The quern and millstone quarries of Bibracte and Autun: The case of Saint-Andeux (CÙte-díOr, Burgondy, France)

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Abstract: The millstone research carried out at the *oppidum* of Bibracte has recently been bolstered by finds deriving from preventive archaeology carried out at the Roman city of Autun. A new phase of this research has focused on the quern and millstone quarries supplying the two centres. Among the quarries is the vast vaugnerite outcrop of *Bois de Joux* at Saint-Andeux (Côte-d'Or). Field surveys identified two sectors producing mostly rotary querns dating to the Late Iron Age and Antiquity. Examining the roughouts renders it possible to reconstruct the operational sequence of their manufacture while the study of the quarries offers data to distinguish the Late Iron Age from the Roman quarries and identify their sequences of production.

Keywords: querns, millstones, roughouts, production, quarries, Saint-Andeux, Bibracte, Autun, operational sequence

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Introduction

A recent research project has focused on the rotary querns and millstones brought to light in the excavations of the *oppidum* of Bibracte and the city of Autun, two centres dating to Antiquity about 30 kilometres apart (Fig. 1). Since 2013, a new phase of the project, involving archaeologists and geologists has focused on the question of the quarries supplying the stones to these centres. The project was conducted in collaboration with the European Archaeological Centre of Bibracte and the Archaeological Service of the City of Autun. This research has concentrated on an assemblage of 313 ancient querns and millstones unearthed in Bibracte and 139 in Autun. The group from Autun can be broken down into 75 from the excavations of the Faubourg d'Arroux, 41 from the Lycée Militaire and 23 from elsewhere. The total assemblage from the two sites comes to 450 stones ranging from Late Iron Age (La Tène Dl) to the end of Antiquity.

The Bibracte group consists mostly of sandstones (231 of 313), which can be subdivided into seven different types. The assemblage is otherwise represented by a variety of granites (13) whose outcrops are near the *oppidum*, vaugnerites (49), a specific rock known in the area of Avallon, and volcanic basalts (20) from the Massif Central. The stones from Autun are also for the most part local, although there are a few cases of exogenous basalts and granites. The sandstones at this site can be broken down into five types.

Geological surveys carried out throughout the area of Autun identified a series of outcrops that

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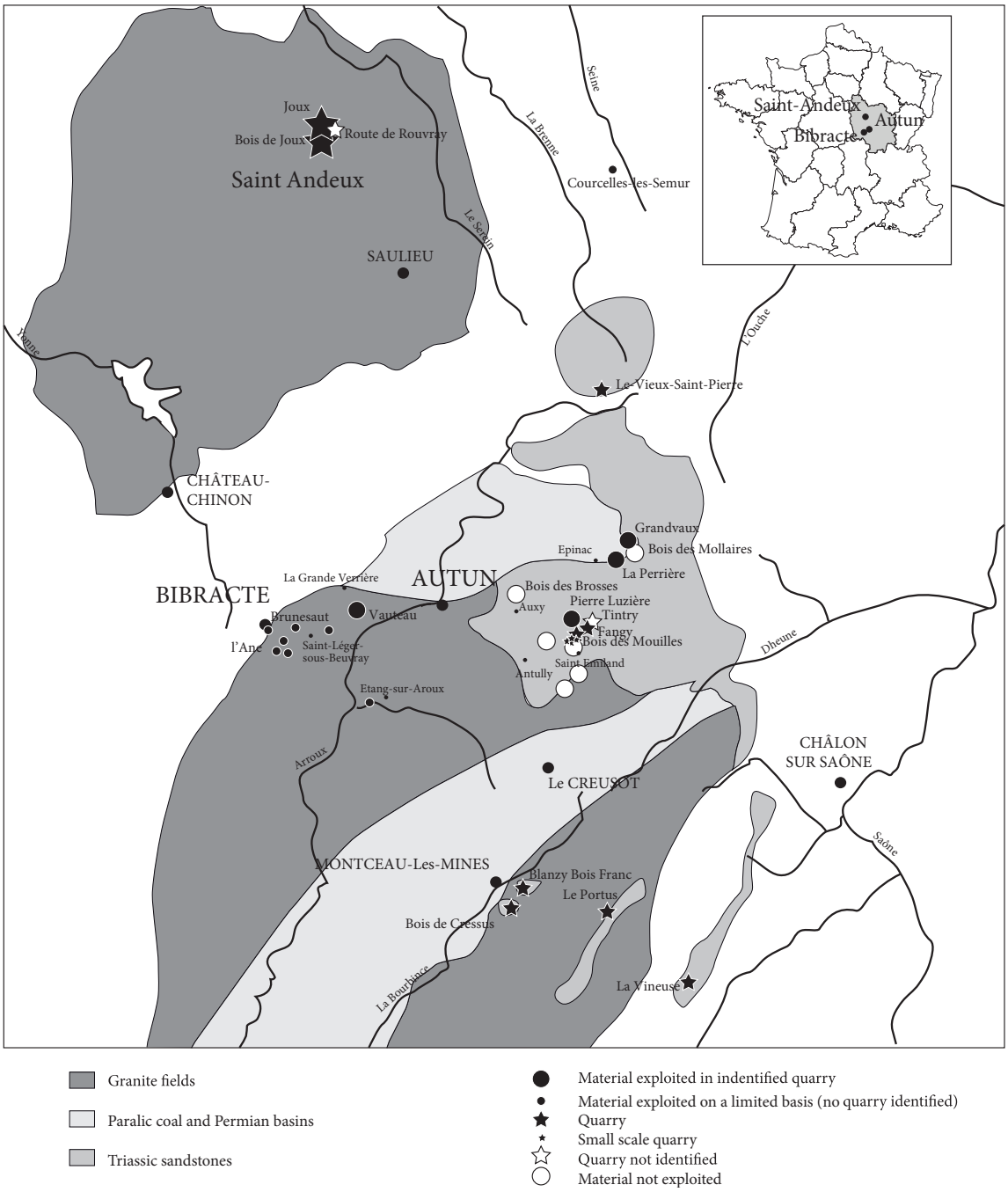


Fig. 1: Map of the quern and millstone extraction sites supplying the ancient centres of Bibracte and Autun.

could have been exploited to manufacture grinding tools from the Late Iron Age and the Roman period. These surveys are an essential facet of this study as they offer data to pinpoint the zones of extraction.

Identification of the extraction workings was initiated by examining the geological data. This was followed by surface surveys in wooded areas to attempt to identify quarry features (excavations, pits, mounds ...) and working debris (discarded cylindrical roughouts, chipping flake concentrations ...). The extraction zones bearing traces of millstone making, once located, were then mapped by GPS. These phases allowed to define the extension of their surfaces, the approximate number of roughouts (blanks) and advance a preliminary dating.

This was followed by more detailed surface surveys of the specific spaces bearing evidence of grinding stone extraction. This consisted of plotting all the extraction remains, a technological study of the type of production and a petrographic characterisation of the rock. The survey allowed pinpointing the position of the extraction areas, the roughouts and the areas of working debris. The technological study of the abandoned cylindrical roughouts involved recording and drawing them directly in the field. This aspect of the research allows to reconstruct

the operational sequence based on the tool marks and the flakes.

A preliminary assessment of this global study indicates that 74.9% of the stones from each of the sites (Bibracte: 70.7%; Autun 90.4%) could be provenanced. An overview of the main findings related to quern and millstone procurement is thus the following:

-A first assemblage of querns come from the granite formations and Permian sandstones outcropping between the *oppidum* of Bibracte and the city of Autun.

-The sandstones to the east of Autun can be subdivided into two areas (Saint-Emiland and Epinac).

-The closer northern sandstone outcrops of Saint-Pierre-en-Vaux served as a source for Autun. A single quern is from the Permian basin of Creusot to the south of Autun.

-The more distant outcrops of Courcelles-les-Semur to the north-east sporadically supplied Bibracte. The extraction zones of Portus in Collonges-en-Charollais (Jaccottey *et al*. 2011), Blanzy and Saint-Vallier, by contrast, do not appear to have supplied either centre.

-Extra-regional outcrops at Saint-Andeux and Puisaye, as well as volcanic basalts from the Massif Central, supplied stones to both sites.

Local raw materials make up a minority (6.19%) of Bibracte's grinding stones. These are represented mainly by granites of varied lithology and provenance. No physical evidence of their extraction has been identified. It is most likely that they do not come from true extractive quarries but represent an opportunistic exploitation of surface boulders. A second group, slightly less than half of the assemblage of Bibracte (45.9%), comes from Autun's Triassic outcrops about 40 km from the *oppidum*. To this group can be added a few cases from Saint-Pierre-en-Vaux and from the region of Le Creusot (4.6%), at about the same distance. Two extraction areas exploiting these rocks were also discovered in the sector of Saint-Emiland, and another in the area of Saint-Pierre-en-Vaux, while none has been identified in Epinac. Rocks of regional origin (Courcelles-les-Semur and Puisaye) account for a very small proportion of Bribracte's assemblage (1 case; 3.2%) in spite of the fact that they were at times extracted on a great scale. However, their distance to Bibracte and Autun suggests they played only a secondary procurement role. The same applies to the exogenous basalts of the Massif Central (5.86%). The vaugnerite quarries of northern Morvan, about 60 km to the north, supplied Bibracte with a significant portion (15.7%). Of these, the Saint-Andeux quarries are the only quarries identified in the field to date. They constitute less than 4% of the total assemblage.

Autun, in turn, closer to the sectors of Epinac and Saint Emiland, was for the most part locally supplied (83.1%). The only extra-regional materials are a few Massif Central basalts (7.2%). The reduction in the variety of rocks serving to produce these stones goes together with a narrowing of supplies and a focus on local resources.

A detailed study of the quarries of *Bois de Joux* was carried out in 2013 in the Municipality of Saint-Andeux. This research combined a topographic survey of all the Protohistoric and Antique extraction zones with the systematic drawing of the abandoned roughouts. This extraction zone is particularly rich as it contains numerous unfinished roughouts associated with characteristic extraction features such as zones of working debris. This site is one of the rare ancient millstone production workings benefiting from a systematic exploration in the field. Due to the quantitative importance and the good state of preservation of the roughouts, it was possible to reconstruct the site's *chaîne opératoire*.

Raw materials

The vaugnerite of Saint-Andeux is a coarse, magmatic rock at times characterised by aligned beds of biotite crystals. It is often confused with granite in spite of its low quartz content and the nature of its feldspars (in this case almost exclusively plagioclase). The texture is predominantly coarse and unaligned although the biotite crystals in some fragments or portions are organised into partitions separating the feldspar crystals with a sub-automorphic tendency. This structure with an inter-granular (doleritic) tendency is, however, not very well developed. In addition to the main minerals, the decreasing order of abundance from feldspars, biotite (phlogopite) to quartz, are found in association with rare secondary minerals such as apatite (very abundant in biotites) or amphiboles.

All the analysed samples reveal a similar composition and structure. This homogeneity is noteworthy as there are other facies of vaugnerite both in the vicinity of Quarré-les-Tombes and in other regions. Only several states of alteration can be identified, which are manifested by a transformation of the biotite into chlorite, by the alteration of the feldspars, but especially by a great break up and disintegration of the thin layers of biotite.

The discovery of millstone workings

The first mention of the exploitation of vaugnerite for millstones at Saint-Andeux was penned in the middle of the 19th century. The author commented:

… des collines d'éclats de granite et des centaines de meules ébauchées ou manquées et qui ne pouvaient être livrées au commerce (Moreau 1859: 23-24)[1].

Despite this allusion, the site was only identified in the field nearly a century and a half later when the geologist F. Boyer, while exploring a clearing of the forest, came upon the numerous cylindrical roughouts.

1. Editor translation: "... mounds made up of granite flakes and hundreds of abandoned millstone roughouts that could not serve for trade." (Moreau 1859: 23-24).

Fig. 2: Map indicating the area surveyed at Bois de Joux (Saint Andeux) and the location of the northern and southern quern and millstone extraction zones (S. Beuchot, C. Cherot and L. Jaccottey).

The roughout assemblage

A total of 102 quern and millstone roughouts were studied at Saint-Andeux: 42 from Zone 1 (nos. 1 to 13, 46 to 58 and 101 to 116), 18 from Zone 2 (42 to 45 and 120 to 133). The remaining 41 were found displaced in the town (14 to 41, 59 to 71). Their removal from the quarry by the local inhabitants, although undoubtedly serving to safeguard them, deprives them of information as to their original context. Hence data as to the specific context is only available in 61 cases.

Surface surveys and quarry organisation

Field work at *Bois de Joux*, extending over a surface of 33.27 hectares, was carried out in an area comprising forests and prairies. The survey identified extraction features grouped into two main sectors: the first, the southern group, consists of several large pits to each side of a rural road (quarries 101 to 115 and 201-211) while the second, to the north, is a smaller zone with fewer pits (1-5) along the edge of the forest (Fig. 2).

The roughouts identified in the field are relatively numerous in the two groups of pits along the summit of the plateau (101 to 112) and those to the north (1 to 5). In addition to roughouts, each group contains concentrations of chipping debris clearly associated with the zones of extraction. A few cylindrical roughouts were also found in the workings along the western slope of the communal forest (201 to 209). This zone, as well as that farther north (210 and 211), is characterised by numerous blocks of vaugnerite and an absence of chipping debris and appears, by contrast, to correspond to the extraction of blocks for construction, unrelated to the quern and millstone workings.

The quarries of the northern sector

The exploitations in the northern sector are divided into two zones to either side of the country road. Quarries 1 to 3 are to the south and quarries 4 and 5 to the north (Fig. 3). All the pits are on the slopes of the hill and are relatively large (500 to 2000 m²) and semi-oval. Their depths range between 1.5 and 4 m. The relief of quarries 4 and 5, in a prairie, by contrast, is rather smooth as they were partially backfilled.

The workings are lined with extensive concentrations of working debris (blocks and flakes). The blocks are angular, of varying shape, and measure between 10 and 60 cm. The chipping flakes measure from 5 to 15 cm long and 3 to 8 cm thick. The concentrations of blocks and flakes are situated toward the entrance and below the quarries (rarely to the side). Recent terracing along a stream below quarries 4 and 5 produced a cutting 1 m to 1.5 m deep through the layer of working debris. The reading its stratigraphy confirms that the blocks and flakes correspond to millstone making waste. This area also coincides with most of the roughouts finds.

No roughouts, by contrast, were found in quarries 1 and 3. Several, in fact, were reused in modern walls

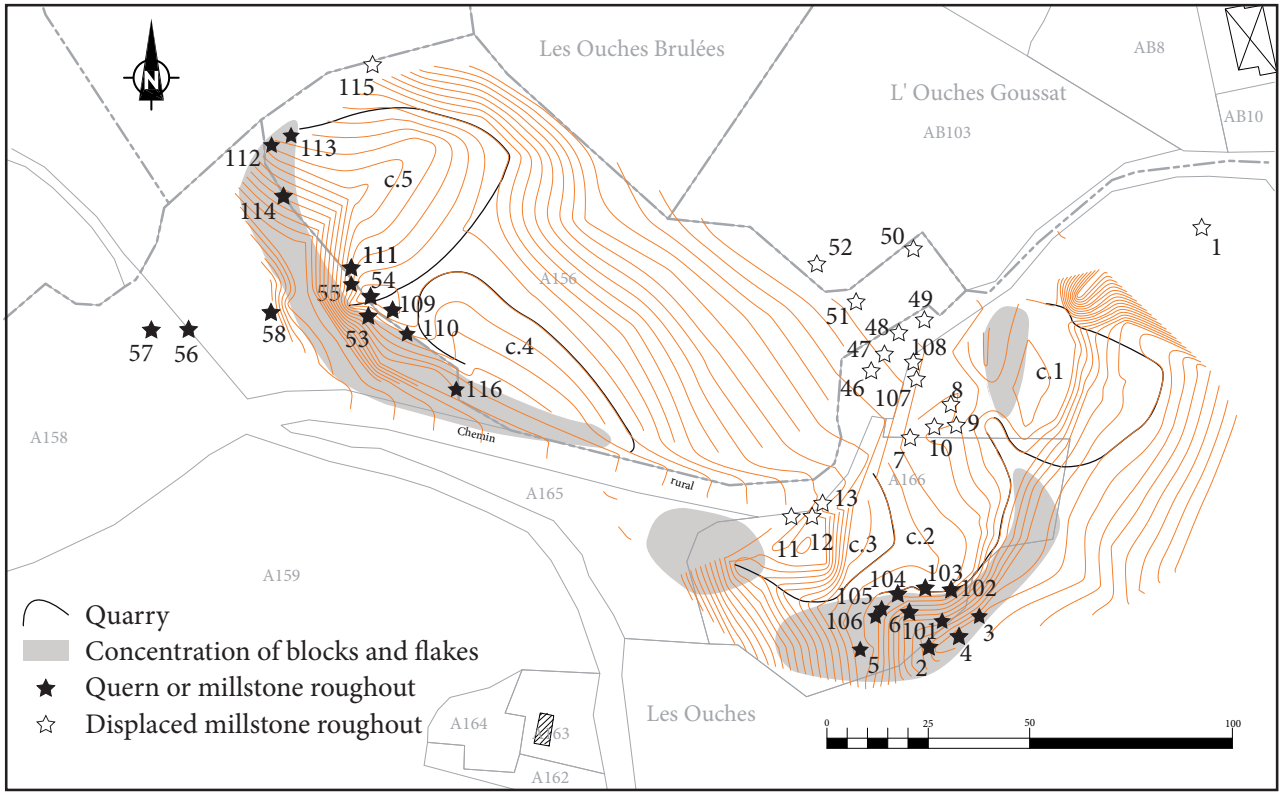


Fig. 3: Detail of the northern millstone quarries at Saint-Andeux (S. Beuchot, C. Cherot and L. Jaccottey).

raised either along the road or along the boundaries of the parcels. Others were simply removed from the quarries. These workings also suffered damage from agricultural work. It is therefore not possible here to conduct a spatial study of the roughout distribution.

The quarries of the southern sector

This series of quern and millstone quarries is concentrated in two parcels in a forest at the top and along the eastern flank of a small plateau bearing the toponym *Bois de Joux* (Fig. 4). The 12 sites consist of pits alternating with mounds of working debris. The pits attain a depth of 4 to 5 m, which, combined with the 3 m high spoil heaps, yield a rolling landscape.

The dimensions of these relatively large extraction zones range from 15 to 45 m long and 20 to 40 m wide. These workings are nonetheless smaller than those of the quarries of the northern zone. Two of the hollows in this area (101 and 102) are much smaller, measuring 5 to 9 m from side to side and a maximum depth of 0.5 m.

The large quarries are most often oval, with a narrowing at the entrance. This tapering is usually flanked by mounds of spoil containing both blocks and flakes. Two large workings with downhill entries on the eastern slope (107 and 112) are semi-oval. The two smaller workings (101 and 102), in turn, are circular or semicircular.

As in the case of the quarry sector to the north, it was possible to map several chipping areas evidenced by abandoned blocks and multitudes of flakes. There are also a number concentrations of small flakes spread over an area of several dozen square metres. These are found on the top of the mounds, between the quarries.

The spatial distribution of the roughouts in this zone, undisturbed by agricultural work, finds those in the process of chipping to the side of the quarries, while those in the process of surface regularisation mostly in or near the areas of small flakes. Modern experimentation indicates that small flakes are produced in the phase of surface regularisation. The roughout distribution therefore suggests that the cylinders were regularised in workshops immediate outside the quarries while the first phase of chipping was conducted directly in the quarries.

The information gleaned from the study of roughout diameter is equally interesting. Indeed, quern roughouts measuring between 40 and 42 cm in diameter are essentially near the small quarries and in an area along the periphery of the quarries (Fig. 5). Roughouts between 43 and 52 cm in diameter, in turn, are found near or in the larger quarries. The hypothesis is that of a production of smaller 40 to 42 cm roughouts dating from La Tène D2 or the early Roman (Augustan) period were hewn from surface boulders or detached from

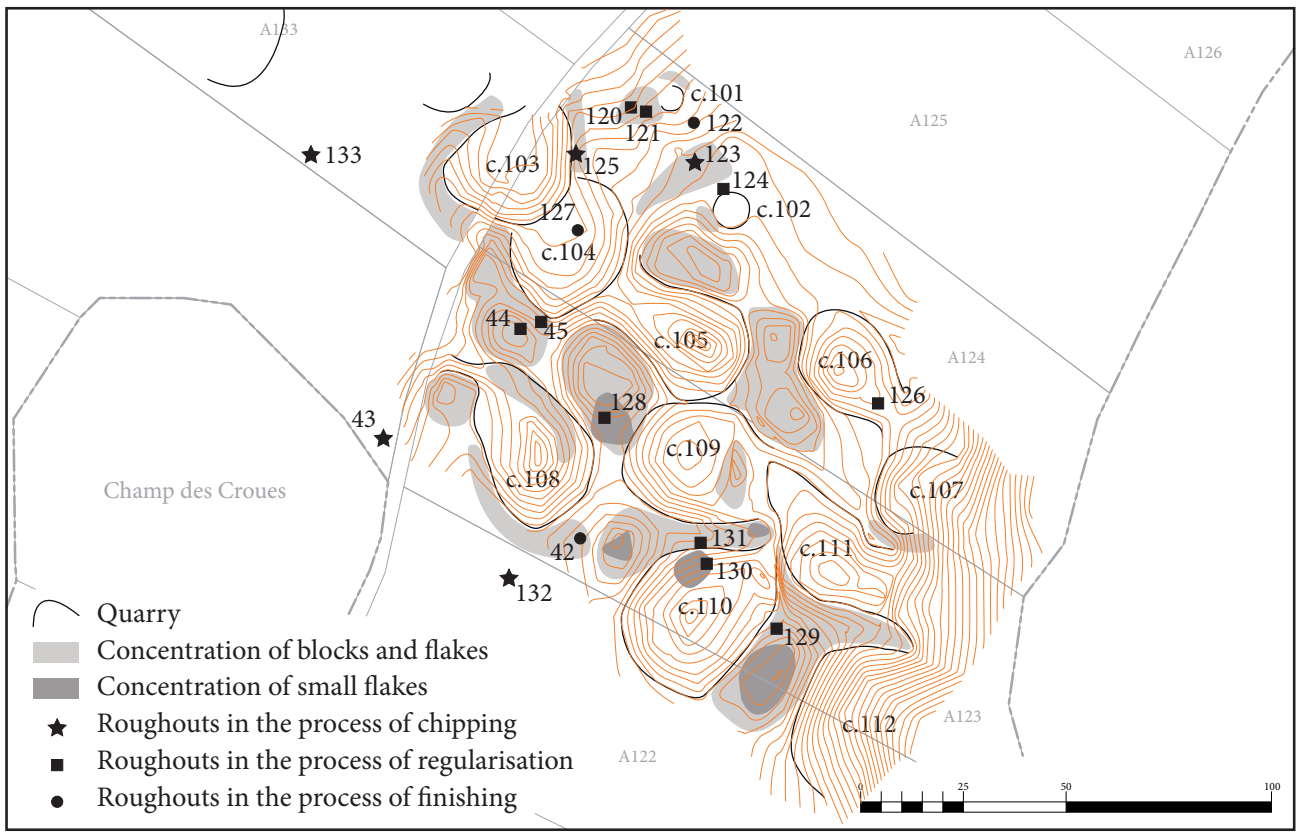


Fig. 4: Detail of the southern quarries at Saint-Andeux with the distribution of the different types of working debris indicative of distinct phases of millstone making (S. Beuchot, C. Cherot and L. Jaccottey).

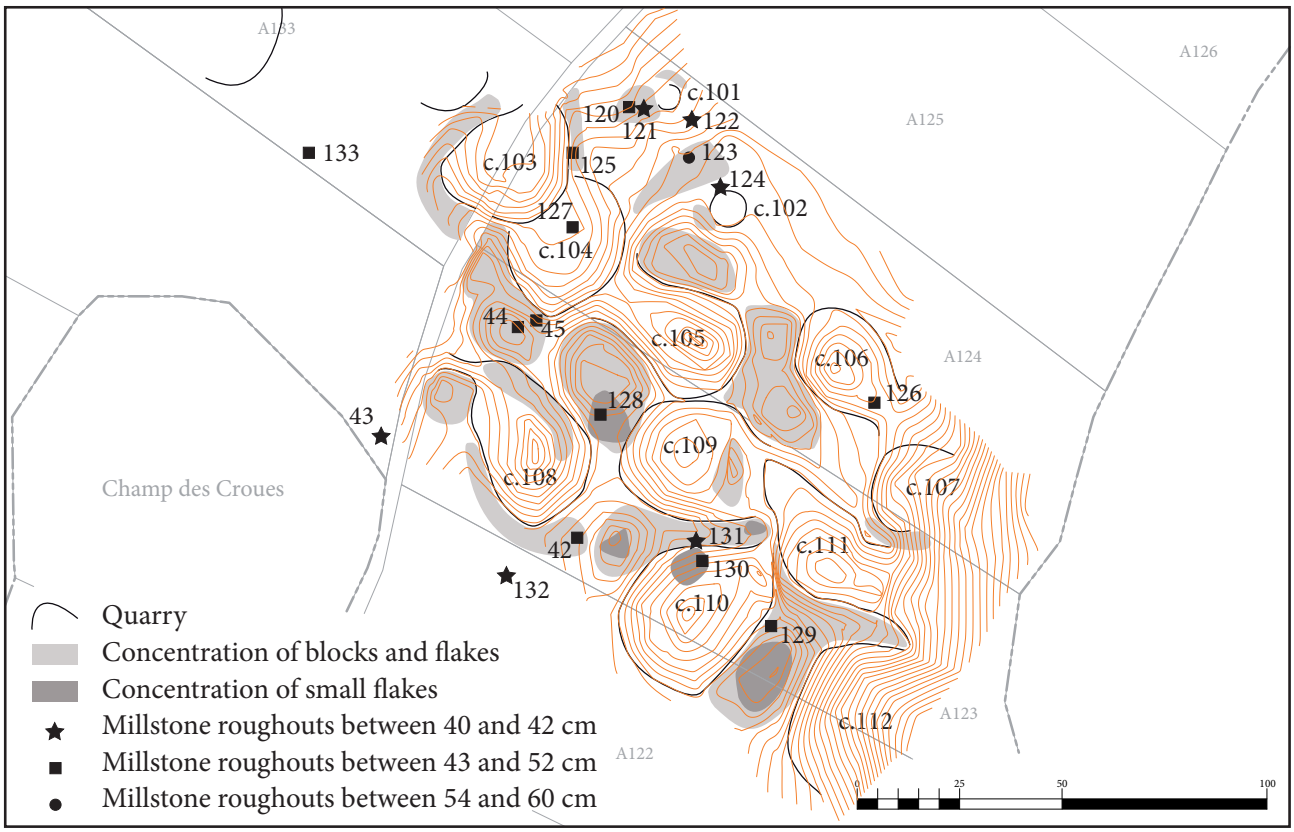


Fig. 5: Map of the southern quarries at Saint-Andeux and the position of the quern and millstone roughouts according to their diameter (S. Beuchot, C. Cherot and L. Jaccottey).

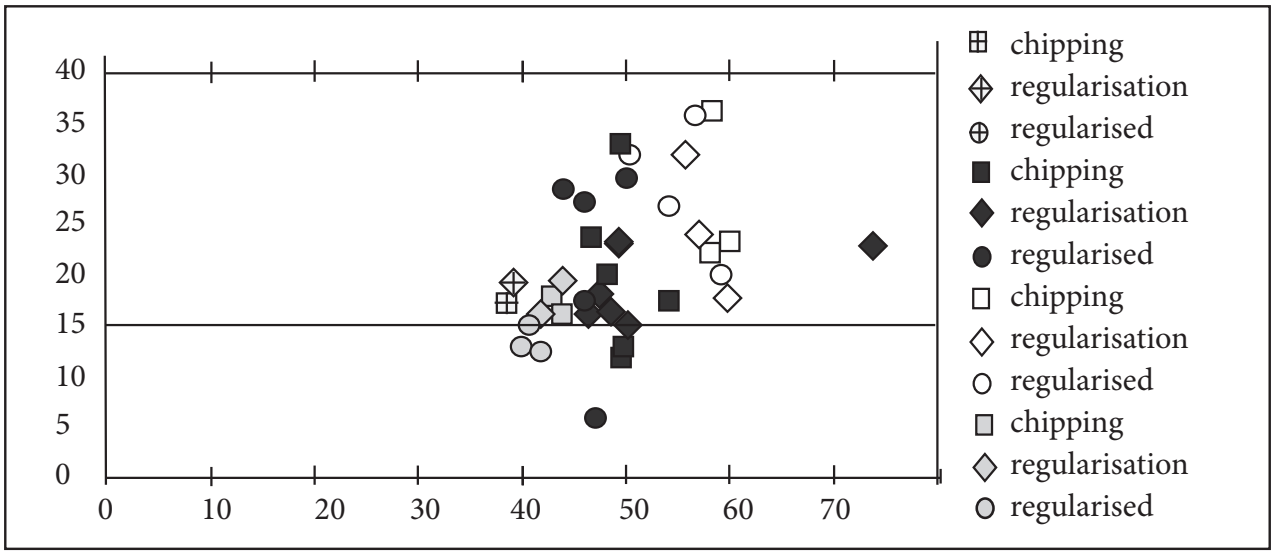


Fig. 6: Roughout diameter (x-axis) and thickness (y-axis) in cm from the quarries of the northern sector of Bois de Joux according to their phase in the operational sequence.

small-scale shallow quarries, whereas the larger 43-52 cm roughouts, diameters tantamount to Roman rotary querns and millstones, were produced in more substantial and deeper quarries.

The cylindrical roughouts

The roughout assemblage comprises 46 cylinders ranging in diameter between 45 and 54 cm. Others in a more advanced state bear totally regularised surfaces and range from 40 to 50 cm in diameter

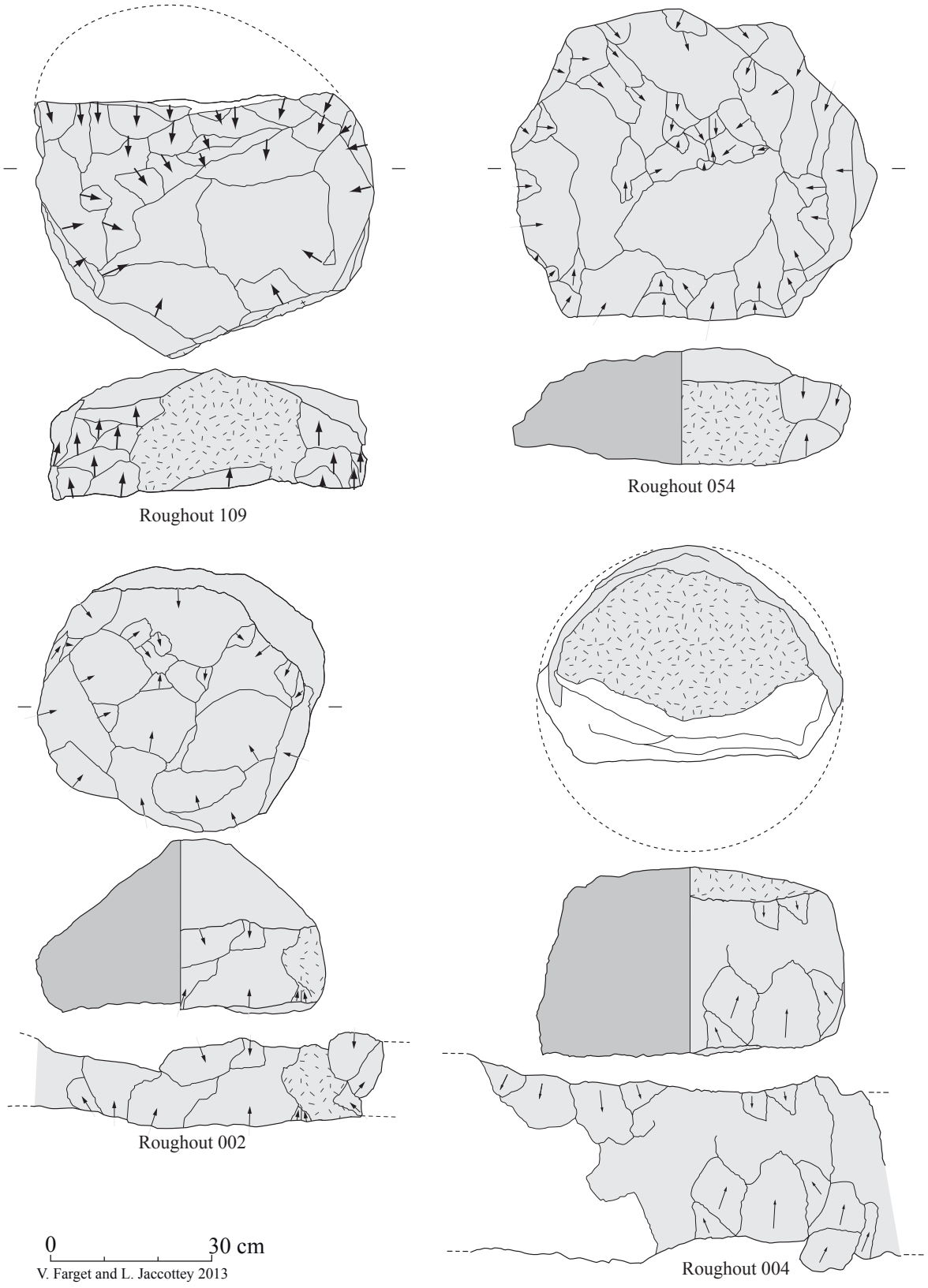


Fig. 7: Rotary quern roughouts from the quarry of Saint-Andeux with chipping scars alternating with patches of the stone's original cortex (dotted areas).

(Fig. 6). This first group corresponds to Roman hand driven rotary querns. The second group of 21 roughouts measure less than 42 cm and correspond most likely to earlier rotary querns dating either to the end of the Late Iron Age or the outset of the Roman period. A last group comprises larger cylinders measuring between 55 and 60 cm diameter. Although presumably no longer driven by hand, this third group can also be dated to Antiquity.

Characteristics of the initial quadrangular blocks

As no quarry face is visible in the field and no trace of block extraction or detachment can be detected from the rough blocks themselves, information as to the techniques of detachment from the quarry has to be gleaned from the blocks themselves. These were initially quadrangular measuring between 15 to 36 cm in thickness and 50 to 70 cm in length. Their different faces are relatively flat.

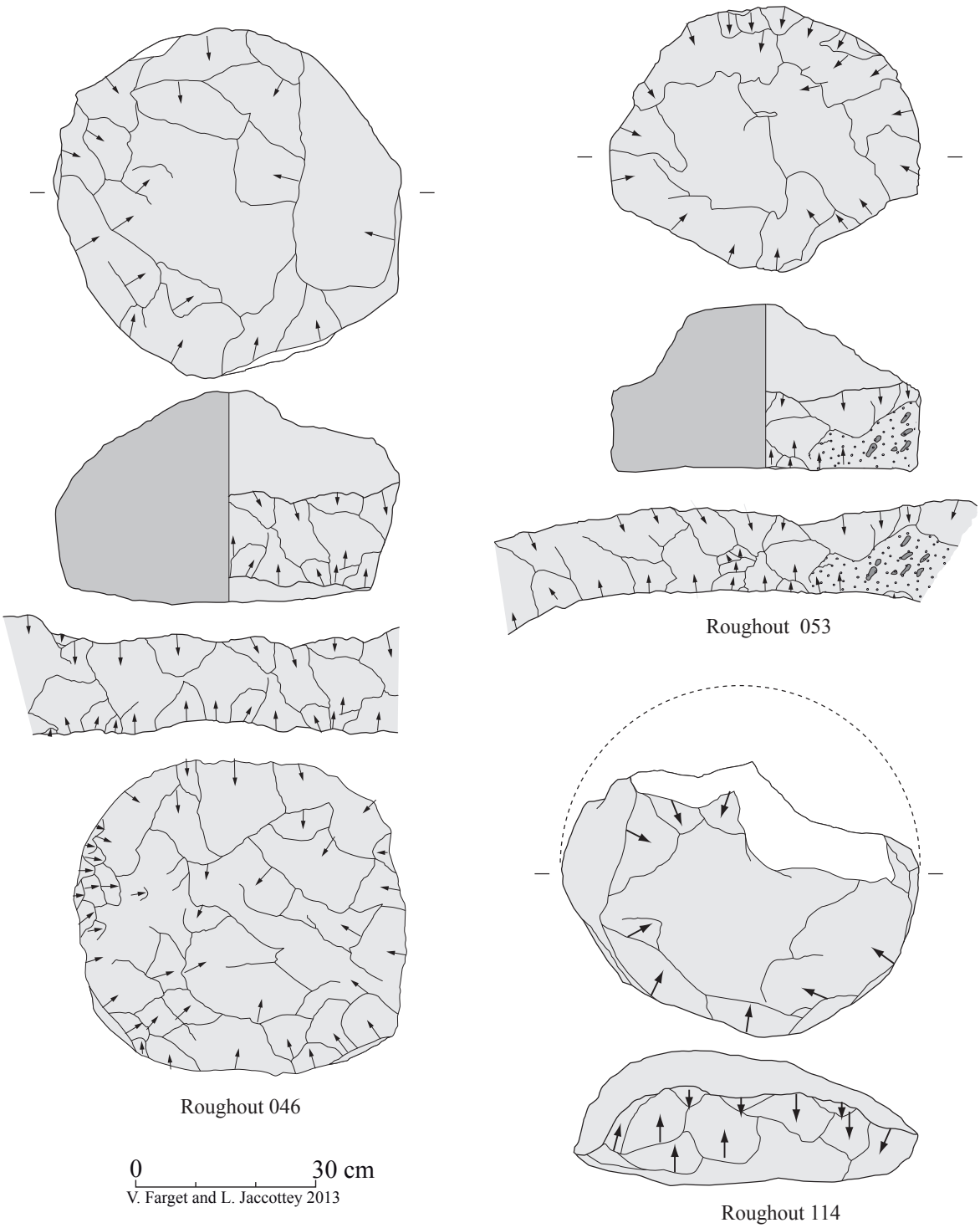


Fig. 8: Rotary quern roughouts from the quarry of Saint-Andeux with chipping scars linked to the fashioning of the edge.

Chipping the quadrangular blocks

This initial phase of the work aimed to chip quadrangular blocks into rough cylinders. Chipping the flat and sharp corners of the blocks results in large flakes. 25 rough blocks of this type were identified (Fig. 7). At this stage, it is not possible to distinguish whether the rough cylinders blocks are intended to become *metae* (lower stones) or a *catilli* (upper stones).

During this phase, the upper surface and the edges are chipped. Most often, the lower surface of is left raw. It is rarely regularised by the removal of large flakes from the edge. Fashioning the edges involved carefully removing large flakes with blows to the rim of the upper and lower faces, always in aimed toward the heart of the stone to avoid breaks (Fig. 8). At this stage, patches of the stone's original cortex, at times visible along the edge, are not common.

Chipping more generally affects all of the cylinder's circumference. At this stage the edges are, as a rule, vertical or slightly flared (Fig. 9).

The chipping scars on the roughouts are 3 to 21 cm apart and correspond to the numerous stone flakes making up the layers of working debris along the edge of the quarries. Two modern stonecutters that visited the quarries indicated that these types of flakes were produced out either in indirect percussion with a punch (blunt chisel) or by directly percussion with a hammer-axe.

Fashioning of the roughout's upper face was then carried out by removal of flakes from the rim of the cylinder's upper edge. As in the case of the flakes resulting from fashioning the edges, they were generally wider than long, ranging from 5 and 25 cm. The removal of these flakes yielded roughout sections that were either pointed or rounded (for lower stones) or convex (for upper stones).

Fashioning of the lower surface is infrequent at this stage. As for the upper face, the point of impact of the tools are oriented from the edge and affect the roughout's entire surface. The section of the lower face is either slightly convex or flat.

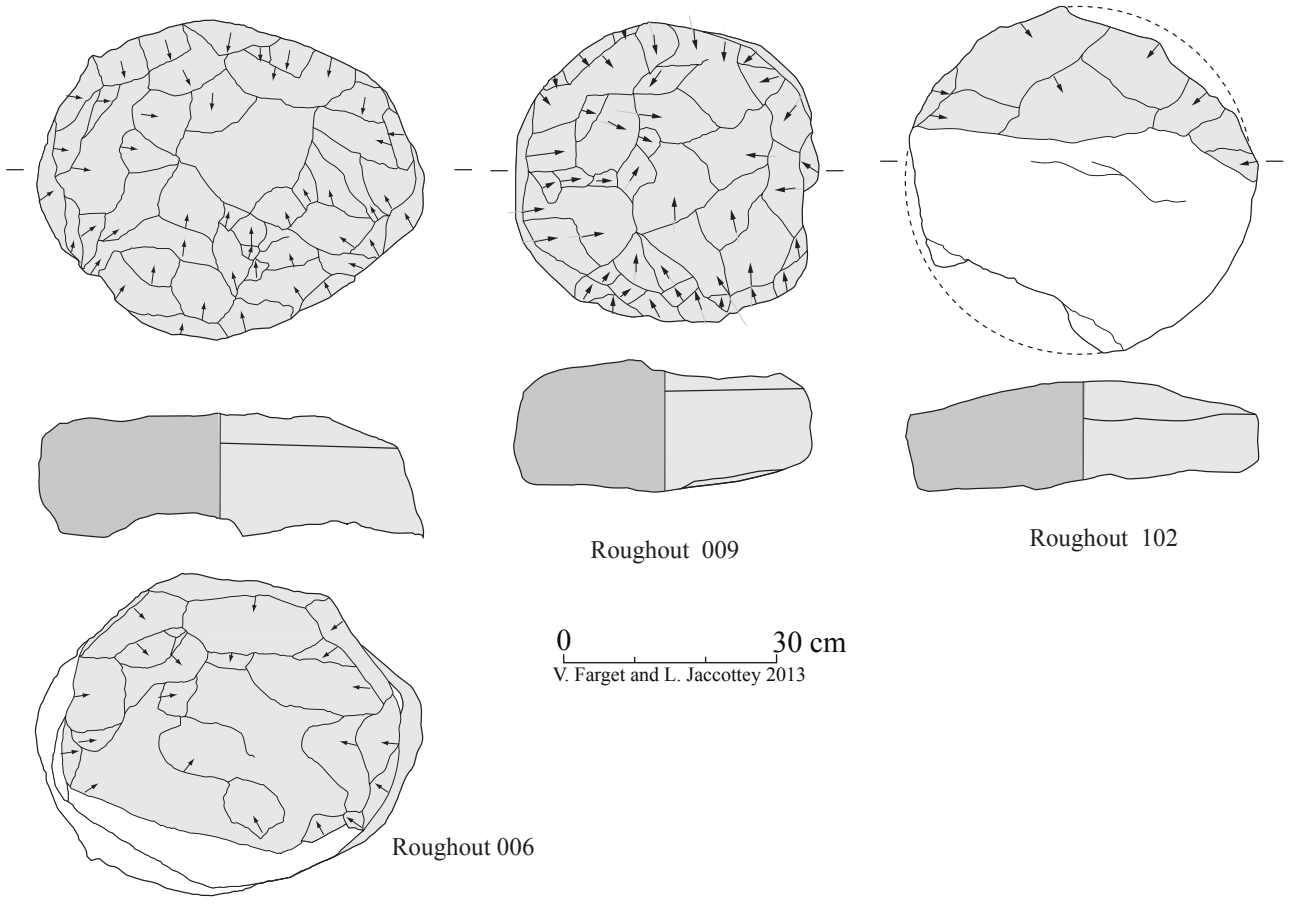


Fig. 9: Rotary quern roughouts from the quarry of Saint-Andeux bearing traces of fashioning by chipping.

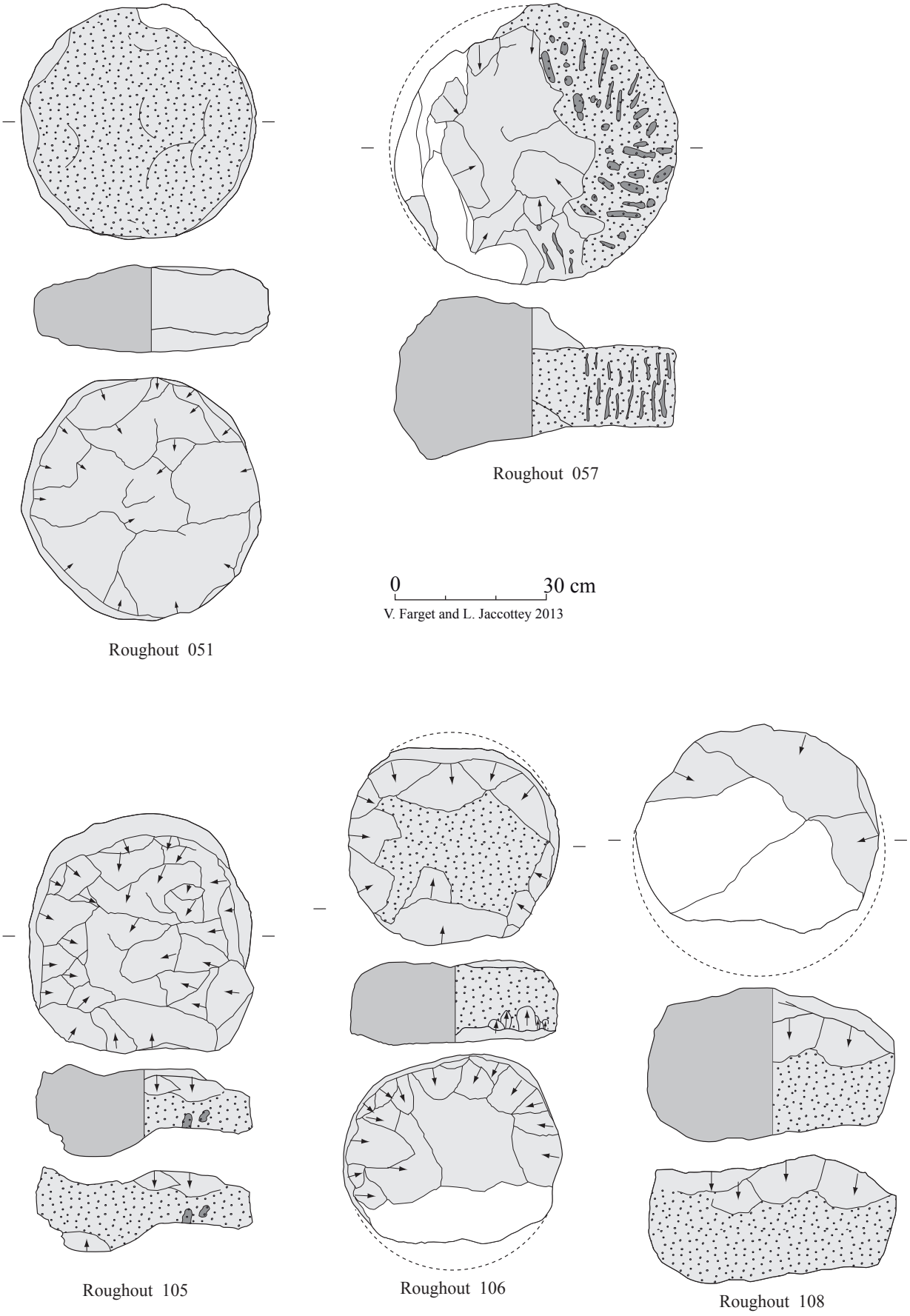


Fig. 10: Cylindrical roughouts from the quarry of Saint-Andeux. The upper surface of no. 51 and the edges of nos. 57, 105, 106, and 108 bear traces of the phase of surface regularisation.

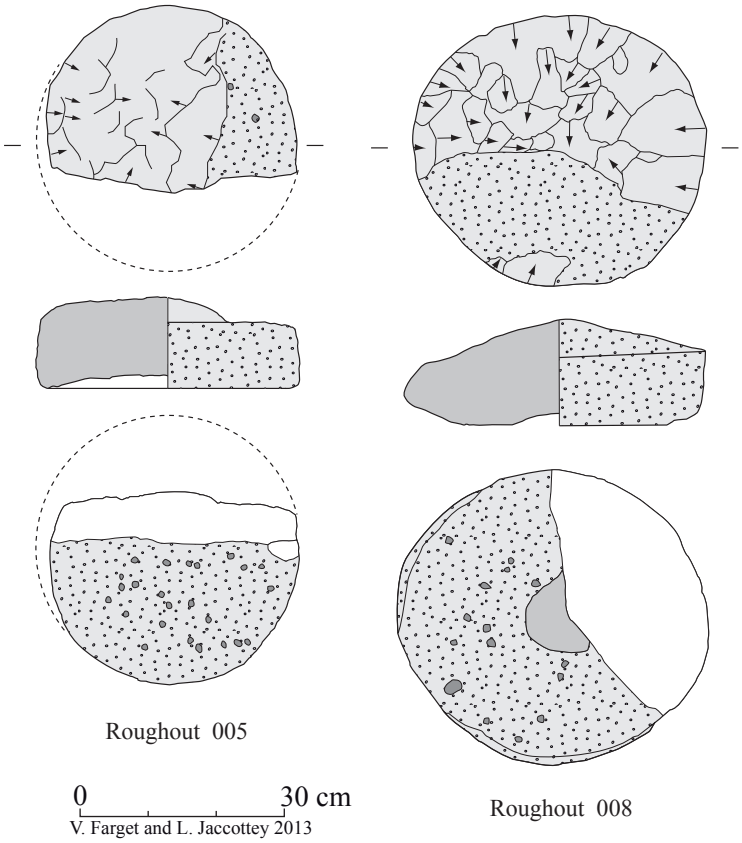


Fig. 11: Rotary quern roughouts from the quarry of Saint-Andeux with traces indicating they were abandoned in the process of regularisation of their upper surfaces.

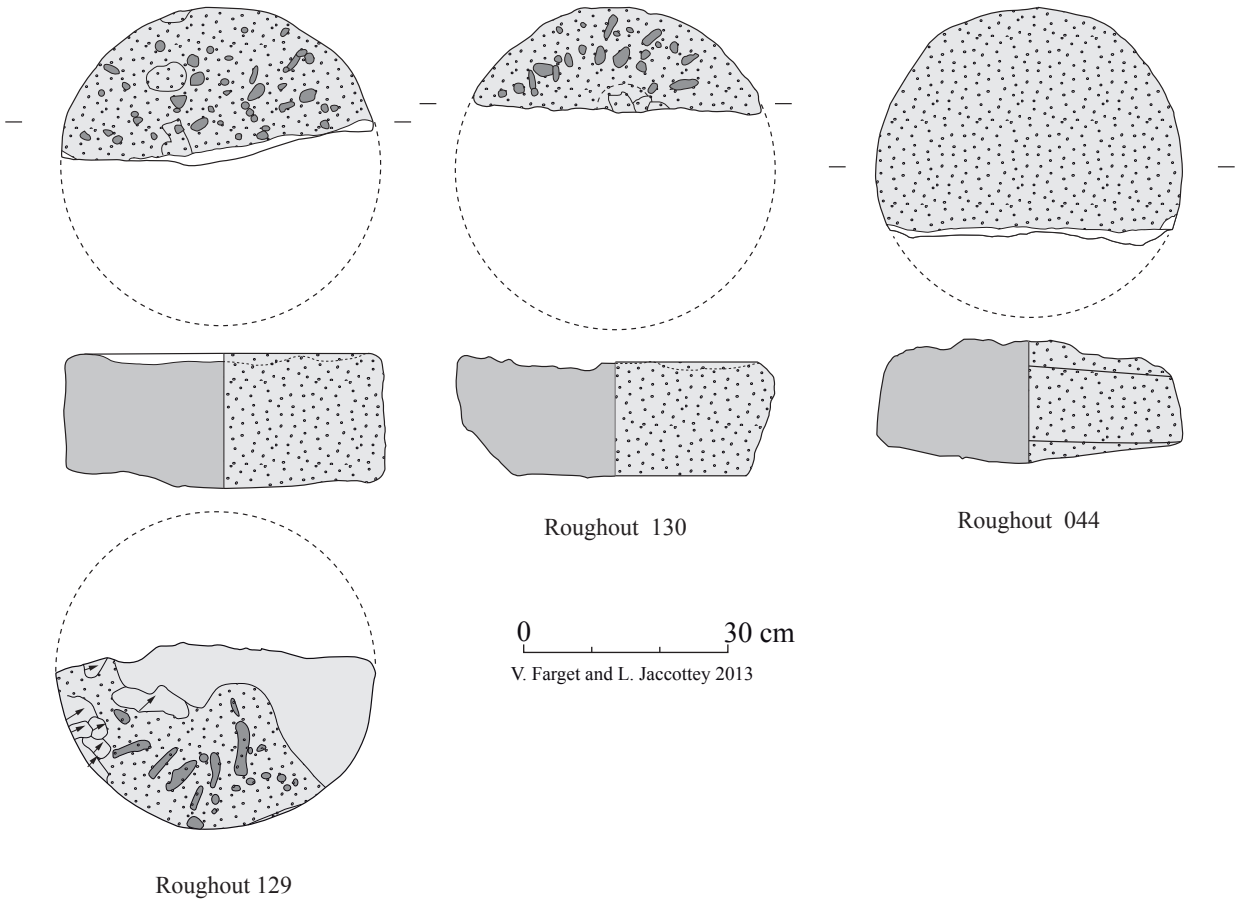


Fig. 12: Rotary quern roughouts from the quarry of Saint-Andeux with traces of regularisation of their upper surfaces.

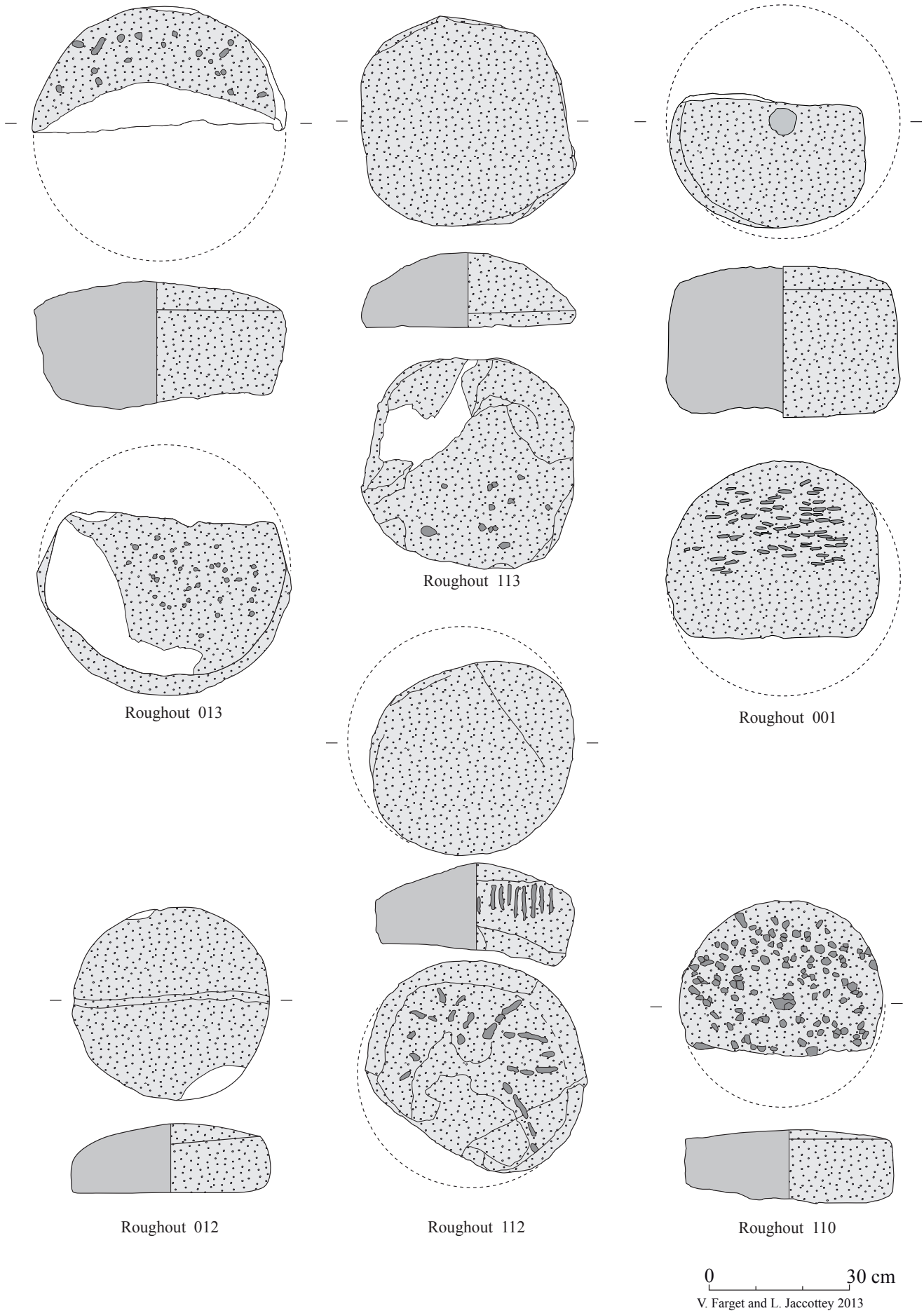


Fig. 13: Rotary quern metae (lower stone) roughouts from the quarry of Saint-Andeux bearing traces of finishing.

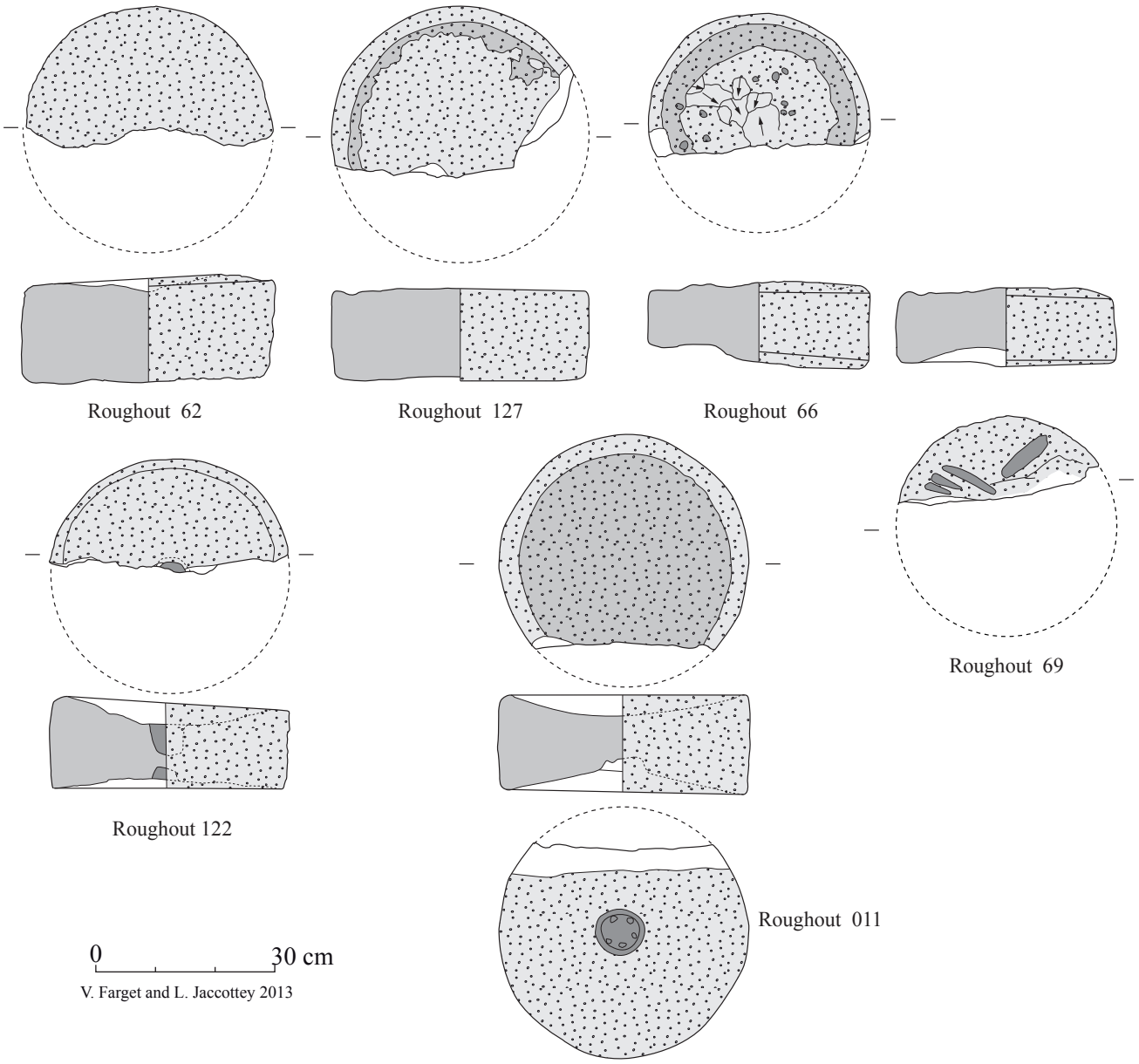


Fig. 14: Rotary quern roughouts from the quarry of Saint-Andeux bearing traces of finishing. The eyes of nos. 122 and 011 are in the process of carving.

Surface regularisation

This stage of the operational sequence is evidenced by 29 roughouts. As a rule, surface regularisation was first carried out along the edges of the cylinder as evidenced by the scars of the original chipping of the edges retained along the rim of the upper face. The edge regularisation was carried out with a single pointed chisel starting at the base of the cylinder. This phase eliminated all the previous flaking scars. One example reveals the rough traces of regularisation carried out along the roughout's edge. These marks were produced by multiple peckings with a pointed chisel and take on the form of parallel vertical lines (no. 57) (Fig. 10).

Several roughouts are characterised by the regularisation with a pointed chisel of their upper face after the regularisation of their edges (Fig. 11). At this stage of the operational sequence, it is possible to distinguish several roughouts corresponding to future *metae*. The work was always initiated on one side of the upper face before progressively extending it to the entire surface (nos. 63, 64 and 121). Lines produced by multiple impacts of pointed chisels are characteristic of this technique. At this stage, the lower faces are most often regularised and either slightly convex or left untouched. Three roughout fragments present a complete regularisation of the conserved areas of their upper surfaces (nos. 44, 129 and 130). The lower face of no. 129 is in the

process of regularisation, whereas this phase was already completed on its other faces (Fig. 12).

Finishing the surface and situation of the eye

The last phase of the sequence is recognised on the roughouts of nine *metae* and six *catilli* (Fig. 13). Initially, the upper side was finely carved with a pointed chisel before turning to the flanks. The eye of the *meta* was marked, but not perforated. In the cases of *catilli*, the hopper was carved, then the upraised rim along the upper surface's contour was hewn with a pointed chisel. The eye was only pierced during the final phase (Fig. 14). Of note is that no *catillus* roughout reveals traces of the carving of the lateral handle hole at this stage.

The number of abandoned roughouts for the phases of fashioning (31) and regularisation (44) is much greater than that of the finishing (19). This indicates that more roughouts suffered breaks and were abandoned in the early phases of work, while they were being hewn into shape, than during the subsequent finishing phase.

Conclusions and comparisons

The process of manufacture of querns and millstones at the site of Saint-Andeux began with the chipping of quadrangular blocks into rough cylinders. This preceded a phase of regularisation culminating in their final shape. Yet there is no evidence of the cutting of the eyes and the handle sockets. This technique is identical to that identified at other rotary quern and millstone stone workings. The findings of the study of the quarries at Saint-Andeux thus allow to define the different phases of millstone making and to define the operational sequence (Fig. 15).

An analogous operational sequence was identified at the quarry of Fossottes at La Salle in the Vosges (Farget 2006; Farget and Fronteau 2011). Furthermore, the detailed study of the puddingstone querns at the early Roman site of Avrilly (Normandy) also reveals an operational sequence that begins with the fashioning of the edges of the blocks into rough semi-spheres. This "preform" phase is followed by a stage of chipping starting from the edge before the future millstone is completely regularised and its eyed pierced (Guillier *et al*. 2005). Another production of puddingstone querns, this time in the United Kingdom and dating to the outset of the Roman Era (Green 2011), is characterised by the hewing of elongated blocks into slabs before a rough chipping (yielding large flakes). Here the work also results in semi-spherical roughouts. These were then regularised before cutting the eyes (Peacock 2013: 143). The production of reddish siliceous breccia rotary querns at Schweigmatt in the German Black Forest dating from the end of the Iron Age and the outset of the Roman period (Joos 1975, Anderson *et al*. 2003) also involved the chipping of detached rough blocks. The same can be said for the site of Marèze in southern France where Protohistoric and Antique cylinders were chipped yielding "bifacial, centripetal and abrupt flakes" before a phase of surface regularisation (Servelle 2011: 160). An analogous operational sequence was applied at the sites of Portus at Collonges-en-Charollais (Saône-et-Loire) (Jaccottey *et al*. 2011) and Saint-Christophe-le-Chaudry (Cher) (Gaultier 2011). Production at this last site is dated between the 1st and 4th century AD.

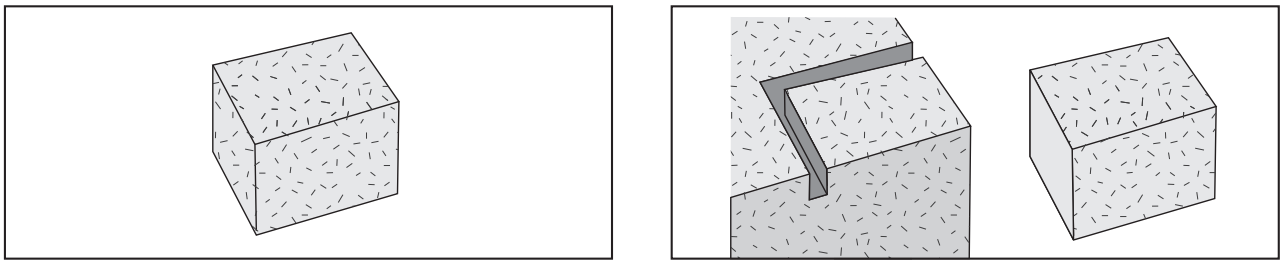
Another analogous example of this type of fashioning technique is gleaned from the examination of the roughouts preserved in the Museum of the Ephebe and at the villa of Embonne in Cap d'Agde (Hérault) in southern France. The list of quarries applying this type of technique is in fact very long. It is therefore obvious that the rotary quern fashioning technique observed at Saint-Andeux was widely applied throughout all of Gaul during the Late Iron Age and the Roman period.

Although the fashioning of rough blocks into grinding stones is a common technique, procuring the rough blocks serving for millstone making can be attained by a variety of methods. The different means of procuring the blocks at Saint-Andeux follows the typological classification of millstone quarries advanced in the doctoral dissertation of T. Anderson (2014, 2016). It aligns with two, possibly three, of the four major quarry categories: type MQ-1a, that is, fashioning millstones from surface boulders (or extracting them from large surface blocks; MQ 1b-1) and type MQ-2b corresponding to the fashioning of angular blocks detached from quarry faces (Fig. 15).

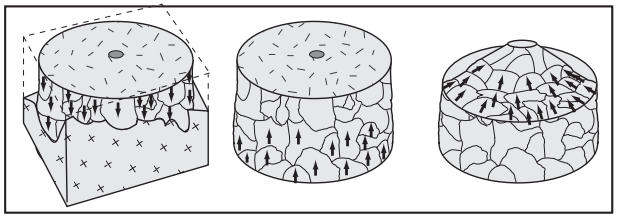
The exploitation of surface boulders (MQ-1a), a technique devoid of a true extraction process, is undoubtedly one of the most common means of procuring materials to manufacture querns throughout both Prehistory and Protohistory.The technique is identified by areas of the surface of querns retaining their original often rounded cortex. Certain cylindrical roughouts at Saint-Andeux measuring less than 40/42 cm in diameter were abandoned among the natural surface boulders of a blockfield in the vicinity of the quarries. These examples of exploiting surface boulders appear to date from the end of the Late Iron Age period or the beginning of the Roman period. This type of site is also identified by Jodry and Holderbach (2017) among the taluses at Purpurkopf near Rosheim (Bas-Rhin, Alsace) to score Gallic rotary querns. This technique is also possibly linked to a series of rotary querns unearthed on La Tène settlements in northern Switzerland carved from reddish breccia surface boulders from Schweigmatt in the Black Forest (Joos 1975). Yet another site exploiting surface boulders is that of Marèze in the south of France (Servelle 2011). Finally, on the Swiss Plateau, there are indications of the exploitation of erratic granite and schists to produce querns dating to the end of the Gallic period (Anderson *et al*. 2003; Jaccottey *et al*. 2009).

Block collected on the surface (MQ-1a)
or detached from a quarry (MQ-2b)

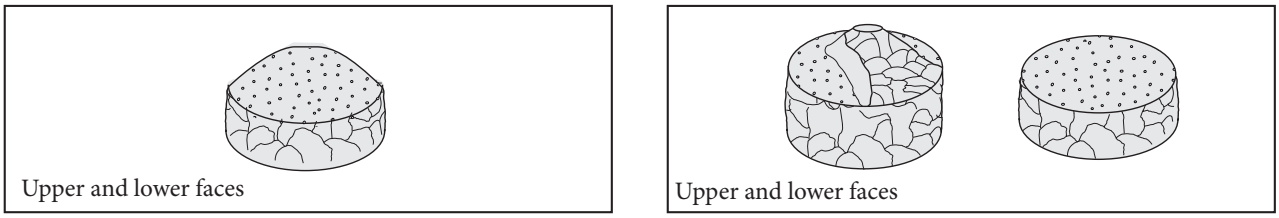
Block cut from a surface boulder (MQ-1b-1)



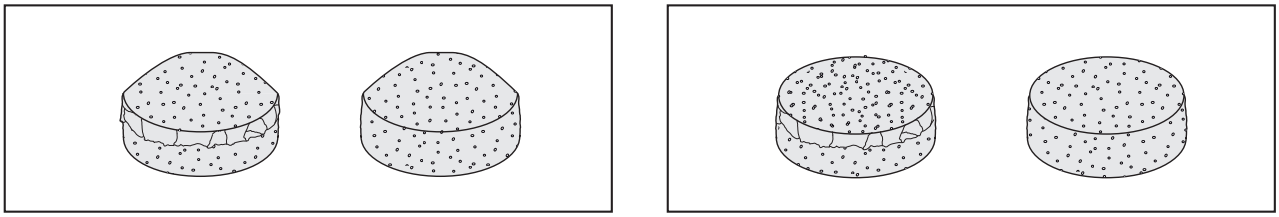
1. Roughing out: chipping into a cylindrical form



2. Regularisation of the upper and lower faces



3. Regularisation of the edges



4. Finishing

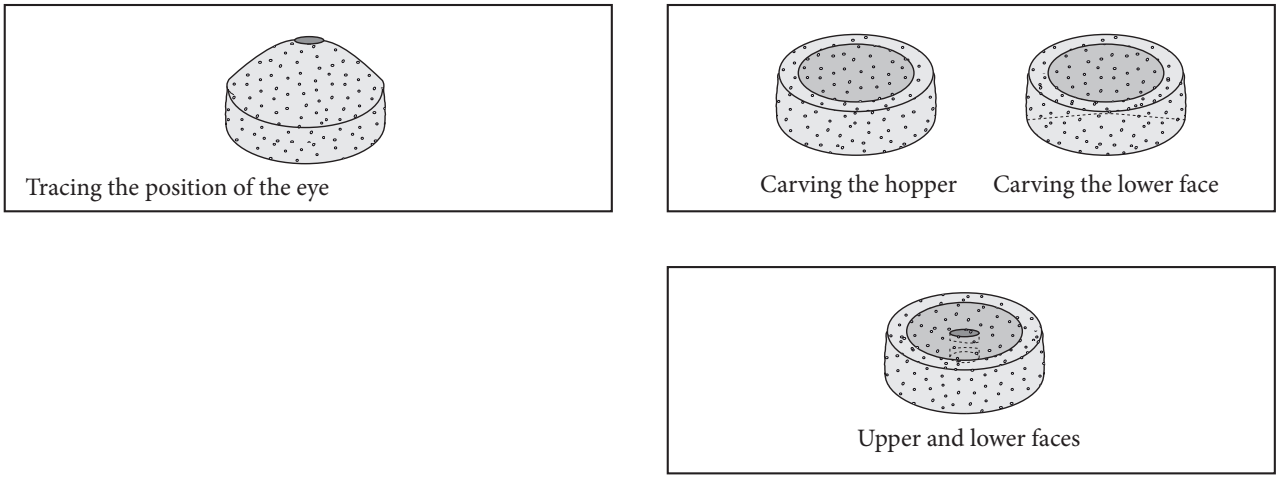


Fig. 15: Schema illustrating the operational sequence of the manufacture of vaugnerite rotary querns at Saint-Andeux (L. Jaccottey, INRAP).

The hewing of querns from surface blocks, as in the case of Saint-Andeux, therefore appears to be common at the end of the Late Iron Age and at the beginning of the Roman Era. This type of exploitation seemingly endured throughout the subsequent centuries, albeit in a more limited manner.

Production of millstones from blocks detached from quarries (MQ-2b) is equally recorded since Prehistory. Small quarries of this type for saddle querns dating to the end of the Neolithic or the Bronze Age were identified at Malange in the Serre Mountains in the north of the Jura (Jaccottey and Milleville 2010). Other similar workings containing many abandoned Iron Age saddle quern roughouts are recorded in the volcanic district of the Eifel (Germany) at Roßbüsch in the Municipality of Oberttingen (Hörter 1994: 14, 107). The same can be said of the productions identified in the surroundings of Mayen (Harms and Mangartz 2002).

Certain quarries also reveal evidence of the use of fire to facilitate block extraction (thermal shock). This technique is also identified for the Roman rotary querns extracted at the site of La Salle in the Vosges (Farget 2006; Farget and Fronteau 2011), at Saint-Christophe-le-Chaudry (Gaultier 2011) in central France and at La Marèze (Servelle 2011) in southern France.

Rotary quern roughouts at Saint-Andeux measuring between 40 and 42 cm in diameter are found for the most part near the quarries whose surfaces range between 30 and 60 m2, while those measuring between 43 and 52 cm are nearer the larger quarries extending over surfaces between 500 to 1000 m2. This pattern of distribution leads to the hypothesis that the smaller rotary quern roughouts of the end of the Gallic period and the beginning of the Roman Era were produced at the smaller workings, whereas the larger models, either hand driven querns or larger millstones driven by other more sophisticated means of traction (man, animal or water), hail from the more extensive and deeper workings.

In this sense, the rotary querns dating from the transition of the Late Iron Age to the Roman Era at Bois des Mouilles (Saint-Emiland) in the Morvan are most frequently associated with smaller quarries (Jaccottey, under study).

Unfortunately, besides Bois des Mouilles, there are few sites that serve for comparison. The partial survey carried out by S. Beuchot and V. Farget at Les Fossottes (La Salle) reveals certain pits on the plateau measuring from 2 to 3 m in diameter corresponding to an area of less than 50 m2. Yet Fossottes is characterised mainly by workings measuring 10 to 20 m in diameter equivalent to surfaces ranging from 300 to almost 1000 m2. This site first yielded saddle querns before turning production to rotary querns in the Late Iron Age and Antiquity (Farget and Fronteau 2011).

The quarries at Saint-Christophe-le-Chaudry measure an average of about 30 by 20 m, and a depth of 1 to 5 m (Gautier 2011). Extraction faces yielding rough blocks detached along fissures are identified in certain cases. Querns made of a material similar to that of Saint-Christophe-le-Chaudry are known among Late La Tène and Roman assemblages. Yet due to the absence of a detailed study, it is not possible to advance a more precise dating for this quarry.

One of the most compelling aspects gleaned from the findings of Saint-Andeux is the spatial distribution of its roughouts. The roughly chipped cylinders at the *Bois de Joux* are mainly found along the edges and inside the quarries, whereas those in the process of regularisation and finishing are for the most part in or near the concentrations of small flakes. These chipping concentrations associated with the surface regularisation phase are found beyond the quarries on the top of the mounds of working debris. This clearly indicates a spatial distribution of types of work with, on the one hand, zones of extraction and initial rough fashioning at the quarry itself and, on the other hand, peripheral workshops beyond the quarry specialised in regularising quern and millstone surfaces.

There exist analogous spatial work distributions at a few other extraction sites. Portus in Collonges-en-Charollais (south of Burgundy) comprises a group of quarries near small Roman settlements. The study of their roughouts combined with that of the chipping flakes inside the quarries and in certain sectors of the Roman settlement suggest that the first phases of the work were carried out near the quarries, whereas the subsequent roughout regularisation was carried out in sectors of the settlement a few dozen metres from the quarries (Jaccottey *et al*. 2011).

Another example is the Roman *villa* of Embonne at Agde (Hérault) were a building comprising two adjoining rooms enclosed many quern chipping flakes. The difference from room to room is that the flakes of the first were large while those of the second were small (Aris 1974). At Saint-Quentin-la-Poterie (Longepierre 2006; 2009), also in southern France, there is evidence of millstone fashioning workshops in rural establishments, including a *villa*, situated between a few hundred metres and up to two kilometres from the quarries.

This geographical distinction of working activities evidences an organisation of the grinding stone production separating the extraction and the initial fashioning phases at the quarry with the subsequent actions carried out in more suitable workshops. This distribution translates into a spatial separation of two different activities that take place at successive stages of the operational sequence.

This type of separation of tasks was observed during the excavation of the limestone building block quarry of Saint-Boil in Burgundy dating to the middle of the 1st century AD. The authors of the excavation of the site noted:

… de nombreux blocs étaient ouvrés et terminés dans la carrière même. Les travaux de mise en forme s'effectuaient pour la plupart à proximité des zones d'abattage et plusieurs ateliers fonctionnaient dans

la carrière, ou aux environs immédiats pour certains d'entre eux (Monthel and Lambert 2002: 103)[2].

Moreover, the quarry comprised a block sawing workshop in one of its sectors as well as a workshop specialised in sculpture (Monthel and Lambert 2002: 105). It is possible to speculate that the status of the craftsmen involved in sawing and sculpting the bolcks was higher than that of the normal quarry workers (Monthel and Lambert 2002: 113). These are therefore potential examples of the spatial segmentation of the different tasks of an operational sequence applied to producing building materials carried out by workers possessing different levels of skills and probably distinct social statuses. It is therefore possible to speculate that the process of quern and millstone making was likewise broken down into different workshops, probably with different craftsmen carrying out different tasks.

The surveys carried out at Saint-Andeux led to the discovery of about 100 rotary quern roughouts dating from the end of the Iron Age and the Roman period. The surfaces of several of these were completely regularised. The hopper (receptacle) and the upraised rim of the *catillus* were fashioned prior to the piercing of the eye. However no case reveals the cutting of the lateral hole intended to lodge the handle. Furthermore, of the seven *metae* bearing fully regularised active surfaces, there are only two cases indicating the piercing of the eye or traces of pecking the eye prior to carving. Similar findings are drawn from the studies currently underway of other Late Iron Age or Antique quarries in Burgundy such as Saint-Emiland, Tintry and Saint-Pierre-en-Vaux.

An analogous was observed at the rural Roman complex of Châbles (Fribourg, Switzerland) dated between the end of the 1st century and the beginning of the 2nd century AD. Of the hundreds of *grès coquillier* (shell-rich sandstone) rotary quern roughouts brought to light during the excavation, only one *catillus* bears evidence of the piercing of the eye and no case reveals a sign of the cutting of the handle hole (Anderson *et al*. 2003). The site's only complete *catillus* was unearthed in a nearby smithy. But it is of granite and therefore not a product of the adjacent quarry. Moreover, no *meta* roughout at this site bears traces of the cutting of the eye.

Eye piercing in progress or completed is observed only on three *catilli* at the quarry of La Salle (Farget 2006; Farget and Fronteau 2011). This site also has three *metae* with partially pierced eyes. Moreover, four *metae* and three *catilli* at the Roman site of Portus (Collonges-en-Charollais) reveal signs of total or partial eye piercing and no *catillus* bears signs of the cutting of a handle hole (Jaccottey *et al*. 2011). The five roughouts from Purpurkopf at Rosheim (Alsace) dated to the end of the Gallic period or the beginning of the Roman period also reveal that the active surfaces of the more advanced querns were not carved and that no eye was cut (Jodry and Holderbach 2014).

The different examples cited above therefore clearly demonstrate that not all phases of the *chaîne opératoire* of the manufacture of querns take place exclusively at the quarry. Although the first phase at the quarry can include carving the general shape of the future quern or millstone (i.e. fashioning of the edges and the active surface, carving the hopper and rim of the *catillus*), coarsely shaping its active surfaces and cutting the eye of the *catillus*, in no case is there evidence of cutting the lateral handle hole.

Moreover, the eye of the *meta* is cut only at the sites of the Portus and Fossottes, while none of the *meta* roughouts at the workings linked to Bibracte and Châbles bear evidence of this.

Despite these differences, a relative homogeneity appears among the extraction sites as to the progression of the operational sequence. All of the above notions highlight the interest of detailed studies of quern and millstone quarries such as that carried out for the workings at Saint-Andeux. Indeed, these findings indicate that the Late Iron Age and Roman workings exploiting vaugnerite were spread over a vast area (approx. 10 hectares). The inventory of querns and millstones (102) from Saint-Andeux's different quarries indicate that they were fashioned from either surface boulders or angular blocks detached from quarry faces either at small exploitations dating to the end of the Iron Age or from larger workings during the Roman period.

Although identification of the precise original extractive technique, before the phase of fashioning, remains unclear, the operational sequence points to a fashioning of angular blocks into cylinders by an initial chipping taking place directly at the place of extraction, before moving the roughouts to other workshops located a few dozen metres away to regularise their different surfaces before carving of their different features (rim, hopper and upper stone eye). Hence, the entire operational sequence does not take place at the extraction site itself. The millstones in fact leave the production area in the form of semi-finished products, as confirmed by the numerous discoveries of roughouts far beyond their quarries (Jaccottey *et al*., this volume).

2. Editor translation: "… many blocks were worked and finished in the quarry itself. Fashioning, for the most part, took place close to the extraction areas and several workshops operated in the quarry, or in their immediate vicinity"(Monthel and Lambert 2002: 103).

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