FROM THE QUESTIONING OF THE ARCHAEOLOGISTS TO THE BUILDERS'. THE EXAMPLE OF THE MEDIAEVAL QUARRY OF SOL DE ROQUES

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ABSTRACT:

The archaeological study of a dressed stone quarry involves much more than the sole detailed results of the digging of the extraction remains. In this example of the Sol de Roques quarry, the historical and technical data, the geological researches and the characteristics of the material itself show the adaptation of the quarrymen to the intrinsic facies of the stone. The questions about the material and the marks left by the workers confirm the conclusions drawn by the builders. The graphic transcription of these data reveals the technical approach of an era.

1. INTRODUCTION

The archaeological study of a quarry is one aspect of the industrial archaeology the technical frame of which is part of the history and chronology of stone exploitation. Sometimes barely visible in the present-day landscape, faded by the paedogenesis dynamics, the remains of a quarry are the negative volume of the extracted stones. The monumental aspect of the quarry faces and floor when dug up, is enhanced by the traces left by the quarrymen's work - essential subject of the field of research.
Therefore we must go back in time to the initial purpose of the opening of a quarry: the architectural project, be it monumental or small, public or private. The search for the materials is the first step, then the specifics of the project guide the technical, physical, mechanical and chemical requirements of the stone, depending on its architectural use.

Sol de Roques quarry © 2013 A. Daussy

From an economical point of view, the geological outcrops locally available will be listed. For every type of rock, each of its different facies will be inspected; its mechanical and physical characteristics will be studied and evaluated, in order to prove their adequacy to the project. This survey also takes the exploitation and transportation possibilities for the construction site into account. Depending on the preliminary criteria for the choosing of the quarry site and the nature of the architectural project, construction techniques have to be adapted to the chosen stone; the builders then have to choose accordingly.

2. THE ARCHAEOLOGICAL STUDY OF THE QUARRY OF SOL DE ROQUES (FRANCE)

The quarry of Sol de Roques in Labastide-Murat is located in the Lot County, at a height of 420 metres, on the edge of the Gramat limestone plateau, some 20 km north of the city of Cahors. The open cast quarry is close to the medieval walled village and to the XIIIth century castle. The digging was limited by the location and dimensions of the future A20 highway. This partial area obviously could not have provided enough material to build the nearby village and castle. It has also been noted that the modern era farm of Sol de Roques was built on abandoned quarry floors and faces, indicating that the extraction site must have been more extended. The landscape surrounding the farm and its many constructions shows no track of the former quarry activity. Before the archaeological intervention the hilly landscape was pasture land.

2.1 The filling of the quarry

The filling of the quarry testifies of the outcome of the abandoned extraction site. It can be of anthropogenic or natural origin, be contemporary or posterior to the rock exploitation. Most of the time, quarries disappear under their own extraction waste or close once the architectural project it provided for has been completed. Nature resumes its work and erases the quarrymen traces by smoothing the sharp shapes. Archaeology studies quarries long after they have closed, replacing the stone work history in its historical, geographical and technical backgrounds.
In Sol de Roques the thickness of the filling is limited. Its analysis covers the changes in the use of the quarry site through two of its aspects: the filling contemporary to the exploitation of the stone and the filling resulting in natural water streaming down and creating soils through time. This particular filling

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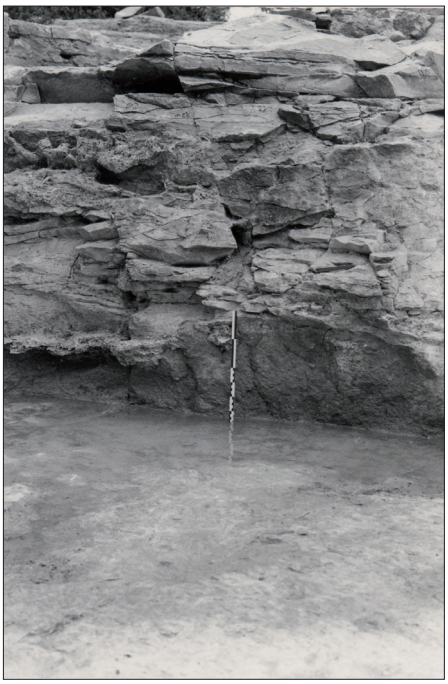
is mainly composed of extraction waste, dirt, and limestone gravel. The analysis of the plant (by A. Bouchette, Inrap) remains brought no characteristic information. However, the seeds of two of the cultivated species found in Sol de Roques are identical to some identified in medieval cereal pits located near Labastide-Murat.

The Filling © 2013 A. Daussy

2.2 The geological context

The substratum is limestone formed during the superior Jurassic era, known as Kimmeridgian. It forms small beds of feeble depth. Limestone beds, hard and very sensitive to frost, alternate with clayey marl often saturated with water. The different facies go down from the top of the outcrop to the quarry floor on which the exploitation stopped. 4 vertical successive formations have been discriminated, noted 1 to 4. Only levels 2 and 3 were exploited by the quarrymen.
The diagram of the lithostratigraphy of Sol de Roques quarry shows the layers of the different facies the quarrymen dealt with. The study of the polar representation of the cracks (by P. Bertran, Inrap) can mechanically and physically explain the extreme cracking of this outcrop.



The 4 stacking layers of rock
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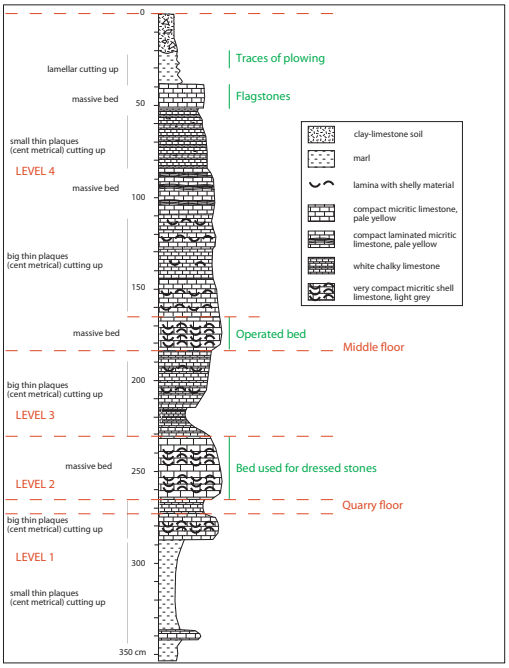

Figure 1. Relations between the lithostratigraphy diagram (natural stratification) and the archaeological levels.
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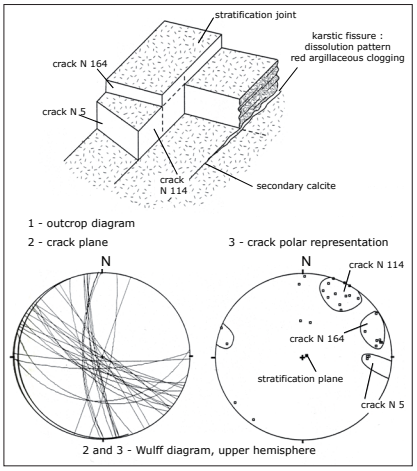

Figure 2. Stereographical projections of structural observations.
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All these physical features of the stone determine a technical choice for the quarrymen. Each level requires an appropriate technical response :
- Level 4 is the altered rock showing on the surface of the ground when the quarry started. In its superior part, the stone is cut up into thin plaques (cent metrical), heterogeneous material that cannot be used as modular blocks. The spotted tool marks are heterogeneous but a portion of the extracted volume could have been used for the rubble of walls.
- The rock in level 3 is a massive decimetric bed showing an important and looser cracking. This bed is the geological match of the sometimes rather large flagstones.

- Level 2 is a massive bed of shell limestone, micritic, very dense, of a light grey shade. The quarrymen used this bed for their modular exploitation.
- Level 1 forms the main quarry floor, yet to be exploited. It belongs to the marl formation with chalk layers.

2.3 Characterization of the stones from Sol de Roques quarry

Example of the level 2 bed in the natural stratification profile : In this study, the characterization of the stone from Sol de Roques quarry is a means of evaluating the behaviour of the rock, from a technical point of view regarding its extraction and from an architectural and structural point of view regarding its use (study by Laboratory GERM of the Ecole des Mines d'Alès in Gard County, E.M.A.).
Samples were taken from the distinct facies of the quarry faces and also from a few nearby buildings, following dimensional imperatives in order to acquire significant results. The trials were numerous enough to determine the mechanical qualifications of the exploited facies of Sol de Roques. Not only did they enable to explain the material qualities shown in the medieval buildings at Labastide-Murat but they also helped understand the disorders observed in some more recent buildings using the same type of stone.
The mechanical and physical characterization of the rock gives a hardness level of 16 for this particular facies. Cold stone, it could be compared to a marble stone but the numerous fossils it contains gives irregular wear, making it less polishable. As the scale of mineral hardness ranks from 1 to 14, this material comes very close to the best concrete that is made nowadays. For this facies, the E.M.A. tests have shown that the rock is altered on the upper part of the bed (around 12 cm high), making the hardness ranking drop to 9. [e.i. Blocks found in filling : SR1002, SR 1003 (1003* for the upper part of level 2 bed and 1003 for the lower part)].

Identification number of stones

	SR1002	SR1003*	SR1003	SR1004
identification number	9	16	7	9

mass densities and porosities average values

	mass density (g/cm3)	porosity (%)
SR1002	2,33	14,3
SR1003*	2,52	7
SR1003	2,32	14,5
SR1004	2,31	14,8

Mechanical resistance to compression and traction

compressive strenght

	sample 1	sample 2	sample 3	average
SR1002	51	107,4	77,6	78,7
SR1003	95,1	116	107,3	106,1
SR1004	81,5	94,1	96,4	90,7

tensile strenght

	prism 1	prism 2	prism 3	prism 4	average
SR1002	11,4	12,3	8		10,6
SR1003*	13,5	7,9			10,7
SR1003			12,2	12,6	12,4
SR1004	8,7	5,7	10,3		8,2

prism with plane-parallel sides

Table 3. Charts show the results of tests carried out on each facies of Kimmeridgian limestone.
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A close examination of the medieval castle of Labastide-Murat reveals the mastery of the builders in the use of dressed stones coming from bed rocks similar to level 2. The materials show the high quality work of the stonecutters and builders. On the contrary, the constructions built more recently, such as all the buildings of the Sol de Roques farm, show important architectural disorders. The lintels, always made out of rock from the second level, are systematically broken in their middle. The characterization of the stone made by E.M.A. has shown that lintels made in this particular facies should be as hard as the best modern concrete. Such disorders can only be the result of mistakes made by the builders.

Level 2 bed and crack in level 1 (main quarry floor)
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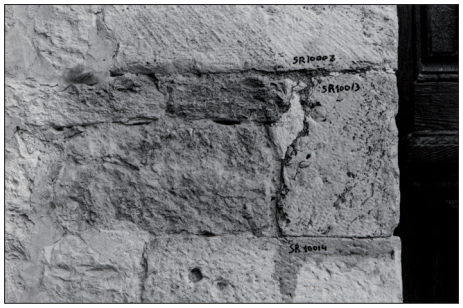
Extraction techniques : For all the facies exploited in Sol de Roques, extraction techniques have followed and used the structural features of the stone : cracks, fractures, stratification joints.
Level 2 bedrock : For this facies, the E.M.A. tests have shown that the rock is altered on the upper part of the bed (around 12 cm height), making the hardness ranking drop to 9. The quarrymen were aware of this loss in hardness and took the opportunity to create modular stones by remaking vertical sockets in the existing cracks. The graphic representation allows to expose both the technical thinking of this era in Sol de Roques and the use reserved for the extracted blocks.
The diagram of the modules extracted in the bed shows the systematic retrieval of blocks - intended for the exterior stones of the walls - alternating with the cut of lintels or jambs for opening frames. The quantification of these material qualities has shown that it could be used for face-bedded jambs.



Blocks SR 10.003, SR 10.013, SR 10.014 in left door jamb of the farm. © M. Vacca-Goutoulli

The lintels have a flexion strength of 750 kg per cm² for a width of 30 cm and a depth of 3,2 cm. These particular elements can be found in the construction of the mediaeval castle of Labastide-Murat.

Level 3 bedrock : This bed outstands by its regular height, the blocks forming naturally regular courses, which enhance the quickness and homogeneity of a building construction.
The raising crabs have been used for the removal of the smaller paving stones from level 3, the wedges for the bigger paving stones. The extent of each paving stone matters less than the underneath surface it revealed. The characterization of the materials has shown that the extraction was made easier by the homogeneous structure and regular stratification of the bed. These paving stones were fairly resistant to wear by friction.
The exhaustive recording of all this information and characteristics of the stone work in Sol de Roques is possible by using two types of files. Every tool mark is numbered and recorded as a specific item. All of these observations are then graphically transcripted through the creation of a graphic recording system for the traces of stone exploitation.

2.4 Development of a graphic recording system for the traces of stone exploitation

The archaeological study of the quarry from a diachronic point of view have been possible only after analysis, evacuation of the filling accumulated in the quarry and a meticulous cleaning of all the dents visible on the surface of the stone. The graphic transcription has eased their spotting during the linear observations and their recording in the technical files. Therefore the dialogue is constant between the archaeologist and the topographer.
The recording and the mapping of the vestiges of the extraction (quarry faces and quarry floors) are dealt with simultaneously; this choice imposed an exhaustive identification of the tool marks registered in the technical files as well as a survey of the traces of extraction tools. All the data recording using these technical criteria allows to highlight the quarrymen's actions. Their choices follow the geological nature of the different bed they exploited.
To locate every extraction structure inside the quarry, the surface has been divided into 4 areas, following the natural division of the quarry split into 4 different massifs (1 to 4, North to South) the dividing lines of which are indicated by the principle cracks spotted on the surface of the main quarry floor.
The quarry floor of level 1 covers an important part of the excavation surface; its cleaning has revealed the main cracks running through it. Following a northwest/southeast direction, they are parallel and regularly spaced out, some of them also go through the residual massifs. They indicate the general direction followed during the exploitation of the quarry.
In order to take into consideration the different facies of the stone each massif has been divided into 4 horizontal levels corresponding to the geological layering of the natural stratification. This partition into massif and layer facilitates the location of the tool marks, each one receiving a 5 digit number.

E.i. Marks from massif 1/layer 1
Marks **1 01 01** to **1 01 99** :

1st entry	Massif 1	**1**
2nd entry	observation level number	**0**
3rd entry	layer or level 1	**1**
4th entry	number of the mark	**01** to **99**

For the hundredth mark encountered in the massif 1/layer 1, in order to keep a 5 digit number, the observation level number is changed to 1. Therefore:

Marks **1 11 01** to **1 11 99** :

1st entry	Massif 1	**1**
2nd entry	observation level number	**1**
3rd entry	layer 1	**1**
4th entry	number of the mark	**01** to **99**

This numbering has enabled to create new numbers easily for forgotten marks and add them to the recording.

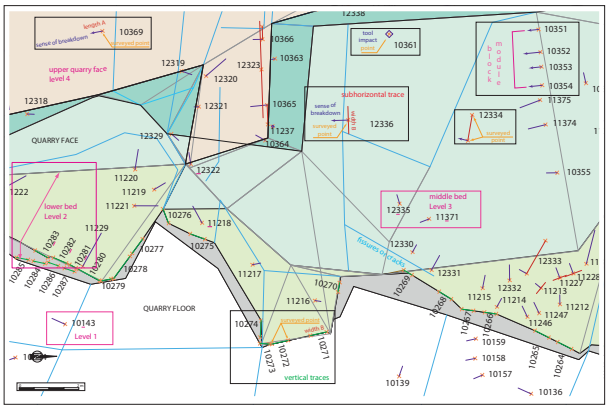


Figure 4. Explanotary diagram of the extraction (e.i. massif 1)
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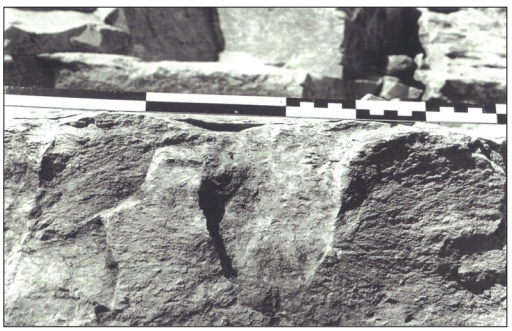
The study of the extraction tool marks is a fundamental aspect to keep in mind when doing research on a quarry. The observed marks (density, orientation and localisation) give information on the nature of the tool, the technical gestures, the quarrymen's intentions and the strategy of the exploitation. That's why the graphic interpretation of the marks, drawn to scale, was mandatory for the study of Sol de Roques quarry.
In addition to the survey, the archaeologist has filled the recording file for every tool mark, consisting of 6 items: the number of the mark, its nature, its geological location, the type of tool, its measurements, its orientation. There were 4 required measurements for each trace: A for longitudinal length, B for opening width, C for bottom width and D for depth.
Two types of traces have been distinguished, horizontal and vertical traces. The first group gathers the marks placed on a horizontal or sub-horizontal stratification joint and surveyed, either with only one point at the intersection of A/B (wedges sockets and grooves) or with 2 points for the width A/B (grooves). The second type includes the vertical traces (sockets and grooves) found on the quarry face in a solid part of the stone or near the geological cracks used by the quarrymen (e.i. traces 10201 to 10294).



Level 2 bed - Vertical tool marks 1 02 37, 1 02 38 (wedge sockets). © 2013 A. Daussy

Joining this descriptive recording to the topographic survey of the tools marks enabled to highlight structuration and progress directions of the exploitation that would have remained undetected otherwise.

The relevance of this method is also clear on the surveying level, where each bed (facies or layer) is shown with a different colour. The geological cracks and the quarry face appear on the same level. The direction followed by the tool marks are represented by an arrow. The arrow length shows, to scale, the A length starting at the surveyed point in the direction degree that has been entered and which shows the direction of the cut up. That way, it has been possible to spot some wedges sockets alignments and some directions that can indicate the modules of the extracted stones. By graphically associating extraction marks and cracks the way followed to extract blocks is easily readable, the extraction techniques are usually determined and their analysis made possible.

The massive bed of level 2 in the quarry face was used to produce dressed stones. On the upper part of the total length of this bed, tool traces of the vertical type have been observed (cf. characterization of the stone, E.M.A.). In order to demonstrate the strategy of extraction on the bed and deduct from it the use of the extracted stones, a graphic representation has been created, named a « frieze ». It connects every vertical mark visible. The measurement of the central distance between two consecutive marks can be compared to the closest cracks in order to determine the possible locations of the extracted blocks and their module.

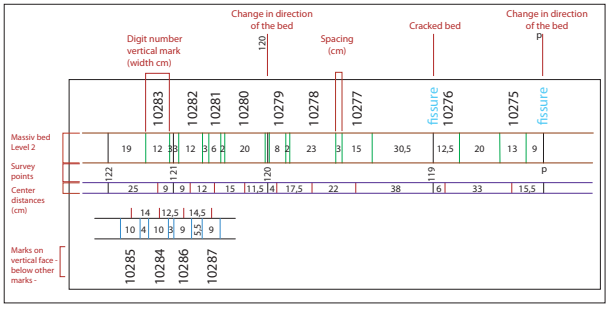


Figure 5. Diagram of modular extraction : «the frieze» in level 2 massive bed. © 2013 V . Vachon

This graphic representation of the stone extraction highlights a layout of regular high blocks. Some of these blocks, ready for shipping, have been left behind awaiting to be loaded on board. Whenever it's required, the graphic representation can be used to find an architectural placement based on the layout (e.i. Lintels and jambs).

Blocks ready for shipping
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3. CONCLUSION

The study of Sol de Roques quarry has enabled us to create a recording procedure of the remains from a descriptive and graphic point of view while also enabling us to keep the existence of the marks of stone exploitation alive. The observation of the tool marks has demonstrated the variation of the exploitation techniques which were adapted to each vertical variation of the stone facies. The placement of the stones obtained was then carefully chosen, depending on the layer it came from.

We thought it was important to create lasting recording systems that would still be relevant in the future and help answer the questions raised by archaeologists regarding the history of stonework. Our research has enabled us to realise that we can now have access to the questioning of the builders and assess their technical and scientific knowledge. The exploitation techniques, the analysis of plant remains and the architectural observations in the village and the castle nearby prove that the quarry was used during the medieval period.

The results shown in our research can be seen in the different types of recording we have provided; the graphic representation gives a clear vision of the technical data in general. New acquisition and analysis techniques (3D laser scanning, G.I.S.) have now emerged but the major part of the recording are still to be carried out; we should also keep in mind that every human activity occurs in a specific historical and social background.

Recent research have shown that the marks left by tools must not be regarded as the only factor to be taken into account when dating a quarry [studies lead in the ancient quarry of Estel at Vers-Pont-du-Gard (Gard), in the quarries of Fos-sur-Mer (Bouches-du-Rhône) exploited from Antiquity to modern era and in the sarcophagus quarry of Late Antiquity of Orgon Bouches-du-Rhône)].

The perception of space and its mental representation at every period of time is of extreme importance. "Technical reflexion" that lead to the choice made by builders and quarrymen is present in our research. And the technique born of reflexion is the chronological marker throughout the history of stone construction.

Panoramic view of Sol de Roques quarry

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