare" and at Lourmarin "Les Lauzieres" (Lazard 1993). Both are dated from the end of the Neolithic period.

Diffusion of the products and chronology

During the Neolithic, the distribution of the glaucophanites never passed about fifty kms around the alluvial natural deposits (Ricq-de Bouard 1996). During the Early Neolithic, the glaucophanites are used in western Provence and near by the littoral of the eastern Languedoc, until the valley of the Aude river, on both banks of the Rhône delta. During the Middle Neolithic, the use of the glaucophanites is poorly developped, but always on the same area. During the final Neolithic, the glaucophanites are abundant but on an area more important westward, until the valleys of Ardeche and Hérault. On the left bank of the Rhône, they are well attested in western Provence until the Mont-Ventoux northward, and until the Mediterranean sea southward.

1.2. THE MASSIF CENTRAL

1.2.1. ECLOGITES AND JADÉITITES IN AUVERGNE (F. Surmely)

Definition

Cf. § Alps.

Location of the deposits

From a geological point of view, the eclogites exist in Auvergne, especially in Haute-Loire, between Brioude and Langeac (Lasnier 1977; Lasnier & Marchand 1982), but also in the zone of Saint-Flour (Cantal; Goër & Tempier 1990), Ardes-sur-Couze (Chaillou 1967) and Dore-l'Eglise (Puy-de-Dôme). They can be find also on the limit between the *départements* of Cantal and Lozere, near by the viaduct of Garabit (Colin 1960; Lapadu-Hargues 1948). The eclogites are also well present in the nearby Limousin (Santallier et al. 1986).

But, generally speaking, the eclogites of Auvergne and Limousin are formed under conditions of high pressure, then more or less retrogressed under the amphibolite facies. Consequently, they are rich in amphiboles and plagioclases, and they are caracterized by a weaker density than the "fresh" alpine eclogites (density of 3 to 3,2). Nevertheless, in Auvergne and Limousin, exist real eclogites not retrogressed and " fresh ", that can be find at the heart of the biggest masses. However, those rocks are rare (Goër de Herve & Surmely 2001).

Nevertheless, in opposite of what some former researchers have written, our own researches, based on petrographic examination under thin sections, tend to prove that almost all the eclogites used for the axe heads found in Auvergne are coming from the Alps (Surmely et al. 2001). The same result can be applied at the jadeitites, which are totally unknown in Auvergne as natural deposits.

Production sites

They have to be searched within the alpine massif (cf. § Alps). The axe heads seem to have been introduced in Auvergne as finished products. They could have been resharped during their use.

Diffusion of the products

In Auvergne as a whole, the eclogites are the most used rocks after the fibrolites (*cf.* § below ; about 20 % of the axe heads inventoried). In opposite, the jadeitites are rare (4 %). Both materials have been used for the fabrication of a broad range of axe heads, which testify varied uses (functional and "prestige" pieces). Notable variations are observed from case to case. The *département* of Haute-Loire, which forms the eastern part of Auvergne,

attracts attention by the notable importance of the rate of the alpine metamorphic rocks (35 % of eclogites and 9 % of jadeitites). The axe heads in jadeitites are absent on the both sides of the *département* of Cantal, south-westward of Auvergne, where the eclogites are well present. In return, they are numerous on the big hilltop site of Corent (Puy-de-Dôme).

1.2.2. FIBROLITES IN THE MASSIF CENTRAL (F. Surmely)

This metamorphic rock is essentially composed by sillimanite, which gives a great tenacity to it (due to it's texture formed by bunches of fibres), as well as a great hardness (7 to 7,5) and a weak rugosity (which make the polishing easier). The fibrolite exists mostly as centimetrical nodules, easy to extract from their gneissic context. During the Neolithic, this nodules have been simply regularised. According to it's mechanical qualities, this material appears as really suitable for the fabrication of polished axe heads. Nevertheless, the size of the nodules forbidds the fabrication of long axe heads (Surmely et al. 2001). The colour of the fibrolite is very variable: milky white, sometimes with grey-blue, red or black veins.

Location of the deposits

Sometimes called *« jade »*, *« jade gris »* or *« jade néphritique »* by the naturalists of the XIXth century (Gonnard 1870, 1883), the fibrolite is abundant in Auvergne, especially into the metamorphic series of the upper valley of the river Allier (Haute-Loire; Gonnard 1883; Lasnier & Marchand 1992) and of the lower valley of the river Alagnon (Cantal; Gonnard 1883; Pagès-Allary 1908). Consequently, the fibrolite is used in aboundance in the axe heads of this area (western part of Haute-Loire, eastern side of Cantal). Piles of fibrolite have been pointed out in Puy-de-Dôme, in the zone of Saint-Ours (Gonnard 1870, 1883) and of Pontgibaud (Hottin & Camus 1989). But they can also be found, as pebbles, in the alluvial deposits of the upper terraces of the river Allier as far as in Bourbonnais. F. Gonnard pointed out their aboundance in the zone of Issoire-Perrier (Puy-de-Dôme), with pebbles of 400 g, indeed 1000 g in some exceptional cases (Gonnard 1883).

Because of the multiplicity of the deposits (outcrops and alluvial deposits), and the great diversity of this rocks, the precise determination of the sources(s) of supplying remains difficult.

Production sites

In numerous cases, the axe heads seem to have been shaped on the dwelling sites, from pebbles taken in the alluvial deposits, with a shaping out often partial (cutting edge). It is the case for numerous small pieces used in the middle part of Val d'Allier (site of Corent, Puy-de-Dôme; Goër de Herve & Surmely 2000).

A shaping worshop as been signaled on the commune of Beaulieu in Puy-de-Dôme (Balsan 1956). The site gave hundreds of worked or rough nodules. Some roughouts had more or less wide grooves, realised in the aim to divide the nodules. Nevertheless, this collection has disappeared, and had not been examined by us. Another similar workshop is known in Haute-Loire (Gonnard 1883), but the objects stored at the Museum of Le Puy-en-Velay consist mostly in raw nodules. Above all, the fibrolite seems to have been sawed, wich gives an explanation for the frequent traces of sawing on the axe heads, notably in the *département* of Haute-Loire.

Diffusion of the products

Because of the multiplicity of the potential sources of supplying, it is difficult to precise the ways of distribution of the products. In Auvergne as a whole, the fibrolite is, from far, the most employed material (44 % of the axe heads). They are mostly small to very small pieces (5 cm in average), with a great variability of forms. Most of them are triangular and flat, but some of them are some kind of small and elongated cisels. The reason of this variability, functional or depending of the natural shape of the pebble, is difficult to understand.

Generally speaking, the axe heads in fibrolites are numerous in the sectors where this material is naturally abundant: Haute-Loire, Puy-de-Dôme, eastern Cantal (Surmely et al. 2001). The size of the axe heads of Haute-Loire is more important than the size of the ones of Puy-de-Dôme. That could be explained by the supplying modalities. In opposite, the axe heads in fibrolite are almost totally unknown on the western side of Cantal, where this material is totally away (2).

The diffusion of the fibrolite seems to be limited to a small scale, not morer than some tens of kilometers. But some rare axe heads in fibrolites are noted in the neighbouring regions: Lyonnais (Masson 1977), middle valley of Rhône (Thirault 2001a), Limousin (Santallier et al. 1986), Berry (Le Roux & Cordier 1974; Le Roux et al. 1980), indeed Charentes or Périgord (Surmely & Santallier 2002). In some cases, a coming from Auvergne can be supposed, but, especially for the western regions, this pieces could come aswell from Brittany or from Vendée (*cf.* below).

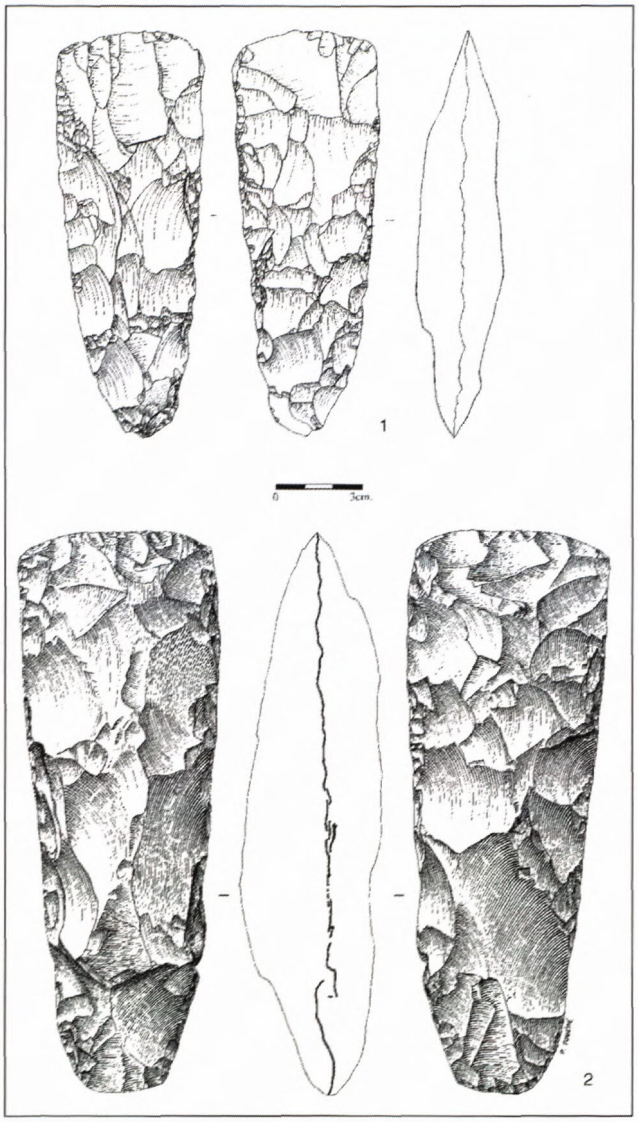

Figure 2.
1. Axe head in Bartonian flint coming from Flins (Yvelines; drawing A. Lo Carmine).
2. Axe head in Turonian flint coming from Ozillac (Charente-Maritime), collection Musée des Carmes of Jonzac (drawing P. Fouéré).

Chronology

Because of the lack of chronological context for most of the pieces, and of their morphological specificity, it is yet impossible to realise a seriation of this axe heads productions in fibrolites. Nevertheless, the fibrolite is known in sites attributed to the Middle Neolithic and to the Final Neolithic. In the middle Rhône valley, some pieces in fibrolite, which seem to come from Auvergne, have been discovered in Chassey sites contexts (Thirault 2001a).

1.2.3. AXE HEADS IN SERPENTINITE IN AUVERGNE (F. Surmely)

The serpentinites are metamorphosed peridotites (olivine → serpentine). This material is not very hard, which cannot resist to the most violent shocks. Nevertheless, this poor hardness is compensated by a much more important tenacity, due to the engaged texture of the rock. Experimentations should be realised to test it's real efficiency on such materials as wood. The serpentinite is often marbled or moiré, it's colour is real green or dark, indeed almost black, and it's rock is a very decorative one. The density varied between 2,5 to 2,7, depending to the variety.

Regional deposits and production sites

The serpentinites are common inside the ancient massifs. In Auvergne, they are present in the metamorphic series, mostly like enclaves of several square meters, principally in the upper valley of the river Allier (*département* of Haute-Loire; Lasnier & Marchand 1982; Marchand et al. 1989), in northern Margeride (Goër & Tempier 1990) and in the region of Riom-es-Montagnes (Cantal). One of the biggest outcrop (more than 200 m of diameter), forms the hill of Rocheneyre, nearby Bouchet, under the pass of Fageole. They are also present on the *départements* of Puy-de-Dôme and Allier, especially in the Cézalier and the Combrailles (Gonnard 1870; Chaillou 1967). A detailed and descriptive inventory as been realised by F.-H. Forestier in the upper valley of the river Allier (Forestier 1964), completed for the realisation of the geological maps (Lasnier & Marchand 1982 ; Goër & Tempier 1990). The serpentinites exist in the north of the *département* of Allier and are also abundant in the adjacent *départements*, Aveyron for instance (Couturier 1996). At this day, no study has been realised to precise the geographical origin of the serpentinites.

At this day, no site of extraction as been identified in the Massif Central as a whole.

Diffusion of the products & chronology

Some authors thought that the serpentinite composed a lot of axe heads. In fact, it was a confusion with the eclogites, and the axe heads in serpentinite remain scarce. The explanation is certainly linked to the poor hardness of the rock. The serpentinite seems to have been reserved to some « ceremonial » pieces.

In the corpus studied in Auvergne (more than 1200 axe heads; Surmely et al. 2001), 3 pieces only are composed by serpentinite. One of them is an exceptionnal piece, a bipenne and boat-shape axe head, which offers a great quality of finishing, and wich had certainly no utilitarian fonction. It comes from nearby Davayat (Puy-de-Dôme).

The serpentinite has been used to realise bracelets too. One of them, entire, comes from the great site of Corent (Puy-de-Dôme; Grange 1857; Marchant 1865; Mortillet 1907; Goër & Surmely 2000).

In any cases, the serpentinite used as got very beautifull colours, unknown at this day in Auvergne, and it could be materials originated from the Alps or other regions.

All the objects in serpentinite have been discovered without any archaeological context.

1.2.4. THE USE OF THE VOLCANIC ROCKS IN AUVERGNE (F. Surmely)

Two categories exist within the volcanic rocks: the recent lavas from the Tertiary and Quaternary periods, and the paleolavas from the Primary period, which are often metamorphosed. This distinctions are often impossible to establish, because of the patina of polishing and alteration. For this reason, it is often difficult to distinguish a recent lava from a paleolava or a metalava, which gives an imprecision in the determinations at the naked eye. This problem disappears with the realisation of analysis under thin sections.

During the Neolithic period, the most hard and resistant lavas have been choiced. The studies realised for the nowaday industrial exploitation demonstrate that this materials are particulary shocks-resistant, especially the paleolavas (Surmely & Murat 2003). The less tenaceous rocks, especially some lavas with a vacuolary texture of the Quaternary period, have been neglected.

Location of the exploited deposits

The volcanic rocks are abundant everywhere in Auvergne. The recent lavas are omnipresent in the three *départements* studied, and only absent in the *département* of Allier. They are also abundant in the abjacent *départements* southward: Ardeche, Lozere and Aveyron. Most of them form lava flows, put on top relief by the erosion and then, easy to access. So the supplying is easy, guided by the prismation of some stages and by the alteration zones.

The paleolavas and the metalavas are scattered on the whole region, everywhere the hercynian basement offers formations not or few metamorphised. They often form veins. Their age is comprised between the Devonian and the Permian, including the Visean and the Stephanian.

The undoubtfull axe heads in paleolavas or metalavas appear essentially in two regions: the western Cantal and the northern part of the *département* of Puy-de-Dôme. This is due to the proximity of potential deposits, which correspond, for the Cantal, to the Sillon Houiller (paleolavas coming from the stage of the « tufs anthraciferes »): region of Ayrens, Maurs or Saint-Céré (Brousse et al. 1980 ; Bogdanoff et al. 1989 ; Muratet 1981 ; Guillot et al. 1992) and for the Combrailles, to the Visean deposits (regions of Pontgibaud and Volvic: Hottin & Camus 1989). Although a regional origin seems probable, a coming of metalavas from other regions can't be excluded, for instance from the Forez, where they have been abundantly used (Masson 1977 ; study in course by V. Georges).

The determination of the origin of this rocks remains difficult because of the extreme variability of them: ignimbritic tufs, basanites, trachytes, more or less alterated and metamorphosed. The research of the geographical origin remains impossible by examination in thin section and naked eye, and set a geochemical study (Vuaillat et al. 1995).

Production sites

No site of extraction has been recognized at this day. For the recent volcanic rocks, the probability of discovery of such sites is nil, considering their topographic position, which authorize a supplying on the side of a flow, which is quickly masqued by the natural and later collapses. The probability is higher for the paleolavas, but the regional research did not really cared of the question.

Diffusion of the products & chronology

The diffusion ways of these rocks are impossible to restitute because of the problems of geographic characterization and of the broad distribution of them. The volcanic rocks, easy to find in Auvergne and available in nodules of all sizes, have been few used (more or less 7 % of the whole regional axe heads). Notable differences exist between the regions. They are numerous in westward Cantal (17 % of the whole) and northward Puy-de-Dôme, and they are almost absent in Haute-Loire (1 %). The distribution between recent and old lavas remains difficult to do without systematic analyses.

This rocks seem to have been reserved for the realization of great and heavy pieces. In fact, the most imposing axe heads of Auvergne are realised in lavas. The longest piece discovered at this day, at Dore-l'Église (Puy-de-Dôme), which is more than 31 cm long, is probably a paleolava (but a microscopic examination is required).

The lack of archaeological contexts for the most important part of the studied pieces, forbid to examine the chronological variations in the productions.

1.2.5. THE CINÉRITES OF THE ROUERGUE (E. Thirault)

Définition

Formely named « silexites », the cinerites of the Rouergue are volcano-sedimentary rocks comprised within the permo-carboniferian basin of Brousse-Broquies (Aveyron), nearby the river Tarn. The formation, 100 to 150 m thick, includes two series: the lower series, 60 m of thickness, offers quick alternations of cinerites and sandstones, which facilitates the extraction ; the upper series offers massive beds of cinerites (Servelle 1993). The raw material allows a delitage of great slabs, to 1 m of length and few centimeters of thickness. The cinerites offer a good availability for the knapping, are easy to polish and offer real attractive qualities due to their microstratification.

Location of the exploited deposits and production sites

The only exploited outcrop have been discovered by C. Servelle near by Réquista (Aveyron). The whole series outcrops on abrupts sides, where the quarries, the mines and the knapping workshops are located. The extraction consists in delitage of thin slabs with a lever, following the beds and the cracks of the rocks. The choice of the extracted beds depends on the technical (thickness, morphology, cohesion of the rock) and attractive qualities required. The knapping allows to obtain roughouts ready to be polished, wich have an average length of 8 to 12 cm, but sometimes more than 20 cm (Servelle 1993; Servelle & Vaquer 2000).

In a radius of 20 km around the Réquista quarries exist knapping and probably polishing workshops, for instance Juéris at Martrin and Prat-Sarrat at Cassagnes-Begonhes. Their datation is centered on the Chassey Middle Neolithic, but may also be more recent (Servelle & Vaquer 2000; Dausse 1996).

Diffusion of the products & chronology

The roughouts realised on slabs are not diffused more than 50 kms around Réquista, excepted for the long ones discovered as intentional deposits. The roughouts realised on pebbles coming from the Tarn deposits, wich reveal a low technical investment, are not diffused and the polished blades are used on a local scale (Servelle & Vaquer 2000).

The finished axe blades on slabs are diffused till around 280 kms from Réquista, preferentially southward, westward and northward. They appear in the Chassey Middle Neolithic of the Aveyron, the Quercy, the valleys of Garonne and Aude (Servelle & Vaquer 2000), and also nordward in Auvergne and notably in the Cantal (Surmely et al. 2001; Goër de Herve et al. 2002; Surmely et al. to publish). The cinerites are unknown before the middle phase of the Chassey Culture, around 4000 BC calib., and they are well known in the first half of the fourth millenium BC calib. Then, the diffusions decrease till the end of the Neolithic, around 2300 BC calib. (Servelle & Vaquer 2000).

1.3. THE MASSIF ARMORICAIN (E. Thirault)

Coordinated researches in Brittany and it's eastern side have been realised since more than 50 years. The first one have been initiated by P.R. Giot and J. Cogné, then by C.-T. Le Roux (historical record *in* Le Roux 1990, 1999). In proper Brittany, three main petrographic groups have been identified, and in the eastern part of the Massif, several petrographic groups which are poorly diffused are recognized by Le Roux (ibid.).

1.3.1. MÉTADOLERITES OF PLUSSULIEN (CÔTES-D'ARMOR)

Numerous doleritic veins occur in the Massif Armoricain, but only one outcrop has been surely exploited during the Neolithic period, at Plussulien. The metadolerites of the Plussulien's outcrops, formely called « metadolerites of A type », which are metamorphosed during the Hercynian orogenesis, offer exceptionnal qualities. The grain of the rock is very fine, the texture of recrystallization is very tangled, which strengthen the tenacity of the rock (Le Roux 1999).

Location of the exploited deposits, production sites and chronology

Only one outcrop has been exploited during the Neolithic, on a hill located nearby Sélédin and Quelfenec, on the commune of Plussulien, at the geographical heart of Brittany near by the upper valleys of the Blavet and the Oust (Giot et al. 1998; Le Roux 1999). The prospections and the sondages realised from 1963 to 1966 after the agricultural reallocation conducted to delimit the main sectors where the neolithic exloitations were, on a superficy of cca one hundred ha. The excavations realised from 1969 to 1976 on 300 m^2 on the foot of an still visible outcrop has permitted to study the chronology and the modalities of the exploitation, from the extraction to the pecking of the roughouts. Four phases of extraction are identified: first from the alterated upper rock, then from the massive rock pulled down by firing, lastly the exploitation of old blocks coming from the former extractions. The activity of the excavated quarry has been dated by C^{14} from the beginning of the Vth millenium BC calib to about 2500 BC calib.

Around Plussulien, production sites are attested by surveys in a radius below 15 kms, whith the proof of flaking (Le Roux 1999). This workshops are late (Néolithique récent, Campaniforme, i.e. IIIrd millenium BC).

Diffusion of the products & chronology

The petrographic studies lead westward of France have precised the importance of the diffusion of the metadolerites coming from Brittany (Le Roux 1990, 1999). Several facies of dolerites have been identified, but only one, which was exploited at Plussulien, is broadly diffused: in Brittany, this rock represents most commonly more than 50 % of the axe heads, and two main preferential ways of diffusion are identified in the lower Loire basin, and in direction of Normandie. But geochemical studies lead on the metadolerites of Limousin, which are identical to the metadolerites of Plussulien, considering a petrographic point of view, indicate that the metadolerites of Limousin have been used during the Neolithic. This fact questions the reality of the diffusion of Plussulien in the Loire basin (Santallier et al. 1986; Vuaillat et al. 1995).

The available datations on the receiving sites indicate that the metadolerites of Plussulien are diffused since the end of the V° millenium BC calib northward of France, and up to the end of the Neolithic, at the end of the III° millenium BC calib (Le Roux 1999).

1.3.2. THE FIBROLITES OF BRITTANY

Definition

Cf. fibrolites of Massif Central. The fibrolites form nodules or pebbles detached from their matrix and then, directly suitable for the exploitation.

Location of the exploited deposits & production sites

In the Massif Armoricain, two coastal regions offer suitable deposits of fibrolites (Le Roux 1990). At the western part, northward Brest around Plouguin (Finistere), the exploitation is suspected thanks to the discovery of technical indices (roughouts, hammerstones) in a sector where the nodules of fibrolite outcrop. Southward, in the Morbihan gulf southward Vannes (Morbihan), the fibrolite outcrops in the peninsula of Rhuys, but no indice attests a production. Nevertheless, the fibrolites are well known on the near neolithic sites. According to the concentrations of axe heads in fibrolite, other exploitations have to be researched in the south part of the *département* of Finistere, the north-eastern part of Brittany (region of Saint-Malo, Ille-et-Vilaine) and the estuary of the Loire (region of Saint-Nazaire, Loire-Atlantique).

Diffusion of the products & chronology

Axe heads in fibrolite are very scarce outwards the aforesaid regions, wich indicates very restricted diffusions (Le Roux 1999). But it seems that the use of this rock occurs mainly during the old phases of the Neolithic of Brittany (V° millenium BC): it appears in domestic and funeral contexts of the early Neolithic (Villeneuve-Saint-Germain group), then inside the funeral chests under low mounds and inside the giant barrows of the south part of Morbihan (Cassen et al. 1998 ; Cassen 2000, p. 530-532). The use of the fibrolite is so prior to the beginning of the exploitations of Plussulien.

1.4. THE VOSGES (E. Thirault)

The use of the tenaceous rocks coming from the vosgian deposits has been recognized since the XIXth century, but the first elaborated work on this subject is much more recent (Piningre 1974). Then, the diffusion and the petrography of those formerly called « aphanites » have been precised (Willms 1980 ; Diethelm 1989). Nevertheless, the questionning and the field informations have been deeply renewed since 15 years within the framework of a pluridisciplinary programm not yet finished (Jeudy et al. 1995; Pétrequin et al. 1993, 1996; Pétrequin & Jeunesse dir. 1995). We present here the two main productions identified, the pelites-quartz (the most important) and the nodulosy schists, but more than ten exploited deposits have been identified in the Vosges.

1.4.1. THE PELITES-QUARTZ
(quarries of Plancher-les-Mines, Haute-Saône)

The rocks exploited at Plancher-les-Mines are dark coloured, sometimes with white veins, with a very fine grain, generally homogenous. They are volcano-sedimentary and detritic rocks (pelites), dated to the Visean, composed by grains of quartz, felspar and sometimes mica, with a variable proportion of organic material. The very siliceous cement, coming from an acid volcanism, gives a very great consistency to those rocks, which are real curiosity within the sedimentary series of the vosgian Visean. The fine and homogenous grain, allied to the hardness given by the silica, explain the good ability of this rocks for knapping (Rossy in Pétrequin & Jeunesse dir. 1995).

Location of the exploited deposits

The existence of quarries devoted to the extraction of the pelites-quartz has been recognized by P. Pétrequin and it's collaborators in 1989 (Jeudy et al. 1995; Pétrequin et al. 1993, 1996; Pétrequin & Jeunesse dir. 1995). It is a quarrying area composed by two distinct groups on the steep sides of a small valley near by Plancher-les-Mines. Within the main group, the quarries are formed on 6 ha by numerous working faces up to 15 m high, and by the screes formed by the wastes of the exploitation which form cones lower down each forking face. The layout of the quarries, partially recovered by the later cones, autorize to propose a chronology of the exploitations, from the lower part to the upper part of the side, and a chronology of the tecnical schemes of extraction and debitage.

Production sites

Two groups of neolithic sites with the proof of fabrication are known (Jeudy et al. 1995; Pétrequin & Jeunesse dir. 1995; Séara 1995): southward and southwestward of Plancher-les-Mines, at about 20 kms maximum (i.e. one day of walk), in the region of Lure, Belfort and Montbéliard; eastward of the quarries, at about 30-40 kms (i.e. two days of walk), between Altkirch and Thann in upper Alsace. On those sites, the knapping flakes are numerous, but also the roughouts in course of pecking.

Diffusion of the products

The pelites-quartz are diffused essentially westward, southward and eastward from the Trouée de Belfort, between the *département* of Haute-Saône and the Bodensee for the most intensive diffusions (at least 50 % of the axe

heads), i.e. maximum distances of more or less 200 kms. Sporadic diffusions are recognized eastward the Paris Basin, northward the Vosges, in the region of the upper Rhine valley around the Federsee and in the region of Ulm (South-West part of Germany), and up to the Léman Lake and the Valais at some distances exceptionnally upper than 300 km (Piningre 1974; Willms 1980; Pétrequin & Jeunesse dir. 1995).

Chronology

The collective work directed by P. Pétrequin correlates the exploitation of the quarries, the production sites on the dwellings, the fabrication schemes, the diffusions and the uses of the axe heads in pelite-quartz, and then proposes a network of global understanding of this phenomenon. Briefly, the good fortune of the pelites-quartz is linked to the cultural mouvements and of the social transformations identified at a bigger scale (Pétrequin & Jeunesse dir. 1995; Jeunesse & Pétrequin 1997). After a first phase of recognizing of the vosgian rocks, during the early Neolithic (*Rubané i.e. LinearBandkeramik*), where the pelite-quartz are not in the majority in the polished tools, the quarries and the diffusions become more and more important in course of the Vth millenium BC calib.: the sites of production are located in upper Alsace up to around 4200 BC calib. (groups of Roessen III and of Bruebach-Oberbergen) and the diffusions extend westward and eastward. At around 4000-3800 BC calib., the exploitations of Plancher-les-Mines attain their apogee, the sites of production are closer to the quarries (Trouée de Belfort) and they are controlled by the *Néolithique Moyen Bourguignon* Culture ; the diffusions are the most intensive throught several cultural frontiers. After 3600 BC calib., the long-distance diffusions collapse, but the productions of Plancher-les-Mines remain notable at a regional scale up to the extreme end of the Neolithic, around 2200 BC calib.

1.4.2. THE NODULOSY SCHISTS
(quarries of Saint-Amarin, Haut-Rhin)

The *schistes noduleux* exploited in the Vosges, in fact *cornéennes*, are sedimentary rock of the Visean period (pelites and grauwackes), constituted by quartz, feldspars and phyllitean minerals (micas, chlorites). This *cornéennes* are metamorphosed by thermal contact with a granitic magma, which as caused the recrystallization of the cement. The rocks obtained are hard and consistent, they are sometimes bedded, and they can contain millimetric or more smaller nodules. Their availability to the knapping is proved (Rossy *in* Pétrequin & Jeunesse dir. 1995).

Location of the exploited deposits

After numerous prospections realised under P. Pétrequin's leadership, only one outcrop of *schistes noduleux* suitable for the neolithic use as been discovered at Saint-Amarin/Finsterbach on the side of the Markstein (Pétrequin & Jeunesse dir. 1995). On a square of one hectare are preserved the wasted of the exploitation and of the knapping: a depression resulting of the extraction of the rock, the tested blocks, the knapping wastes and the rejected cores allow to understand *in situ* the organization of the work, from the extraction to the preparation of the knapped roughouts.

Production sites & diffusion of the products

As well as for the pelites-quartz, the shaping out is realised outside the quarries, on the dwelling sites located south-eastward Saint-Amarin, in the plain of the Rhine between Thann and Altkirch, a dozen kms far from the quarries.

The *schistes* noduleux are diffused close together with the pelites-quartz, but they represent only a small part of the total of the axe heads.

Chronology

The chronology of both productions and diffusions is parallel to the one of the pelites-quartz (Pétrequin & Jeunesse dir. 1995). The axe heads in *schistes noduleux* are known as soon as the Early Neolithic (*Rubané i.e. LinearBandkeramik*), but the first important activities are not older than the second half of the Vth millenium BC calib. at Saint-Amarin and on the sites of production of the Rhine plain. The apogee is also dated around 4000-3800 BC calib.

2. FLINT PRODUCTIONS

2.1. FLINT PRODUCTIONS OF AXE HEADS IN AUVERGNE (F. Surmely)

Beside the axe heads in blond flint of the upper Cretaceous, probably imported from the edge of the Paris Basin, in Auvergne can be find pieces realised in Tertiary flint of the upper Oligocene, which seem to be regional materials. These flint have a texture sometimes heterogeneous, with an aspect frequently zoned, and colours from light grey to black. Their aspect is very variable, with nodules sometimes important (flagstones of more than one meter of diameter). Some experimentations realised by C. Sestier have demonstrated the good quality of those modules for the shaping out of the axe heads.

Location of the regional deposits

Numerous sedimentary Tertiary basins exist in Auvergne and in the nearby fringes, which offer silicifications (Surmely 1998). These basins may have constitute the potential areas of supplying. The most important of

them are the basin of Aurillac/Mur-de-Barrez in the *département* of Cantal, and the basin of the Comté d'Auvergne in the *département* of Puy-de-Dôme (Surmely 1998; Surmely et al. to pubblish). Most of them are dated of the upper Oligocene. The best materials are located in the basin of Aurillac/Mur-de-Barrez (Pasty et al. 1999).

Production sites

For the regional flints, a mining site has been formerly signaled in the locality of « La Côte blanche » at Mur-de-Barrez (Aveyron), which would have been linked with the axe heads production (Balsan 1957; Boule 1884 et 1887). A new examination of the archives, joined to the periodic supervision of the working face of the current quarry on the site, show that this mining site wasn't really important. Moreover, no indice demonstrates that the production was linked to the axe heads (Santallier & Surmely 2003). During the ancient excavations, no roughout has been discovered.

So it is easier to suppose that the axe heads realised in the regional Tertiary flint have been shaped from blocks revealed by the erosion on the sedimentary deposits. Some indices of this have been signaled, for instance roughouts or knapped axe heads discovered around Aurillac (keeped in the Museum of Archaeology of Aurillac). Considering the superficy of the outcrops and their partial reworking by the volcanic phenomenons, it is almost impossible to discover the traces of the human removal.

Diffusion of the products & chronology

The axe heads in Tertiary flint are numerous in the areas where the material is naturally present (middle of the *département* of Puy-de-Dôme and especially the western part of the département of Cantal). Elsewhere, they are scarce or even almost absent (for instance, in the *département* of Haute-Loire; Surmely et al. 2001). Even in the privileged regions, the local flint seems to have been competed by over siliceous materials: cinerite of Réquista (*cf. § supra*) or allochthonous Tertiary flints (Surmely et al. 2001; Surmely et al. to publish; Surmely & Murat 2003; Surmely & Pasty 2003). So the diffusion seems to have been quite local, even if there is a lack of informations about a potential traffic on the direction of the Quercy or the Rouergue.

Lastly, the caracterization of the geographic origin of the Tertiary flints remains hypothetical. It is very possible, but unprobable at this day, that the flint axe heads discovered in Auvergne may have come from the significant mining sites of the Paris Basin (*cf. § infra*).

As always concerning the axe heads of Auvergne, the corpus is almost composed by objects devoided of stratigraphic context, which forbidd to give chronological arguments.

2.2. AXE HEADS PRODUCTIONS IN FLINT AND OTHER SILICEOUS ROCKS IN THE NORTHERN PART OF THE AQUITAINE BASIN
(P. Fouéré & C. Chevillot)

The materials

The silifications of the northern part of the Aquitaine Basin, from the Poitou to the Périgord and the Atlantic coast, are well known thanks of the interest of several generations of researchers, around the famous regional prehistoric sites.

The flint of the layers of the Jurassic and of the upper Cretaceous, but also the millstones (*meulières*) of the Tertiary and the epigenetic formations derived from it, are all potential sources for the neolithic supplying in axe heads. Nervertheless, all the varieties haven't been used. Several criterions are probably be retain for the selection, such as the abundance of the raw material, the facilities of extraction, the dimensions of the matrices. But we can notice that in fact, the most resistant materials have been used first, in relation with the constraints of the use of this kind of tool. So, the black or brown flints of the Senonian used for the current tools have been neglected for the axe heads, because they are two or four times less resistant to the crushing than the other flints (Fouéré 1994). As we know today, the most exploited flints are ones of the decalcification clays of the upper Turonian of Saintonge (region of Taillebourg-Ecoyeux, Saint-André de Lidon and Pons) and of Angoumois (La Couronne, Vallée de la Boëme), the flints of the middle Jurassic of Poitou (Sommieres-du-Clain), and also the flints of the end of the Senonian of the region of Bergerac. Locally, we can add the millstones of the Tertiary (Saint-André-et-Appelles) or the silico-ferruginous flagstones of the valley of the Dronne. The main articles given in references, most of them old, give a glimpse of this exploitations.

Modalities of extraction

The documentation is really unequal for the different areas of production. The excavations on the mining sites and workshops in the Aquitaine Basin remain almost non-existent, and in most of the cases, we have to deal with the surface gatherings.

The modalities of extraction are almost unknown, but they are probably pits or working faces in the decalcification clays of the changed covering of the underlying limestones dated to the Tertiary. The higher concentrations in nodules, the higher quality of the flints and the facilities of exploitation of this geological deposits justify their exclusive exploitation.

Some examples of the structures of extraction are known: pits have been signaled on the workshop of La Petite Garenne at Angouleme (Favraud 1911) and most recently on the neighbouring site of La Couronne (Cha-

rente) where exist also some small working faces open in the clays covering the upper Turonian (Fouéré et al. 2001). At Saint-André-de-Lidon (Charente-Maritime), a small pit has been discovered during a poll on the workshop of La Merletterie (Fouéré 1994). Lastly, the same kind of exploitation has been observed for the silico-ferruginous flagstones in Dordogne, at Sauclaud where pits digged in the clay allowed to touch, two meters deeper, a diaclasis dug in the Turonian limestone, filled with silico-ferruginous flagstones (Chevillot et al. 1999, 2000, 2001, 2003).

The strategies of exploitation are yet poorly described. At La Couronne, the quarriers looked for the concentations stratified within the clays, with more or less success. For this they made working faces or sporadic diggings, from the outcroping layers. Curiously, the best part of the deposit, burried at less than one meter in the clays, has not been exploited. Most of the extracted blocks have been tested, freezed or not. The pit of La Merletterie has been dug on more than one meter deep in the silts to reach a level with stones and flints of various qualities.

Shaping out the preforms

In all the regions considered, the shaping out of the preforms seems to be realised for the most important part on the sites of extraction, revealed by the areas of high concentration in raw materials. The numerous knapping wastes and the faulty abandoned roughouts allow to discuss the conduct of the debitage.

The first transformations are probably realised immediately after the extraction: quality test of the material, then preparation of the preform following the methods appropriate to the morphology of the raw material. For the nodules or the polyedric blocks of suitable dimensions, the direct shaping out of the roughouts is used; when the blocks are too much important or when the aim is to realise small axe heads, the debitage of big blank-flakes is privileged. At La Couronne, a first stage is to cleave the lens-shaped nodule in two parts, because of the frequent presence of a geode in the equatorial plane of the block. Those works on the extraction sites are realised almost in any cases by direct percussion with a hard hammer ; actually, the stigmatas of the soft percussion (lip, lack of impact point, ...) appear on few scarce flakes. Once never find (or very few) roughouts ready to be polished on the natural deposits, the best preform being taken out by the knappers.

Sometimes, all or part of the shaping out chain is realised on the dwelling sites, after importation of the raw material or the preform sometimes on several kms. It is the case on the site dated at the *Néolithique récent* type Peu-Richard and of the site at Diconche in Saintonge dated at the *Néolithique final* (Artenac group; Fouéré 1994; Burnez & Fouéré dir. 2000). Once find the cortex removal flakes and up to the "peelings" of finition. Some small workshops, corresponding only to the ultimate phase of the shaping out of the preform, are known too for the *Néolithique récent* of Bergeracois, at Les Gillets (Fouéré et al 1998) or at Les Réclaussoux (Fouéré et al. 2003). Unlike the extraction sites, the shaping out of the preforms on the dwelling sites seeks most commonly a soft hammer.

Polishing

This ultimate stage of the fabrication of the axe heads is probably the most difficult to understand. The unpolished roughouts may sometimes diffuse on long distances. Then, the preform ready to be polished of axe heads realised in flint of Saintonge can be find on numerous regional dwelling sites, as far as the Vendée. It is also the case for the axe heads in flint of Bergeracois recovered on the Atlantic coast of Médoc. Some megalithic whetstones are known in Dordogne and in the basin of the river Charente, but they are too much scarce to prove the existence of workshops devoted to the polishing. The finishing of most of the axe heads has probably been realised mainly on the dwelling sites, where small whetstones are frequently discovered.

Typology

Define a type or a standard for the axe heads isn't easy, because most of the available pieces are broken, reknapped, or even repolished and resharpened. Then, the dimension of the nodules used is very variable. According to the roughouts abandoned on the workshops or the scarce intact axe heads, some specific criterias may appear in the regions of production. The axe heads of the Poitou, seen on four workshops of the valley of the Clain, are small sized, rarely longer than 15 cm, with sometimes plano-convex sections caracteristic of the adzes. The axe heads of the Saintonge, where the adzes are scarce, are frequently 15 to 20 cm long, or even more according to the size of some fragments. This is also a maximum for the productions of the Angoumois and of the Bergeracois, even if we know some long roughouts ready to be polished of 26 and 28 cm on this region and for the millstones of Saint-André-et-Appelles in the *département* of Gironde (Cauvin 1971). Numerous axe heads of the Bergeracois have particular squared sides and an invasive and blading (« *laminaire* ») retouch on the proximal part, retouch realised after polishing. Nevertheless, those lateral ledges aren't an exclusivity and may exist on the productions of the Saintonge.

Datation

The scarcity of datations is linked to the lack of excavations on the mining sites of the Aquitaine Basin. No date is available for the sites of production of Saintonge, Poitou and Périgord. One of the pits of La Couronne is attributed to the *Néolithique récent* by the radiocarbone. In return, the products discovered on the dwelling sites autorize to suppose the beginning of the exportations at

least at the *Néolithique moyen* for the productions of the Bergeracois (cave of Les Perrats at Agris, Charente, Roquefort at Lugasson, ...) of the Saintonge (Les Châtelliers at Auzay, Vendée). The full growth of the regions of production corresponds probably to the *Néolithique récent* and *final*, linked to a probable demographic growth illustrated by the abundance of sites.

Extent of the exportations

The precise study of the exportation of axe heads in the Aquitaine Basin and their spatial and temporal variations is a long work which, for the main part, still have to be realised. Each region of production had probably it's own area of influence which may have evolved according to economic, social or cultural criterions (which remain unknown). Considering the Neolithic period as a whole, the productions of the Bergeracois are probably the one which have the most circulated. Axe heads are known as far as the Saintonge and the Angoumois, near by the centers of production of the axe heads in turonian flint, and the exportations go probably broadly southward, up to the foothills of the Pyrénées (Vaquer 1990; Delage 1993; Fouéré 1994). The axe heads of the Saintonge have rather a littoral diffusion, known from Brittany up to the Gironde (Fouéré, *op. cit.*). Except for the local use, once doesn't known the scale of the exportations of the axe heads of the Augoumois. Those later are probably in competition with the crystalline rocks of the Limousin, the Bergeracois and the Saintonge. The same observation can be realised for the axe heads of the Poitou: the scarce known workshops did probably not give the same mass production as the other regions.

Numerous points have to be developped concerning the axe heads productions of the Aquitaine Basin. Some elements of answers would probably be given by the works in course, especially the excavations on the mining sites of Sauclaud (Villars, Dordogne) and the researches programms on the Bergeracois.

2.3. THE PARIS BASIN

2.3.1. THE MINING SITES IN THE TERTIARY FLINT OF THE PARIS BASIN (F. Bostyn & F. Giligny)

The Tertiary flint of the Paris Basin is coming from the marly-limestone levels of the middle Bartonian (limestones of Saint-Ouen), which is a lacustrine limestone in which the silicification isn't always complete. The presence of numerous microfossils, sometimes bad recrystallized, may cause irregularities in the raw material.

Location of the exploited deposits

The strata of the Bartonian outcrop in the whole Paris Basin, between the valleys of the rivers Aisne and Oise northward, the valley of the river Marne and of it's main tributaries southward. Eastward, the Île-de-France cuesta forms a natural and sharp limit in an arc of a circle form. Westward, the concerned strata are limited by the river Epte on the right bank of the river Seine, and by the river Vaucouleurs on the left bank. In fact, the levels are accessible only on the sides of the main rivers and of their tributaries, and also in the outliers which subsist in some areas.

Production sites

At this day, three sites of extraction are certified:
- Jablines « le Haut-Château » (Seine-et-Marne), mining site recognized by aerial photograph and excavated on a strip of 500 m long and 60 m wide on average (Bulard et al. 1986 ; Bostyn & Lanchon 1991, 1992, 1995, 1997). On this area, more than 750 shaft holes have been recognized. From this sample, it is possible to estimate at more than 5000 the number of shafts on this mining site (Bostyn & Lanchon dir. 1992).
- Coupvray « Les Chauds Soleils » (Seine-et-Marne), mining site formerly recognized by surface gatherings (Giraux & Reynier 1911) and identified as a mine during the widening of the railway at the end of the 1970'. Some shafts have been also repeared by aerial photograph in 1989. No recent excavation has been realised.
- Flins (Yvelines), mining site formerly recognized by surface gatherings (Silvestre de Sacy & Baudouin 1926, 1927). Aerial photographs realised in 2000 by the *Service Archéologique Départemental* of the Yvelines have permitted to locate several areas of high concentrations of shafts. A pedestrial and fine prospecting linked to a geophysical prospecting (realised by the Society Terra Nova), complete the knowledges about the extension of the mining site, which remain still partial at this day (Bostyn et al. 2002, 2003).

Chronology

At present, the mining site of Jablines is the only one which gives precise data about the chronology of the exploitation and so, of the production of the axe heads which is intimately linked. The radiocarbone datations realised on 16 different shafts demonstrate that the exploitation is lasting from 4060 BC cal to 3050 BC cal, i.e. during the *Néolithique moyen* and the beginning of the *Néolithique récent*.

Diffusion of the products

Considering the great likeness between the small plates coming from the several outcroups of the bartonian flint, we are not able yet to precise the exact coming of the finished products discovered on the dwelling sites localized outside the Tertiary Basin (Bostyn 2003). During the *Néolithique moyen*, axe heads in Tertiary flint are known eastward on the site of Mairy (Ardennes; Hamard 1993), westward on the site of Louviers « la Villette » (Giligny dir. to publish) and northward in the

département of Oise (Hamard 1993, Verret 1987). At the opposite, south-eastward the Paris Basin, no product as been signaled at this day on the dwelling sites (Augereau 1993).

2.3.2. FLINT EXTRACTION AND AXE HEADS PRODUCTION, THE EXAMPLE OF THE MINING COMPLEX OF THE PAYS D'OTHE
(Aube & Yonne; P.-A. de Labriffe)

Upon the construction of the motorway A5 between Paris and Troyes (Aube), four flint mines and their workshops have been observed (3). Those interventions have also permitted to locate or to rediscover a ten of mines, knapping worshops and polishings.

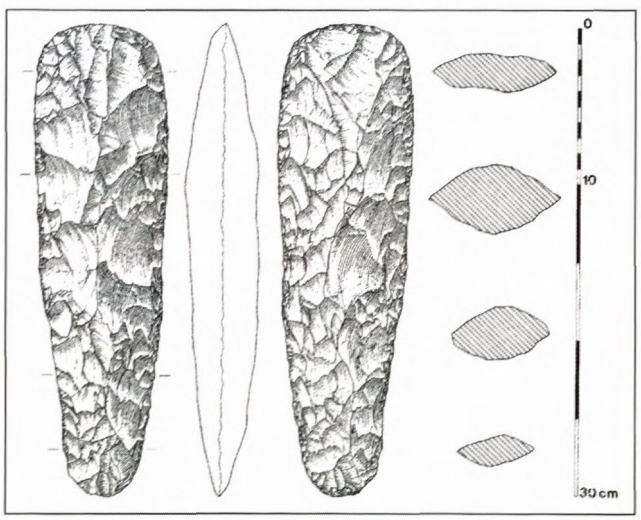

Figure 3. Axe head in Bartonian flint coming from Jablines " Le Haut Château " (Seine-et-Marne, drawing S. Vacher).

Geographical and geological context

The Pays d'Othe, located between 100 and 150 km south-eastward Paris, belongs to the Paris Basin, from a geological point of view. The substratum is mainly constituted by chalky deposits of the Senonian abundantly provided in flint. They are sometimes surmounted by Tertiary remains which contain numerous blocks of sandstone.

In spite of a common geological frame, each of the excavated sites had it's own conditions of geological deposit. All the extraction sites are established on Secondary aged deposits (Campanian or Coniacian). At Villemaur « Grand Bois Marot » and Serbonnes, the Senonian layers are recovered by Quaternary deposits, resulting from the alteration of the underlying chalky deposits.

The beds or nodules of exploited flint are either in primary position within the chalk, or in secondary position within the Quaternary sediments. Generally speaking, there are small and irregular nodules, with numerous excrescences. Within the chalk, they form sub-horizontal beds. But the neolithic miners have also exploited the nodules present within the Quaternary deposits, which are formed by the demolishing of the beds of flint. The miners have often exploited several beds in the same time.

Organisation of the sites

Each of the excavated sites covers a surface of several hectares, in which only a very tiny percentage has been specifically studied. The both mines of Villemaur could have a extent comprised between 15 and 40 ha. Some sites have a considerable density of structures per hectare. Actually, we estimate that on the site of les Orlets at Villemaur there are more than 800 structures of extraction per hectare. The numerous crosses between structures tend to demonstrate a long duration of the occupation.

No dwelling vestiges nor domestic wastes have been discovered on the four excavated sites. Nevertheless, a child burial as been discovered at Villemaur « Les Orlets ». It was settled in the upper filling of an extraction shaft. Considering the layout of the body, it is a real burial and not an accidental death.

The structures of extraction

Three types of structures have been identified.
- *The pits*: they are not deeply dug (several tens of cm), generally sub-circular shaped in surface, with a basin shape in profile. They are rare and localized on the margins of the mining sites, where the banks of flint outcrop on the surface.
- *The shafts*: this word gathers all the deep structures. Their size and morphology are very variable. The location and the layout of the raw material govern their shape. The depth vary from 1,50 to more than 6,50 m. They have a circular opening, which is prolonged by a chimney or access shaft. This vertical chimney is open at the level of the bank(s) of flint, by chambers of extraction disposed in radius. They are small sized, go not far from the shaft (2 or 3 m maximum) and are only 80 cm high in average, which forbid the miner to stand up.
- *The trenches*: this system of exploitation, revealed on other european mining sites, as been used at Pâlis, where one of the exploited bank outcroped. This trenches are narrow, sinuous and not very deep.

The tools used for the extraction

The antlers have been preferentially used on the four mining sites. Several hundred of objects, representing all the stages of fabrication, use and surrender, have been collected during the excavations on these sites (4). The form and the functions of the tools are varied: picks or pickaxes, rams or loosers for the nodules, rakes, etc. The falled antlers are the most frequent, but some slaughter antlers are also present. On the site of Le Grand Bois

Marot at Villemaur, we have also discovered some picks in flint, but they are much less abundant than their equivalent in antlers.

Technics of extraction

In the Pays d'Othe, the technics used for the digging are particular. The neolithic miners adopted a system aimed to reduce to the minimum the efforts for a optimal result in spite of the random distribution of the raw material.

In most cases, a first pipe has been dug to recognize the raw material. This hole, a cylindrical shaft with a small diameter, permitted to observe the nature of the flint on it's faces. If the conditions were good, then the exploitation begun, with the digging of small chambers of extraction disposed in radius from the shaft. If several beds of flint are present in the same shaft, the first to be exploited is always the lowest. Then, the neolithic miners always tried to let the most as possible of sterile sediments inside the spaces freed by the advancing of the work.

On several of the excavated mining sites, we fund examples of test-shafts abandoned without being used for the exploitation, because they didn't reached any suitable flint. These test-shafts are perfectly cylindrical pipes without any chamber of extraction. They are generally located at the margins of the mining sites.

Production

The conditions of preserving of the four sites are very different. At Villemaur « Le Grand Bois Marot », the workshops of debitage located at the exit of the shafts were perfectly preserved. In opposite, on the other sites the production is known only by the wastes of debitage trapped inside the upper fillings of some of the structures of extraction.

On the three sites excavated in the *département* of Aube, the dominant production is the axe head. But there is also, marginally, a production of short and wide blades, and also flakes. All the stages of the fabrication of the axe heads are represented on the sites, excepted the polishing which should have realised near by the mines, on one of the numerous whetstones of the region.

Datations

The objects suitable for answer directly to the question of the chrono-cultural assigning of these mining sites are extremely rare. Nevertheless, we have to signale the discovery of a tulip-shaped vase in the upper filling of one of the shafts of the mining site of Les Orlets at Villemaur-sur-Vanne. From a cultural point of view, this vase could be related to the Michelsberg Culture, to the Group of Noyen or to the Néolithique Moyen Bourguignon.

On the site of Le Grand Bois Marot, inside the debitage piles, few notched scrapers have been found, tools belonging to the *Néolithique récent* or *Néolithique final* (Seine-Oise-Marne Culture or Group of Gord).

On both sites of Villemaur, these impressions are confirmed by the radiocarbone dates realised on charcoals discovered inside the fillings of the shafts. At Les Orlets the dates rise in tiers from 6510 ± 50 BP to 5100 ± 130 BP. Most of the dates are around 5300 BP. At Le Bois Marot the dates are more recent and are comprised between 4320 ± 80 BP and 3980 ± 30 BP.

Conclusion

The sites excavated thanks to the opportunity of the building of the motorway A5 have also permitted to rediscover other probable sites of extraction. Added with the sites excavated, it forms in this small region one of the important centers of extraction of flint and of fabrication of axe heads. Despite the lack of precise informations on this subject, we can assume that the axe heads of the Pays d'Othe have not only supplied the populations located immediately near these deposits, but also the communities located at several tens of kms eastward in sectors where the flint is totally absent.

2.3.3. THE AXE HEADS IN CRETACEOUS FLINT OF PICARDIE (F. Bostyn)

In Picardie, most of the chalky layers of the Cretaceous (Campanian, Santonian, etc.) comprise beds of flint more or less dense and continuous. All of them may have been potentially exploited, but at this date, the extraction of the beds of flint is known on several broad sites. Nevertheless, the production of axe heads is studied or mentionned only on few of these sites. Only those sites are presented here.

Location of the exploited deposits

- The mining complex of Hardivilliers-Troussencourt (Oise): the neolithic exploitations affect a bed of white shalk of the Campanian (Agache 1959, 1960). The knapping workshops installed immediately near by the shafts for flint have given an abundant documentation on the making of the axe heads.
- Hallencourt (Somme; Fabre 2001)
- Nointel (Oise; Fouju 1891)
- Champignoles (Oise; Fouju 1891)
- Margny-les-Compiegne (Oise; Quenel 1913).

Diffusion of the products

Few studies have been realised on this aspect in so far as the fine work of recognizing of the possible differences between the deposits of raw material is hardly roughed out. In other respects, on numerous sites, the researches are very old and the datas remain sporadic.

Considering the abundance of the raw material in the region, it is probable that the diffusion of the axe heads remained at a regional scale.

Chronology

No C^{14} date has been realised on the mining sites of flint previously quoted. For this, the datation of the extraction and of the fabrication of the axe heads realised on the very place of the acquisition remains indirect, by the presence of products on the dwelling sites. Since the Middle Neolithic, the presence of numerous axe heads is signaled on the dwelling sites (fortified or not) and this production continue during the *Néolithique récent* and *final.*

2.3.4. THE MINING SITE OF HALLENCOURT (SOMME) AND ITS APPROACHES (J. Fabre)

Location of the exploited deposits

The mining site of Hallencourt is located on a shalky outlier of the Campanian belonging to the plateau of the Vimeu, on the left bank of the river Somme (Fabre 2002, 2003). It is constituted by 17 separated *loci*, scattered on an area of 200 x 600 m. Each *locus* presents structures of extraction and knapping workshops accompagned by their suite of rejected pieces which reflect the whole fabrication schemes. All these *loci* give also shaped tools, on blocks and on shaping out flakes, which are associated to the exploitation: picks, edged hammer stones, backed knives, thick scrapers and scarce large scrapers, but very few domestic material. So the conduct of this mining site, a small-scale production because of the scattering of the *loci*, is different of the conduct of Jablines, where the exploitation is intensive. Hallencourt functionned mostly from extraction shafts, and the surface cartography shows structures of various dimensions (on 15 *loci*), but also probably, according to the geological study, two annex exploitations in the open air, on the outcrop. The Campanian flint of the mining site is found on several peripheral sites, especially the site of the Group of Gord (*Néolithique final*) of Bettencourt Saint-Ouen, located at 19 kms, which gives for a part a datation for the mining exploitation of the flint. Another C^{14} datation has given, on antlers found in a excavated shaft, an age of the Old Chassey Culture for the mining site, which so functionned in continuity or not at least from the Chassey Culture to the Group of Gord.

Diffusion of the products and chronology

The relations with the peripheral sites (Fontaine sur Somme, Liercourt, Allery, Bettencourt), were not limited to the diffusion of bifacial pieces but also to domestic material (scrapers, notched srcapers, backed knives, etc.) from Campanian flint previously shaped. The knappers of the villages shaped also axe heads in Coniacian flint. The proportion of this domestic material decrease from the mining site till Allery (4 kms; 66 %), Fontaine (6 kms; 40 %) and Bettencourt (19 kms; 8 %), which implicates social relations in a context of micro-regional finage. Endly and at this day, there is no testified communication between this mining site and some sites excavated attributed to the Middle Neolithic (Longpré-les-Corps- saints, enclosure of L'Etoile). On the other hand, there is less than 1 % of Campanian material at Pont-Remy, a surface site also attributed to the Middle Neolithic. So the mining site initiates shyly its activity during this time and is at its full power during the period of the Group of Gord.

Generally speaking, the sites located on the edges of the plateau give indications about the presence of neolithic people on the outcrops of flint of the Coniacian c, b and scarcely Coniacian a. On the sites located in the bottom of the valleys, the situation is reversed. The most used flint for the axe heads is the Campanian one of the mining site of Hallencourt, but the Coniacian flint b/c and exceptionally the Coniacian a are also used.

2.3.5. SYSTEMS OF PRODUCTION OF AXE HEADS IN THE MIDDLE NEOLITHIC IN THE PARIS BASIN (A. Augereau & F. Bostyn)

The different productions of axe heads

Since the Middle Neolithic (*Néolithique moyen*), the two main resources of flint of the Paris Basin, the flint of the Tertiary (Bartonian) and the flint of the Cretaceous (Coniacian, Santonian, Campanian), are widely exploited for the making of axe heads on the sites of extraction. The production of axe heads in Tertiary flint is realised on plates of big dimensions, which give products relatively standardized (the longest are 30 cm long). The forms of the rare roughouts ready to be polished studied at Jablines « Le Haut-Château » and also the polished tools coming from the Yvelines are slightly trapezoidal, the sharps are regular and convex and the sections are oval and regular. The stage of competence required for the shaping of these pieces is necessary high (Bostyn 1992).

The axe heads realised in the flint of the Cretaceous are less long (less than 20 cm), but differences within the quality of production are perceptible between the South-East of the Paris Basin and the Picardie. In the Pays d'Othe and the Sénonais, the pieces ready to be polished are often irregular and not really long (often around 15 cm). The failures of production are particularly abundants and testify the relatively low degree of competence (Augereau 1995). In opposite, the knappers of the mining area of Hallencourt (Somme) owned a sufficient degree of know-how to product roughouts of axe heads more regular, even if the accidents remain frequent on the studied rejects (Fabre 2001). The axe heads of the mining site of Hardivilliers-Troussencourt (Oise) precisely described enough by R. Agache (1959 & 1960) present very close characteristics to the axes of Hallencourt.

Once observe a bifacial and bilateral shaping, ended by a stage of regularizing of the edges and of the sharp. There is also a similarity in the dimensions: the lenght of the roughouts vary between 12 and 15 cm in majority.

The impact of the raw material

The quality of the finished products is greatly linked to the initial morphology of the blocks and to the quality of the raw material. Actually, the Tertiary flint of the Bartonian looks like small plates more or less thick, with a morphology adapted to this production. The silicification is mostly homogenous, and the possible crackings are easy to locate on the surface of the plates, which avoid numerous accidents during the knapping (or during the shaping). This qualitative selection of the raw material has a reflect on the organization of the underground exploitation of the flint, because the upper bed of flint (of lower quality) has been almost neglected during the extraction. The differences of thickness observed on the plates coming from the different zones of the mining sites have also an impact on the finished products, because for the thinest blanks, some cortical surfaces are often preserved on the central part of the tools, on one or both faces.

At Villemaur (Pays d'Othe), the raw material of the Cretaceous is globaly of mediocre quality, and some bad silicified zones can frequently be observed. The nodules have random morphologies and dimensions, and they form discontinuous beds. The two upper beds are constituted by nodules of small dimensions, and they have been few exploited. The third bed comprises mostly faulted small plates. The last bed, which is the most researched, contains nodules of better quality, but they have various forms and dimensions.

On the mining sites which exploit the Campanian flint of Picardie, the choice for the making of the axe heads was realised preferentially at the advantage of the biconvex nodules, sometimes almost table-shaped. These nodules have a form closest as possible as wanted for the roughout ; the more irregular nodules are devoted to the production of flakes. At Hardivilliers, the miners have also neglected the nodules coming from the silts containing flints, which are almost all frost-broken.

The production of axe heads as a reflect of various social organizations

Only the situations of Jablines and of the Pays d'Othe have been studied enough to allow the discussion about such aspects of the socio-economical organization of the productions of axe heads. In the Pays d'Othe and the Sénonais, the very random quality of the raw material, the relatively low degree of competence (translated by the production of short pieces and of mediocre quality) and the abundance of sites of extraction in the valleys occupied during the Neolithic, all these facts are convergent elements for an hypothesis of the fortuitous exploitation of the deposits of flint for the satisfaction of local needs. If the products have been diffused, it has probably been a limited one.

In the case of the productions of axe heads in Tertiary flint, the situation is very different. The extremely structured extraction of the lower bed of flint suppose that the conduct of the deposit was strict, and it requires a precise know-how. These facts suggest a speciallized activity of craft. In other respects, the technical quality of the long axe heads is the matter of specialized knappers which own a high degree of know-how to carry out this production. The quantity of flint extracted on the single mining site of Jablines probably passed the needs of a single village and the long axe heads have probably been included in the exchange networks which were functionning during the Middle Neolithic. Actually, some axe heads in Tertiary flint have been diffused eastward till the Ardennes (Mairy) and westward till the valley of the Eure (Louviers), which represents each time several tens of kilometers.

2.5. THE LORRAINE: THE FLINTS OF THE OXFORDIAN AND THE MINING SITE OF SAINT-MIHIEL (E. Thirault)

Definition & location of the exploited deposits

The white oolithic and lithographic limestones of the upper Jurassic (Oxfordian), which outcrop in the valley of the river Meuse are the only one in Lorraine to contain flints of good quality (Guillaume 1987; Georges 1995). The are chalcedony-flints and limo-siliceous cherts wich form nodules often ovoidal, mostly grey coloured with a white and shalky cortex. At Saint-Mihiel, three beds of flint have been exploited between 2 and 4 m of deepness in average. The deeper bed is the most suitable for the knapping and is associated to blocks of quartzites which have been extracted and used to make tools.

The mining site of Saint-Mihiel

In the zone of the Oxfordian outcrop, 6 mining sites and 3 zones of concentrations of knapping workshops have been discovered. The mining site of Saint-Mihiel, known since 1878 is the only one to have been partially excavated under the direction of C. Guillaume from 1972 to 1979 and in 1986-1987. The mining site is located on the left bank of the Meuse on a hill shelf. 18 surveys and areas of excavation permitted to understand the extension and the organization of the mining site. Four zones of extraction are located on two ha. Within the excavations, 65 structures have been identified: 47 shafts, 18 galleries and one trench, for a total estimated about 1000.

Two types of units of extraction are identified:
- a shaft associated to a gallery,
- several shafts associated to a long gallery; the seconds are the extend of the firsts.

In average, from a shaft of 1,5-2 m of diameter, the galleries are dug on 2-3 m wide, and 4 to 7 m long. The extraction begins by the removal of the lower bed of flint, the best, then the upper beds are extracted and the spoil hearth is set down on the bottom of the gallery. The study of the filling and the organization of the shafts allows to imagine an exploitation by successive units gradually agglomerated. This kind of exploitation requires a team of 2 to 6 miners during the bad season (outwards the agricultural works).

Diffusion of the products and chronology

According to the available dates, the exploitations of Saint-Mihiel are in activity during the IIIth millenium BC calib., i.e. the regional Néolithique final. The products (polished axe heads, tranchets, arrowheads, products of debitage) are known on the sites of the « Mosellan Group », subsequent of the Group of Gord and of the Seine-Oise-Marne Culture, which indicates a preferential diffusion eastward in direction of the Rhine valley and none diffusion in the direction of the Paris Basin nor the Champagne. So maybe the mining site of Saint-Mihiel was exploited by only one community for it's own benefit.

2.6. THE LACUSTRINE FLINTS OF HAUTE-SAÔNE AND THE MINING SITE OF THE REGION OF ETRELLES (E. Thirault)

Definition & location of the exploited deposits

The lacustrine flints of the Tertiary (Oligocene) of the *département* of Haute-Saône occupy a basin of around 30 x 15 km between the rivers Saône and Ognon. The flints are included within the marls and the limestones, forming discontinuous beds of variable forms: plates, flagstones and nodules. The dimensions can attain 80 cm and the masses can exceed a tens of kg. Among the varieties of flint identified, only the « type 207 » defined by J. Affolter has been intensively exploited.

The neolithic exploitations are known since 1878 in the region of Etrelles (Piningre 1974). Surface prospecting led since 1960 confirmed the presence of the Paleolithic and the Neolithic, and, from 1986 to 1991, a global study has been conducted about the Tertiary basin and the workshops of Etrelles under the direction of C. Cupillard (Cupillard & Affolter 1995).

Production sites

Around 20 open-air sites are count, including 7 mining sites of 2-3 to 7-10 ha; one group is located at Etrelles and at Mont-les-Etrelles. The whole forms a complex of 20 to 30 ha. The excavations of 1986-1991 concerned a sector of 360 m^2 excavated on the mining site of Blanc-Saule at Etrelles-et-la-Montbleuse, for a total superficy estimated to 3 ha. Apart form the knapping piles, 10 dug structures (pits and shafts) have been excavated. They are dug up to the substratum, i.e. a deepness of 2,4 m maximum.

Diffusion of the products and chronology

On the mining site of Blanc-Saule, a group of C^{14} dates indicates the presence of exploitations at the end of the *Néolithique moyen II* and at the beginning of the *Néolithique récent* (4000-3000 BC calib.), i.e. at the end of the *Néolithique Moyen Bourguignon* and the late *Cortaillod*. Some younger dates indicate exploitations around 3000-2600 BC calib.

The distribution of the knapped axe heads is linked to the Tertiary lacustrine basin, i.e. the sector close to the mining sites. In opposite, the polished axe heads realised in flint « type 207 », are broadly distributed in the *département* of Haute-Saône, but they are hardly kwown upwards.

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Notes

(1) The writing of the notices as been entrusted to the authors indicated at the head of each notice. Besides, E. Thirault assumed the coordination of the whole.

(2) Fibrolite could exist in some areas north-eastern of the Cantal.

(3) Serbonnes « Le Revers de Brossard » (Yonne), excavation leaded by Manuel Mendoza,
- Pâlis « Le Buisson Gendre » (Aube), excavation leaded by Jacqueline Hascoët,
- Villemaur-sur-Vanne « Le Grand Bois Marot » (Aube), excavation leaded by Pierre-Arnaud de Labriffe,
- Villemaur-sur-Vanne « Les Orlets » (Aube), excavation leaded by Pierre-Arnaud de Labriffe.

(4) They have been studied by Isabelle Sidéra (UMR 7041 of CNRS).

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