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Research Article

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An Invention Shading Light to the Socio-History of Bonneuil Quarry Basin: The Roadheaders with Rotating Drill Bits

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Abstract: The Bonneuil quarry basin is located in the North-East of Paris; it played a role in the well-known stone trade for Paris and its surroundings in the nineteenth and the beginning of the twentieth centuries. Stonecutters of this area mainly used the extraction with the lance, a long iron spin bear by a scaffolding. This tool helped the quarrymen speed up their work allowing them to be competitive in trading. At the end of the 1930s, Martial Lefèvre, a wealthy owner of quarries in the Bonneuil's basin, created a machine, roadheaders with rotating drill bits, following the movement of his quarrymen using the lance. The story of this machine was also involved in the Second World War and the occupation of France. Merging modern archaeology, history, and archaeology of technique, the aim of this paper is to explore the transition between hand tools and mechanical tools through the *chaîne opératoire* filter, a subject that is currently little studied. It also crossed the path of the delicate story of a small industry during one of the most events in France, the Second World War. Using it as an example, this article questions the status of these quarries during and after this main event.

Keywords: archaeology of technology, chaîne opératoire, France, contemporary period, ethnoarchaeology

1 Introduction

The analysis of *chaînes opératoires* (production chains) for the extraction of blocks from underground quarries has drawn the attention of scholars in France since the end of the 1970s. Rarely excavated (Morleghem, 2022), underground quarries remain a poorly studied topic of archaeological research except for some important quarries like Paris or Bois des Lens (*Département du Gard*, 30) (Bessac, 1996; Blary & Gély, 2020; Bessac, Lamesa, & Sciuto, 2021).

As regards resources in the form of large blocks of stone in the Paris basin, quarrying centres like those of Paris and Creil were at times the subject of detailed studies (Benoit et al., 2000; Gély & Blary, 2012). The authors mainly concentrated on the formation of these quarrying centres and their changes over extended periods of time. Above all, very few studies about extracting industrialization have been led yet because most of the time, they focused attention on the processes of extraction of blocks in periods of the distant past (during Antiquity and the medieval and modern periods), i.e., during pre-industrial historical phases.

Special Issue on Reconsidering the *Chaîne Opératoire*: Towards a Multifaceted Approach to the Archaeology of Techniques, edited by Marie-Elise Porqueddu, Claudia Sciuto & Anaïs Lamesa.

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These orientations in research partly explain the scarcity of archaeological studies on quarrying basins of lesser importance, and whose extractive activities mainly developed at the end of the nineteenth century, at a time when underground quarries were being mechanized.

Although exploitation techniques of fitted carved stone have changed relatively little during Modern Times in the quarries of the Oise, the appearance in the nineteenth century of lance extraction was the first technological step prior to mechanization, which revolutionized stonemasonry in the mid-twentieth century. This mechanization of extraction came in the wake of innovations favoured by technical, economic, or social factors, as in the case of the site which is at the core of our study: the “Masures du Tranloy/SCOM” quarry located in the municipality of Bonneuil (Oise; Figure 1).

The goal of this article is to question the impact of the *chaîne opératoire* – and therefore to go beyond the technical factor to explain the invention of this machine: to what extent does this machine’s production line clarify the genesis, location, and reasons for its invention? What are the dynamics at play in the process of invention of the extractive technique that uses roadheaders with rotating drill bits?

In order to answer these queries, it seemed interesting to dwell on the three factors (technical, social, and economic), which appear to have played a part in the process of creation of roadheaders and which also provide explanations for their demise in the post-war era. We shall first of all deal with the technical factor and then with the socio-economic one. By doing this, we will thus reveal the complexity of the process of invention of the extractive technique that uses roadheaders with rotating drill bits.



Figure 1: Geological maps of the Paris Basin with the localization of Éméville (after É. Collomb, *Carte géologique des environs de Paris*, Savvy Ed., 1865). A, Alluvion (Quaternary); L, Montmorency cavernous siliceous limestone (Upper Oligocene); F, Fontainebleau sands (Upper Oligocene); M, Brie siliceous limestone (Lower Oligocene); V, Gypsum and marls (Priabonian); H, Saint-Ouen Lacustrine limestone (Upper Bartonian); B, Auvers and Beauchamp sands (Lower Bartonian); G, “Calcaire grossier” limestones (Lutetian); S, Sand and clay (Ypresian); C, White chalk (Campanian).

1.1 Current State of Art

Mainly abandoned nowadays, quarries currently located in the municipalities of Bonneuil-en-Valois, Éméville, and Haramont in the Oise *département* were part of a cultural heritage management program implemented by local associations (“*Roches & Carrières*” and “*Carrières Patrimoine*” in particular). As a result, these sites are essentially mentioned in the bulletins and newsletters of these associations. The “*Carrières Patrimoine*” association, which focuses on the “Sarazin” quarry,¹ appears to have published *L’Écho des carriers* until 2017.² The association “*Roches & Carrières*,” which is in charge of the promotion of the “Chemin de Vez” quarry, publishes on a very regular basis, since 2006 (normally every trimester), a bulletin called *La vie de la pierre*, as well as special issues where the unpublished archives curated by Guy Launay, the association’s founder and president, are highlighted. Apart from these scholarly publications and a single entry in Pierre Noël’s inventory (1970, pp. 158–159), two articles on this quarrying basin have recently appeared. The first, by Guy Launay and Annie Blanc, deals with lance extraction techniques – a non-mechanized tool – used in the Bonneuil basin’s underground quarries (Launay & Blanc, 2011). An article published by Laurent Pradoux makes a note of the Sarazin quarry (Pradoux, 2019).

Few written archives are preserved during the transition period when machines replaced human muscle. Noël (1970, p. 159) is the first person to have carried out an inventory for the twentieth century, we know of, which is based on data collected directly in the field, and on testimonies of quarrymen still working at the sites visited between 1956 and 1965 (Noël, 1970, p. 5). It is on the occasion of this data collection work that he mentions the roadheaders with rotating drill bits (*haveuses à fleurets rotatifs* in French – designated as machines to make horizontal channels in the rock),³ a device assembled sometime in the 1930s and associated with the quarry of “Masures du Tranloy.”

Apart from rare written sources dealing directly with the quarries of the Bonneuil stream valley, it is noteworthy that the owner of the “Masures du Tranloy” quarry from the 1930s, Martial Lefèvre, drew the attention of scholars working on policies intended to compensate for the lack of raw materials and the housing crisis in France during the successive governments between the two World Wars, and the executives of the Second World War and post-war times (e.g. Delemontey, 2015, 2019, 2020).

The scarcity of sources explains why our research is based mainly on the documentation collected by the Association of “*Roches & Carrières*” society. They include above all testimonies by quarrymen who lived in the Bonneuil basin and by their offspring. These were collected by Guy Launay and informed us of the technical, economic, and social history of these quarries.

1.2 Brief Description of the “Masures du Tranloy” Quarry

The “Masures du Tranloy” quarry is located underground and nowadays extends several tens of hectares under the agricultural plateau and the hamlet today called La Croix-Sainte-Barbe (previously named La Briqueterie).⁴ One accesses the quarry through an excavated entrance, which originally was simply meant for the entry of men; two shafts were dug in succession at the level of the galleries and allowed communication between the quarry and the brickworks built above. It is a quarry with hand-built pillars⁵ – a method of quarry planning whose principle is to leave pillars in the mass of extracted stone to support the quarry’s roof (Blary & Gély, 2020). Galleries dug during the extraction process are distributed on both sides of a large central gallery, which was used for moving blocks until their exit from the underground quarry.

¹ One should note that on an archive document that we recently discovered, and which is kept by the Haramont municipality, the owner’s name is spelt “Sarasin”.

² Available online: <https://carrierespatrimoine.wordpress.com/>.

³ *Machine à four* in French.

⁴ In English “The Brickworks.”

⁵ *Piliers tournés* in French.

The quarry “of hard stone and soft stone” was opened in 1892, as attested by a letter kept in the Bonneuil-en-Valois archives.⁶ In this document, signed by Léon Gilquin and Charles Duquesnoy, the surface of the original land is given as “1 hectare and 87 hundredths of a hectare,” the entry is mentioned as being “located at approximately 100 m along the great communal road n°50, from Crépy to Haramont, and access to this entry is to be through a path ending in the one mentioned above.” The type of stone and the mode of extraction are also detailed: “the mass of rock is made up of hard and soft stone, covered by several benches of limestone, called *caillasse*, used as roofing ... the exploitation is to be done in underground galleries.” It was not yet linked to the brickworks, which were nevertheless in existence, as attested by Louis Grave in his census published in 1843 (Graves, 1843, p. 78). The two quarrymen were then essentially exploiting the hard horizontal layers of rock. The soft stone quarry further expanded after it was bought in 1910 by the Boubouleix family, who expanded it under the brickworks. The soft stone quarry was then ceded in 1930 to Martial Lefèvre, the owner of the brickworks located above.⁷ From this period, the quarry was modernized and became a place of technical invention. Around 1945, Martial Lefèvre founded the *Société des Carrières de l’Oise et de la Meuse* (SCOM), as well as the *Bâtisseurs Réunis* (“United Builders”) in the 1950s, as shown by documents in the National Archives (AN: IG 78, 19780242/4 & IG 79, 19780242/5).

1.3 Methods of Study

We shall follow the social–anthropological approach, which, as defined by Godelier (1996, p. 96),⁸ “renders apparent forms of culture and society that could not appear at just any moment, and that required, in order to exist, that certain conditions be reunited and combined.” Allowing one to go beyond archaeology and material culture, the social–anthropological approach provides a better understanding of the technical environment. Beginning with this field, we shall deal with the study of roadheaders with rotating drill bits, following the anthropology of techniques’ approach, as defined by Cresswell (1983) and more recently Boëda (2005). Robert Cresswell, following the thought of André Leroi-Gourhan who is considered to be the father of the *chaîne opératoire* concept,⁹ defines technique in the following way:

The latter requires an agent, material, and an instrument, linked together in a process of transformation, or an agent and an object linked together in a process of consumption. We shall then postulate that all techniques can be distributed in two groups: (1) techniques that express social relationships; (2) techniques that create social relationships. (Cresswell, 1976, p. 25)

The second technical group is that on which Cresswell bases his studies. The works of Boëda derive from the school of thought of Simondon (1989), which tackles a “technical object” by looking at its genesis, to be understood as a process (Guchet, 2019), by making use of the notion of technical evolution – not in a historical sense but in an operational one (Guchet, 2008). One should note that one of the points of contention between Boëda and Leroi-Gourhan’s school is emphasized by the former in a seminal article. According to him, the notion of “trend,” as defined by Leroi-Gourhan, “provides the key to move from conjectural technology to comparative technology,” but he nevertheless regrets Leroi-Gourhan’s “attachment to functional determinism.”¹⁰ According to Boëda, the concept of “genesis” borne by Simondon permits one to transcend the static nature of the technical object, by focusing on structural characteristics.

⁶ Copy preserved in Guy Launay’s archives.

⁷ Testimony collected by Guy Launay from Josette Furet-Lefèvre (Martial Lefèvre’s daughter). Transcribed in the *cahier* n°4, 1 June 2011.

⁸ Godelier (1996, p. 96): “méthode qui *fait apparaître des formes de culture et de société qui ne pouvaient pas apparaître à n’importe quel moment, qui supposaient pour exister que soient à chaque fois réunies, combinées, certaines conditions.*”

⁹ On the notion of “*chaîne opératoire*” and its final use by Leroi-Gourhan, see Djindjian (2013).

¹⁰ Boëda (2005, pp. 46–47): Leroi-Gourhan “*donne les clefs pour passer d’une technologie conjoncturelle à une technologie comparée.*”

The comparison and contrast between these two aspects (functional and structural) of the technical object allow us to question the notion of “technical invention,” the very idea to which Simondon repeatedly lectured (Simondon, 2005), and which made Leroi-Gourhan dedicate a sub-chapter of his book *Milieu et techniques* (Leroi-Gourhan, 1945). This notion seems to mark particularly well the extraction of stone using roadheaders with rotating drill bits, a process that is unique to the quarrying basin of the Bonneuil stream. This concept of “technical invention” allows one to highlight the complex dynamics between the technical environment and society, which determined its creation and disappearance.

2 Technical Context

2.1 Local Geological and Geomorphological Environment Favourable to the Extraction of Soft Stone

The “Bonneuil stream” is a tributary of the Oise’s left bank. Oriented east-west, the valley of the Bonneuil stream deeply cuts through the sub-horizontal plateau of the Valois region. This plateau is made up of geological formations of the Paris basin, dating from the Cenozoic era, which reveal from bottom to top the succession of the following sedimentary rocks: sands and clays, sandy limestones, and soft limestones, followed by hard limestones. The latter are located at the summit of plateaux surrounding the Bonneuil stream valley. The entire set of these limestones, which are marine in origin, is called “Rough limestone” (*calcaire grossier*), and belongs to the Lutetian, an international designation for a geological era between 47.8 and 41.2 million years ago, whose name comes from *Lutetia*, the Latin place-name for Paris (Merle, 2008).

This rough limestone is the main construction stone resource in the Valois region. It was exploited and mined in many quarries of the Bonneuil valley. There is an underground quarry that is still in activity at Bonneuil-en-Valois (Oise), which extracts the soft Lutetian limestone called “*Vergelé*.” This *Vergelé* is a soft, homogenous bio-clastic limestone with very little clay, beige in colour, appearing in layers or veins several metres thick (Figure 2). In this rock, the quarrymen produced middle-sized or large stone blocks meant as structural masonry of monuments and houses. In these limestones, quarrymen would carve staircase steps, lintels, and cornices, as well as slabs. In the Middle Ages, the thickest veins of hard limestones were used to build the bases of walls, the pillars, and the cross springers of ogival arches of Bonneuil valley churches.

Due to its specific petrographic characteristics (homogenous soft limestone in benches several metres thick), the *Vergelé* was the stone best suited to the mechanization of extraction.

2.2 Beginnings and Underlying Causes of the *Chaîne Opératoire* of Stone Extraction Using Roadheaders with Rotating Drill Bits: A Specifically Local Know-How

The *chaîne opératoire* set in motion for the non-mechanized extraction of stone in the “Masures du Tranloy” quarry – described as lance/spear extraction – partly explains the appearance of roadheaders with rotating drill bits (Launay & Blanc, 2011).

Ever since the opening of the quarry in 1892, the tools used to extract soft stone were the needle, the lance and the *ziguet* (small lance) (Figure 3), implements mainly spread in the Aisne and Oise basins (Launay & Blanc, 2011, p. 194).

Consisting of a metal crossbar with a pointed ending and a rectangular cap, these tools differ in terms of the bar’s length, their diameter, and weight, explaining the substantial differences in their manipulation and function. The needle and the *ziguet*, whose dimensions are smaller than that of the lance, are generally

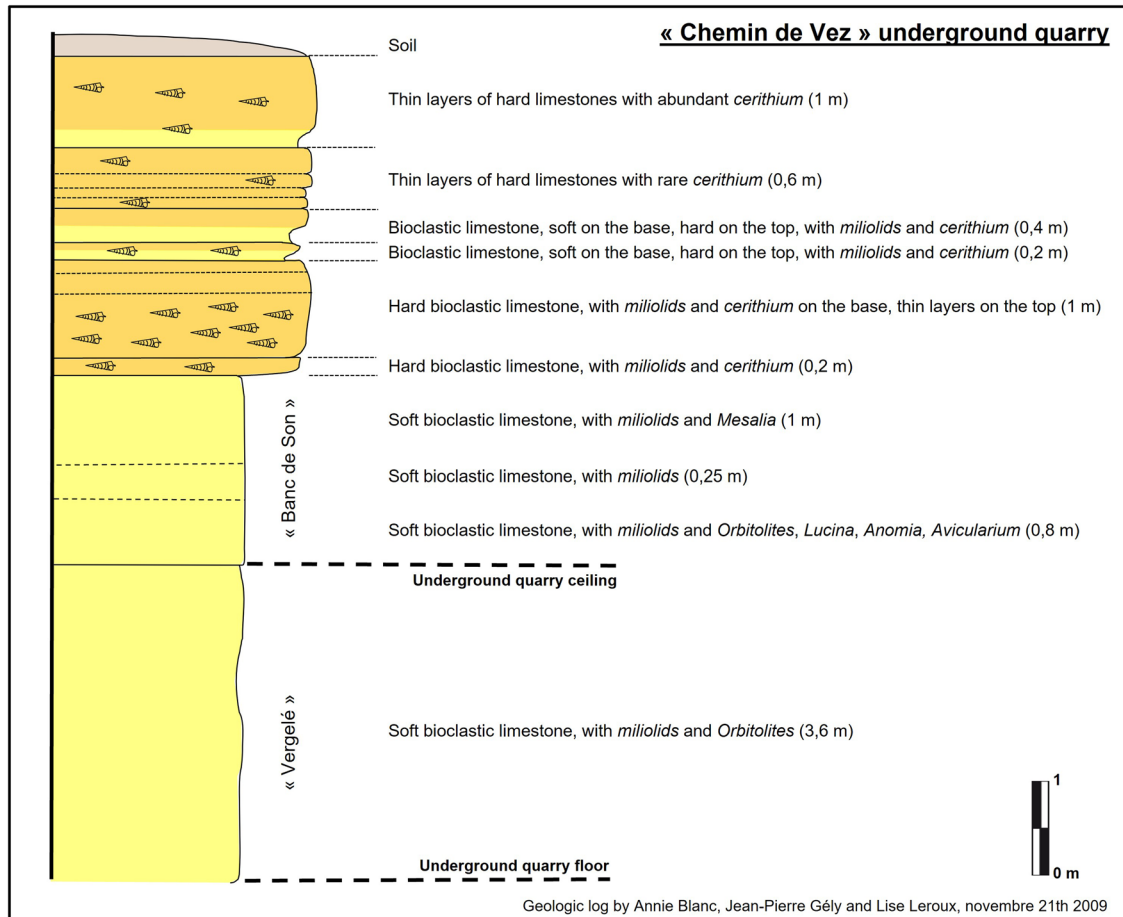


Figure 2: Geological log of Bonneuil quarries – by A. Blanc, J-P. Gély and L. Leroux.



Figure 3: Tool marks of lance (on the left) and rotating drill bits (on the right) – by J-P. Gély.

handled running or thrown by the workers, in contrast to the lance which was systematically suspended for thrown percussion (Figure 4).

The choice of specific tools for the Oise region and the production line derived from it can be explained by the quality of stone horizontal layers, whose thickness was sufficiently important. Without any joint of stratification over a height of several metres, to use as support to extract the blocks, the quarrymen of the Bonneuil basin favoured extraction from bottom to top, going against the most common process used in the exploitation of subterranean quarries: extraction in stepped rows, from top to bottom (Launay & Blanc, 2011, p. 194).

In the “Masures du Tranloy” quarry, the cutting face is divided into two rows: an upper and a lower one. Each row is, in turn, fractioned into three or four blocks weighing several tons. A specific block, located at the level of the inferior row, is designated in French under the name of *block de défermage* (initial vertically cut block) and is the first one extracted this refers to the first block extracted from the cutting front.

- (1) A quarryman digs two horizontal trenches at the base of the cutting edge (a *four* in French) and in the middle part of the cutting edge (the central *four*).
- (2) After checking the quality of the stone in the bottom area of the cutting edge, near the block meant for extraction, the low horizontal channel is dug with a lance. The tool is thrown under the block by the quarryman in order to make a deep horizontal channel.
- (3) By means of a lance, both suspended and thrown, the quarryman gradually digs the two first vertically cut channels (*tranches de défermage*) on both sides of the block. In order to ease the lance's insertion in the mass of stone and remove the stone flakes, the quarryman rotates his wrist when the lance is about to impact on the stone mass.
- (4) With the same tool, the quarryman digs the middle horizontal channel (*four du milieu*).



Figure 4: Lances – Roches & Carrières Archives.

- (5) As regards the first block, the quarryman inserts a series of wedges (at least 12 of them), placed almost next to each other, between the boards meant for breaking the stone. Being hit in order to obtain the same pressure on the entire height of the block, the wedges allow workers to loosen in a regular manner a block and detach it from the carving face.

For the other blocks:

- (1) The quarryman is hoisted on a footbridge to work with a lance on the upper slices of rock.
- (2) He shapes the horizontal channel (*four*) at the level of the quarry's roof, by means of a needle. To this end, the worker carries the tool single-handedly and makes it slide on a metal piece.
- (3) In order to detach the bottom part of lateral blocks, the worker handles the *ziguet*, often suspended and thrown.

For extraction with the lance, a team of three quarrymen was necessary, in particular for the removal of the blocks.

2.3 Extraction Using Roadheaders with Rotating Drill Bits: Between Tradition and Mechanization

The roadheaders with rotating drill bits reproduce the sliding and rotating movement of the two tools used at Bonneuil: the *ziguet* small needle and, above all, the needle. Consistent with the extractive process using the lance, the roadheaders with rotating drill bits are of two types. A first machine creates horizontal channels (*machine à four* with rotating drill bits), and a second one enables the quarrymen to dig vertical channels (slicing devices with rotating drill bits) (Figure 5). The only machine that has been preserved is the *machine à four* with rotating drill bits (Figure 6).

In its most developed state, the drill bit (a steel bar in the shape of a needle, Noël, 1968, p. 176) ends in a propeller-shaped head with a small disk with steel and tungsten. It measures 3.5 m folded and approximately 6 m long extended. The *machine à four* for horizontal channels is generally provided with two drill bits, which

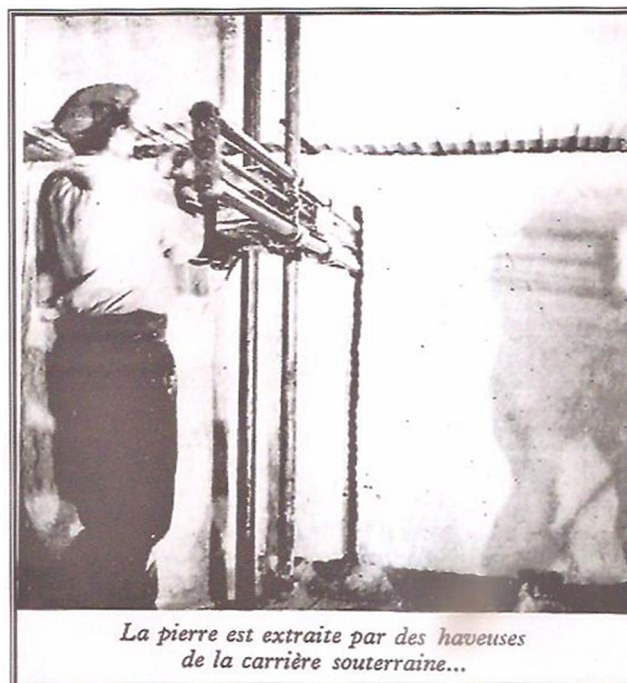


Figure 5: Slicing devices with rotating drill bits – Flyer by SCOM – Roches & Carrières Archives.



Figure 6: *Machine à four* with rotating drill bits – Roches & Carrières Archives.

work simultaneously to excavate stone, their rotation activated by an electric motor (with three or four horsepower). To push the drill bits into the stone, a quarryman turns a crank handle linked to a system using a bicycle drive and a bicycle chain.¹¹ The *four machine* is fixed on a sheet of steel at the front. This sheet is inserted in a perforated iron bar, which allows workers to move the machine sideways in a systematic fashion. In order to make the middle horizontal channels (*four du milieu*), the quarrymen position them on trestles.¹²

The small disks of carburized tungsten are distributed in three or four levels. The maximum diameter of the holes made by these drill bits is 17 cm. These drill bits do not form tangent cylinders, but overlap in order to make continuous horizontal channels that are weakly crenelated. The rotation of the drill bits is synchronized and facilitates the interlocking of the points into one another to avoid jamming (Figure 7).

The production line's sequence reproduces the main stages of manual extraction with a lance (Figure 8).

For the first vertically cut block (*défermage*):

- (1) A quarryman traces two horizontal trenches.
- (2) Near the block that is to be extracted, a horizontal channel made with the quarryman kneeling (*four à genoux*) is cut with a machine for horizontal channels (*machine à four*) displaced some eleven times.
- (3) By means of the slicing machine, the quarryman gradually digs into the two vertical trenches on both sides of the block.
- (4) The *machine à four* for horizontal channels is hoisted on trestles to dig the middle channel (*four du milieu*).
- (5) Wedges are used to detach the block from the stony mass.

As regards other blocks:

- For the other blocks of the upper row, the *machine à four* for horizontal channels did not reach the quarry's ceiling; the ceiling horizontal channel (*four du haut*) was then made manually, by means of a sliding needle.
- In order to begin detaching the block, a quarryman manipulates the *ziguet* (small needle). This manual tool seems to have been replaced later on by a machine for the removal of blocks from the rear (*machine à débouter*) with rotating drill bits – but this information is given in only a single testimony (Figure 9).¹³

The contribution of mechanization was quite significant: at the level of daily extracted cubic capacity, a single man could only remove approximately one cubic metre with a lance, but with roadheaders with

¹¹ Testimony collected by Guy Launay from Roger Bontemps (quarryman at the SCOM). Not transcribed in his notebooks (*cahiers*).

¹² Testimony collected by Guy Launay from Étienne Bouchonville (a quarryman at the 'Masures du Tranloy' until the 1960s). Transcribed in the *cahier* n°3, 11 May 2007.

¹³ Testimony collected by Guy Launay from Étienne Bouchonville. Transcribed in the *cahier* n°3 of 11 May 2007.

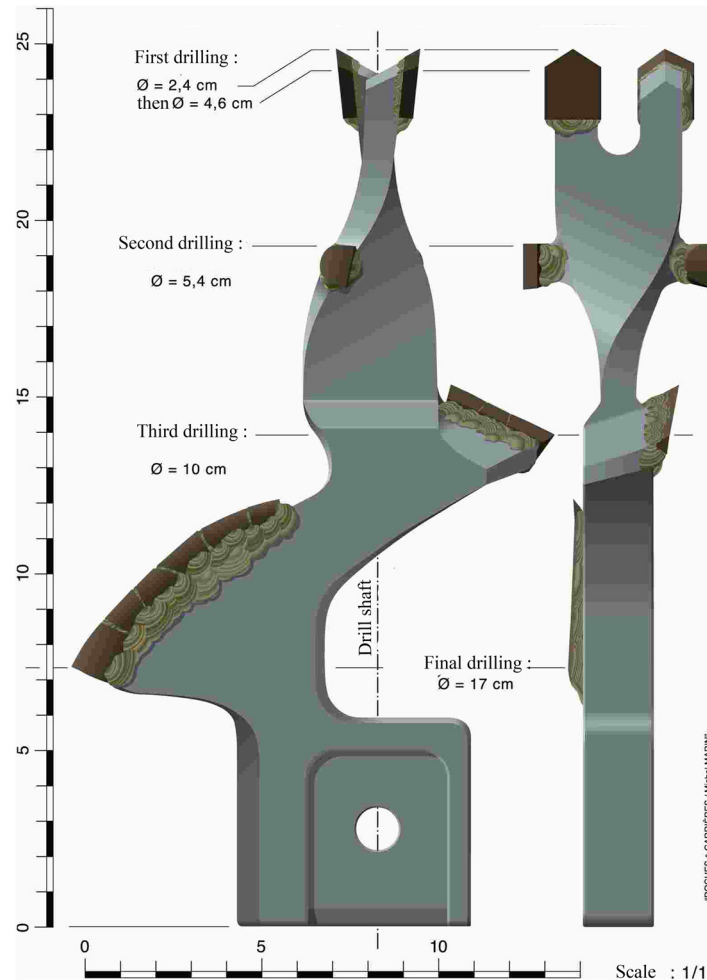


Figure 7: Iron drill and small carburized tungsten disks – Roches & Carrières Archives.

rotating drill bits, he could remove four (Launay, 2019, p. 23). Likewise, teams went from two to three quarrymen, one of them operating the machine and the other removing extraction spoil (Launay & Blanc, 2011, p. 194). Although mechanization demanded a lesser physical effort for the quarrymen, their working atmosphere worsened in a significant way, due to the noise, vibrations, heat of the machine's exhaustion fumes, and because of the stone dust released by the excavation. This same observation can be made for mines, which are better documented concerning this issue (Raggi & Knittel, 2009).

3 Socio-Economic Context: An Exogenous Know-How Associated with Economic Opportunism

This reproduction of the stages of traditional extraction using a lance partly explains the building of the machine and, above all its use during the 1950s at the “Masures du Tranloy/SCOM” quarry – it is known that in 1947, the junction between the soft stone quarry and the second shaft was dug in the sawing warehouse, located inside the enclosure of the brickworks, by means of roadheaders with rotating drill bits.¹⁴ Yet the socio-economic context was also a major factor in the machine's development.

¹⁴ Testimony collected by Guy Launay from Hugues Dubreuil (quarryman for the SCOM). Transcribed in the *cahier* n°3 of 7 December 2005.



Figure 8: Quarry wall with tool marks from roadheaders with rotating drill bits – Roches & Carrières Archives.

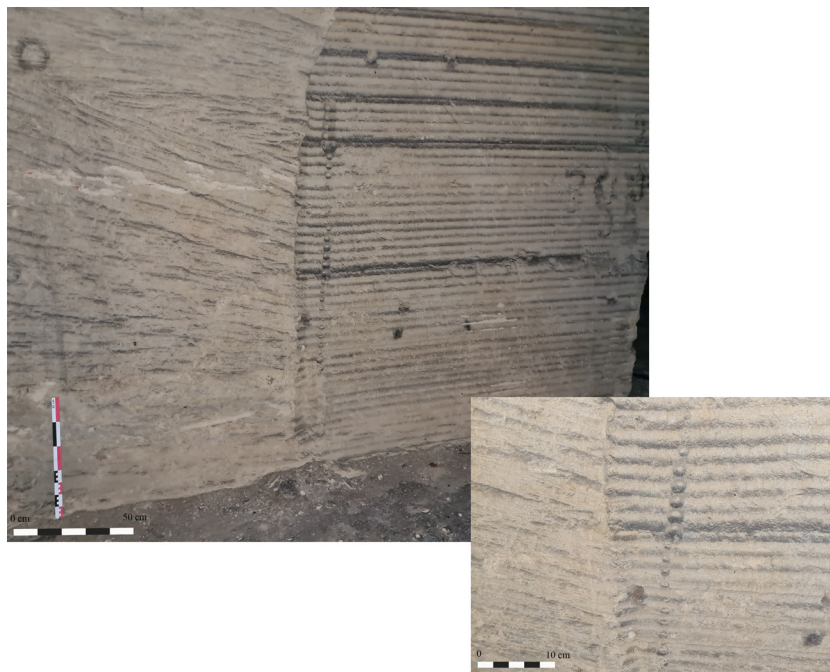


Figure 9: On the left: marks of lance; on the right: marks of milling machine with rotating drill bits at the SCOM quarry – A. Lamesa.

3.1 Development of Extraction with a Lance Before the Second World War: From Craftsmanship to Entrepreneurship

Prior to the late nineteenth century, extractive activities in the Bonneuil basin seemed to be restricted to local needs, for roads and the construction of buildings (Graves, 1843, pp. 73–78; Launay, 2019, p. 4). An early attestation of merchant quarrymen foreign to the basin is found in an 1863 archive document, mentioning a new excavation opening in the municipality of Bonneuil-en-Valois, made by Mazeaud Cottray et C^{ie} – managed by the Parisian quarrymen François Mazeaud and Amédée Cottray (Launay, 2007, p. 8). The establishment of these merchants can be explained notably by the increasing demand for stone (Launay, 2007, p. 8), related to the great works carried out by Baron Haussmann, who entirely redrew and rebuilt Paris neighbourhoods (Pinon, 2014). The exportation of stones extracted in the quarrying basin seems to have become of regional importance at the end of the nineteenth century with the arrival of the railways. The railway line was laid in 1884 in the three municipalities of Bonneuil-en-Valois, Éméville, and Haramont, and linked the cities of Compiègne and La Ferté-Millon (Banaudo, 1982). The opening up of the valley was to local operators' benefit, for instance, Léon Gilquin – a native of the town of Éméville – and Charles Duquesnoy. To these local businesses, one should add between 1900 and 1914 new outside investors in the basin, such as Fréjus Daubin, the owners of quarries at Carrières-sur-Seine (Seine *département*, now Yveline *département*), or Civet Pommier & Cie, a family of quarrymen from Saint-Maximin (in the Oise) (Launay, 2007, pp. 6–7). Attracted by the soft stone and its easy access, they gradually bought the right to dig the subsoil of the quarrying basin.

After the First World War, quarrying activities were resumed because of the important demand for stone for reconstruction. New quarries were opened, like “Sarazin” in 1920 (Pradou, 2019). However, the 1929 crisis had a very negative impact on this industrial prosperity. In 1925, the geographer Madeleine Chamard described it as a valley economy developed as a support for intensive agriculture in the Valois plains. Speaking of quarrying operations, she emphasized: “These are small enterprises, countryside workshops, which employ only some tens of workers. For some time, besides, their production has persisted with difficulty, faced with foreign competition, in the aftermath of the gradual closure of outlets” (Chamard, 1935, p. 501).¹⁵ Another example supports this initial impression: the *Carrières and Scieries de France* firm (“Quarries and Sawing Mills of France”),¹⁶ which employed some 60 workers prior to the crisis affecting the municipalities of Bonneuil and Éméville, and had only two employees in 1938 (Dancoisne, 2011, p. 42 and footnotes 32–33).

The rise of the market stone in the 1900s triggered the idea of a mechanization of extractive techniques, as attested by a patent dating from 1912, which describes a milling machine designed to slice carved stones in underground and open-air quarries. Firms of quarrymen, such as Civet Pommier & Cie, developed the first machines to mechanize the extraction of soft stone. In the 1910s, Léon Civet would use in the Saint-Paul quarry in Méry (Oise), a roadheader of Ingersoll Rand type, described by Pierre Noël as “working by percussion and created for the exploitation of coal” (Noël, 1960).¹⁷ The same slicing machine was attested a little later (1923) for extracting limestone at Chauvigny (Vienne). The machine appears to have been imported from a quarry at Euville (Meuse); it “would hit the bottom of the slice of rock” (Pothen, 1985, 2000).¹⁸ This example is in itself interesting because it demonstrates that know-how related to mechanization was transmitted inside a single firm, from one quarry to another. At Bonneuil, Civet Pommier & Cie seems to have sent some workers to reinforce their team in the Tercé-Normandoux quarry (Vienne). One should not dismiss the hypothesis that these quarrymen could have passed information on this technological advance at Bonneuil, during moments of leisure after work.

¹⁵ “Ce sont de petites fabriques, des ateliers de campagne, qui n’emploient que quelques dizaines d’ouvriers. Depuis quelques temps du reste leur production se maintient difficilement en face de la concurrence étrangère et par suite de la fermeture progressive des débouchés.”

¹⁶ Formerly Civet, Pommier et Cie.

¹⁷ “Travaillant par percussion et créée pour l’exploitation du charbon.”

¹⁸ “Frappait le fond de la tranche.”

3.2 Improvements in Lefèvre Roadheaders with Rotating Drill Bits: Testimonies of an Eventful French History

As early as the period between the two wars, Martial Lefèvre, drawing from the productive crucible of qualified workers in the Bonneuil basin, wanted to mechanize the extraction of soft stone. He hired the engineer Pierre Brunet and provided the quarry with a highly-performing mechanics workshop, where he developed an early machine with rotating drill bits.¹⁹ These first roadheaders were from the start based on machines using the lance extraction technique. They differed, however, from the post-war period's roadheaders with rotating drill bits in several respects: they were made with flat heads of Martin steel. Several inconveniences came as a result: the drill bits had a tendency to jam and, above all, the Martin steel would become very hot, melt, and no longer be able to cut.

By cross-matching André Lecaillon's testimony and the first patent registered by Martial Lefèvre, it is possible to outline the contours of conditions in which roadheaders with rotating drill bits were perfected. In 1939, Pierre Bataille (the quarry's foreman) was sent to the frontline and was captured by the enemy.²⁰ He was apparently given the right to return to France for health reasons, thanks to a prisoner exchange beginning during Laval's *Relève* policy in 1942 (when French prisoners in Germany were traded for a higher number of French workers employed by the Third Reich's war machine, prior to the STO's press-ganging into German factories; Gayme, 2012). During his stay in Germany, he was assigned to work in quarries. The use of carburized tungsten had already been developed in that country's industry (Noël, 1960). In particular, it was used by the army since the 1930s for drilling and digging underground tunnels and rooms (Anonyme, 1954). Two years after Pierre Bataille's return (i.e., 1944), Martial Lefèvre registered a patent for a device for sawing stones, using small disks "in matter as hard as carboram" (INPIdata, no 907347).²¹ It was during the same period that roadheaders with rotating drill bits seems to have been perfected. Martin steel was replaced by small disks of carburized tungsten, thus solving the problem of overheating. It appears, therefore, that an improvement of the extractive method, which had originated endogenously, was linked to the importation of know-how from outside.

One could question the reasons why Martial Lefèvre did not register a patent for his roadheaders with rotating drill bits. André Lecaillon signals that the German Korfmann firm could have sued Martial Lefèvre for patent violation. This information seems confirmed by the patent registered in 1931 by Korfmann, which proposes an attachment device for a roadheader ("*haveuse-rouilleuse*") on drilling columns for horizontal and vertical cuts and channels. The system is similar to that of Lefèvre road heads. Moreover, roadheaders with rotating drill bits were used in mines as early as the 1910s and were based on the same perforation principle (Schember, 1910).

3.3 Outcome of Research on Roadheaders with Rotating Drill Bits: The Need to Respond to a Growing Demand in Stone After World War II

Apart from the local level, it was also the situation of the nation – during the Vichy regime and in the post-war era – that provided clues on the evolution of roadheaders with rotating drill bits. During the Second World War, the French government wished to solve the problem arising from restrictions on materials normally used for building construction – concrete having been requisitioned for the war effort. An attempt to normalize was then decided in this sector, beginning with a law making this process in all industrial fields almost obligatory, decreed on 24 May 1941 (JO, 28/05/1941: pp. 2225–2226. See also Delemontey, 2020, Section 5). This was the start

¹⁹ Testimony collected by Guy Launay from Maurice Lemoine (quarryman and mechanic at the SCOM). Transcribed in the *cahier* n°2, 5 July 2004.

²⁰ Testimony collected by speaking to André Lecaillon (a quarryman at the SCOM). Transcribed in *cahier* n°4, 15 January 2009.

²¹ "*En matière dure comme du carboram.*"

of the “the industrialization of stone.”²² Documents testify to the state’s assistance for the Martial Lefèvre brickworks. The plant benefitted from support given by the Central Office for the Distribution of Industrial Products – *Office Central de Répartition de Produits Industriels* (Dancoisne, 2011, p. 43 and footnote 40). These archive documents concern the brickworks and were published by Éric Dancoisne. They may explain how Martial Lefèvre was supplied during the war with small disks of carburized tungsten. Yet it was above all during the post-war era that Martial Lefèvre’s businesses were valued by the Ministry of Reconstruction and Urbanism (MRU). These mechanized components were financed through huge urban projects. One could mention the F4 individual housing (Logis-Spring model) built in buildings stones. An example of these is preserved at Paray-Vieille Poste (Blanc & Ayrault, 2004, p. 68) and was built by the architect Pierre Bailleau (consulting architect for reconstruction, approved by the MRU for the Eure *département*), in association with the *Société des Bâisseurs Réunis*, the latter owned by Martial Lefèvre (AN, 19780242/4). As for the SCOM, it won several tenders for the large-scale production of elements of pre-carved stone, such as one for part of the reconstruction of the city of Caen in Normandy (AN, 19780242/5-6).

In this context, the roadheaders with rotating drill bits were once more perfected. The drill bit points became propeller-shaped and up to seven drill bits were used in a single machine.²³ On a flyer mentioning the Bonneuil-en-Valois pilot plant, a photograph shows a quarryman using a slicer with seven drill bits. The flyer is not dated, but seems to have been published at the end of the war. In fact, the plan of the Bonneuil pilot plant mentions the sawing workshop and its new shaft dug in 1947. A little later, two testimonies confirm the replacement of roadheaders with rotating drill bits by slicers from the Korfmann brand. These roadheaders, which were lighter, allowed quarrymen to make horizontal channels at the base of limestone blocks (*fours*), to cut both slices and the blocks’ rear part, using the same piece of equipment. In addition, it seems that they destroyed less stone mass.²⁴

Though replaced by better-performing machines, roadheaders with rotating drill bits were still briefly employed during the 1960s, by some operators of quarries like Nino Mascitti, who used them in his Clocher quarry, opened in 1957 at Bonneuil-en-Valois, and at the Trois Fontaines, property of the *Société des Carrières et Scieries de France*.²⁵

4 Conclusion

The technical study has allowed us to grasp the stakes and issues that led to the invention of roadheaders with rotating drill bits. The attempt to reproduce a rotating and thrown movement, already implemented for the lance, certainly played an important part. Likewise, the extraction technique of stone blocks from bottom to top, the use in tandem of the roadheader with rotating drill bits and the *ziguet* small needle permitted mobilizing local know-how dated to the nineteenth century. The setting in motion of the cutting head’s *chaîne opératoire* was therefore eased. The technical context also explains the sporadic reuse of this machine in other quarries at Bonneuil, while it did not spread beyond this quarrying basin.

This study demonstrates, however, that the technical factor, namely the mechanization of a rotating and sliding movement, cannot provide an exclusive explanation either for the invention of the roadheader with rotating drill bits or for its improvements. The local socio-economic context, assisted by policies of governments during and after World War II, as well as the contribution of exogenous technical knowledge – the use of a roadheader with an off-centred wheel (*trancheuse à excentrique*) in quarries in the Oise, Meuse, and Poitou managed by *the Carrières et Scieries de France* and of drilling machines with heads made of carburized

²² We are quoting here the title of Yvan Delemontey’s article (2007).

²³ Testimony collected from Étienne Bouchonville by Guy Launay. Transcribed in the *cahier* n°3, 11 May 2007.

²⁴ Testimony collected from Étienne Bouchonville by Guy Launay. Transcribed in the *cahier* n°3, 11 May 2007, and from Hugues Dubreuil. Transcribed in the *cahier* n°3, 7 December 2005.

²⁵ Copy of the legal acts for the opening of the quarry, kept in Guy Launay’s archives.

tungsten in German mines – in our opinion also bring new light to explain the invention of the roadheader as well as its improvements and massive use during the post-war era. It is also the economic situation at the national scale that can explain the increased pace of modernization of small quarrying basins, such as those at Bonneuil, held by businesses of nationwide scope (Civet, Pommier Cie, and the SCOM). This modernization process, launched mostly in 1945, notably led to the rapid evolution from extraction techniques using human muscle to mechanized exploitation with considerably increased productivity.

The topic of roadheaders with rotating drill bits thus offers the possibility of validating the importance of cross-matching fields and approaches to study a specific technique. To complete Cresswell (1976)'s definition, techniques not only “express social relations, create social relations,” but also stem from social relations that one should properly grasp in order to define the origins of these techniques. Our research also highlights the networks of knowledge and men involved in the dynamics of creation, at the local and national levels.

Abbreviations

AN Archives Nationales
JO Journal officiel

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