Chapter 8
Techniques of underground quarrying: 1. The method of working

The following chapter describes how and with what tools the useful freestone was extracted from the natural sequence of beds at the quarry face, and how the face was laid out for efficient working with respect to the needs of supporting the roof, getting rid of waste or spoil, and removing the useful stone to the surface.

The backfilling of worked-out areas with spoil at Combe Down meant that there were very few examples of the working faces left in progress and the associated areas visible to us, partly because the usual benched or stepped face was finished by being worked back to vertical. It has thus been necessary to relate archaeological observations to known methods used in similar situations elsewhere. Only two or three stepped or benched faces were observed at Combe Down, none of which had obvious relationships to the bulk of the workings. In some cases low faces may have been worked vertically, but on faces four or more metres

Fig. 8.1 Remains of a picking bed entry at top centre, about 0.9 m high in East Firs (Quarry 2205)

high, benches were necessary for both access by the workmen and the handling of the stone blocks. Steps were made either bed-by-bed, or in steps rising over several thinner beds. Use of cranes, in the 'experimental stage' of the mid-late 18th century and during their more common use during the late 19th century probably used large steps or benches, allowing the crane to be closer to the face. It is not clear if the steps were kept covered with rubble as a wearing surface on which to drag blocks (as a possible example in the Grand Canyon may suggest), or if they were kept clear of debris, as the two or three smaller examples suggest and as displayed in a fine and large stepped face seen remaining in Browns Folly, one of the Wiltshire quarries at Monkton Farleigh.

The organization and layout of the working faces – room and pillar methods

Except in the sense that every pillar is part of a working face, very few fully visible working faces survived intact at Combe Down, although the survival of the top two to four metres was not uncommon. In many cases this was because the worked-out face was infilled by spoil from another working area brought in by barrows, and in others the face had been partly reworked by pillar robbers who usually only took the upper part above or just below the spoil levels. Isolated examples of nearly-full faces included a stepped face in south Byfield of undetermined but probably late 18th-century date (see Fig. 7.8) and small benched faces in East Firs. Generally, however, they were only seen at the stage where they had been worked back to a natural vertical joint at the quarry boundary. However, sufficient was seen, which combined with information about quarrying methods elsewhere, to allow deductions to be made as to the methods of working.

Fig. 8.2 Jad slot near the top of a pillar to allow the bed above or below to be wedged out

The working area of all phases had several common features. At the top there was either a picking-bed cavity (in soft, poorly weathering beds of low value) made just big enough to enter (Fig. 8.1) or, alternatively there was some form of jad slot or notch (Fig. 8.2), either made so as to 'free' and allow extraction of the beds below. Below that was the face itself, during working usually formed in a series of steps to allow access, developed in 'rooms' between rock pillars intentionally left behind to support the roof. A typical reconstruction of the

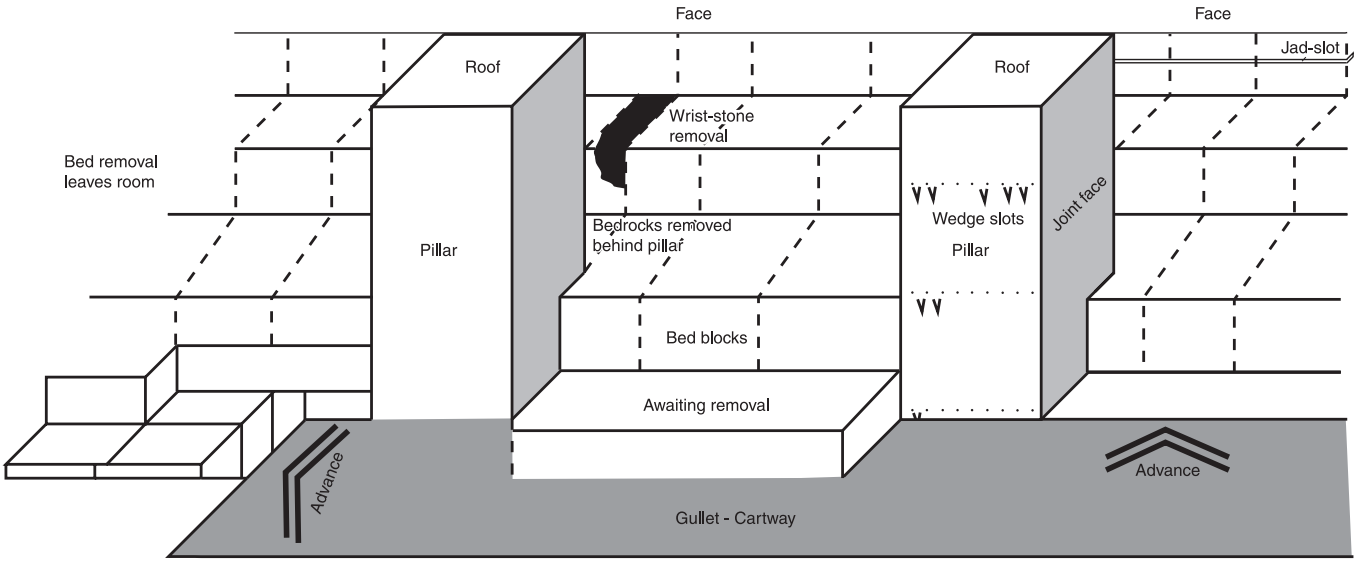


Fig. 8.3 Schematic illustration showing the development of the working face in benches to facilitate stone extraction

Fig. 8.4 Working on the steps of benches just below the picking bed of an abandoned face, Central Firs

layout is shown on the schematic diagram, Fig. 8.3. The beds below were progressively extracted to form the steps or benches that descended into a trench or gullet below the cartway or barrow-way level. The near vertical sides of the pillars were mainly natural joints, but otherwise the stone was picked or wedged (later sawn) off to form them (Fig. 8.4).

The working floor leading at the same level to the cartway was not at the bottom of the steps, but was formed with some of the waste or spoil produced, to a depth of approximately two metres. Blocks extracted above were slid down, while those below were hauled-up making handling easier. The working floor was used as space to drag stone, dress it and load it on to barrows or carts which were dragged back to the entry. This could all be very confined within a narrow gullet, or link to a worked-out area to provide more working space. In the case of Open Rooms, there was a substantial floor space. Any spoil other than that needed for the working floor was removed and stacked in worked-out areas, often at the back of the trench or gullet, held back as necessary by rubble-stone packs. Any space not used for working at the face or for transport was likely to have been used for spoil disposal.

Pre-Allen working (Phase I)

In the earliest undermining workings from an existing outcrop quarry, such as that seen at Horsecombe Vale (Quarry 2376), the opening passage was commonly made at right angles to the outside quarry face for a few metres, then turned left and right to form a passage behind the cliff face, using a gull or widened natural joint fissure resulting from cambering or landslipping of the strata, (Fig. 7.3) for ease of working.

From this the freestone was excavated as above described, to form rooms between pillars left for roof support again using natural weaknesses where possible to locate and form the pillars. The workings were usually developed inwards more or less equidistant from the entry (Pollard 1994). Spoil disposal, at least in the early crucial stages, was to the outside, forming a level working platform in front of the outside quarry, facilitating handling and transport. This led to a simple pillar-and-room system probably usually less than 3 m high including the thickness of any spoil left on the floors to form a barrow-way or cartway. Building-up of spoil behind the working face eased handling problems on higher faces.

This type of working was observed in at least two locations along the edge above Horsecombe Vale, and is also characteristic of some of the smaller apophygate pillar-worked entries of Phase I at Combe Down, except that it may have been necessary to drag the stone up an entry incline or slope to get it outside. Some rooms were left open to accommodate the most convenient routes for cart or barrow-ways and others were filled with spoil. Transport for both blockstone and spoil was probably all at one level.

Early Allen period working (Phase II)

The system used by Ralph Allen was characterized by a more systematic development. To open up more working places quickly and to assist in stone removal and ventilation, he developed pairs of fairly straight cartways, either in parallel or

Fig. 8.5 Apophygate pillar showing the area picked and broken-out at the top, with a small lip below where the freestone beds were removed (Quarry 505)

Fig. 8.6 Block of stone dressed in situ, showing the parallel jad slot used to free it

diverging out, with pillars and rooms developed between them and at either side up to two rooms deep (see Chapter 12, Case Studies 3 and 4). Cartway routes at this time had pillars 2.5 – 3 m apart, but their advance was done exactly as for other rooms. Typically rooms otherwise were around 4-5 m across but in the large underground quarry in Central and East Byfield (Quarry 505), the pillars became comparatively large and the longer spaces between up to double the usual length, with around 10 m and occasionally more between them. However, in the other direction, crossing the main joints, the spans were more normal with pillars 4-5 m apart.

In the majority of both Phase I and II workings, the picking bed was an opening including pillars of just under a metre high, and probably about five metres wide and deep (which is about a superficial perch, a very common measure used in the quarries) but had to be adjusted to the joint positions and any other rock weaknesses. The removal was done by first picking out a block of stone using a joint to start with, or by breaking with a hammer, after which picking or barring out of blocks was possible. The pillars left in solid rock were formed at the top using picks, so that the top was left spread out or apophygated, under the roof on all sides. In this type of pillar, the base of the picking was found marked by a small ledge or lip, from which the freestone below was broken out (Fig. 8.5). In this respect Allen appears to have followed the same practice as most of the previous, Phase I quarries.

As found nearly all faces seen were worked back to the final boundary at the vertical. However, the freestone beds, at his time as well as later, appear to have been extracted bed-by-bed, probably in steps descending to the front of the face, from the picking beds under the roof to the gullet or trench in the floor. By opening out a joint the first block of a row of them between pillars could be broken out after which the whole width of the bed could be barred out, or detached by wedging if tight, starting at the side of the pillar if feasible. By keeping the floor level, by dumping spoil, about two metres or a little more higher than the bottom bed, it not only helped dispose of spoil, but also meant both highest and lowest beds could be easily reached and the blocks dragged back away from the face. The level of the spoil was kept the same as the cartway back to the entry, which in Allen's Phase II workings was about 2.4 m from the roof.

The gullet was progressively filled with spoil as the system moved forward with a slope or a rubble pack holding it back. The side rooms were similarly worked both to left and right as the cartway advanced past their positions, probably opening the uppermost beds round the sides of the pillars while access to them was still convenient, and similarly behind the first row of pillars dividing to the left and right to form the next row of rooms. At the end of whatever extent was intended for quarrying, the beds were removed successively from the top layer down until the final face was vertical.

There was no positive indication found of linkage of picking bed cavities by a small opening or 'window' between them and adjacent worked-out areas, but unnecessary vertical movement of spoil was always to be avoided and some method may have evolved. When working in a room was completed it was generally filled with spoil, the workings near the entries particularly so, practically up to the roof.

Handling and moving the blocks of freestone released was only a considerable problem with thicker beds, and these could be cut into smaller pieces or dressed to size *in situ* unless the larger blocks were specifically required. Figures 8.6 and 8.7 show two examples of blocks *in situ* in a dressed state using two different forms of jad cuts used to free them. Most beds were fairly thin, below 30 cm thick, so were manageable, and thinner beds could be made into coursed rubble, suitable for the huge quantities of walling stone used at the backs and in partitions of buildings, especially in the mid 18th century. Larger blocks might be roughed-out to nearly the form required, for instance for lintels, reducing weight to be taken out. Where large blocks were specifically required, then timber slides and levers would be used to assist. The thickest bed generally seems to have been about two or three metres below the roof, so blocks from it could be slid or rolled straight on to a cart: it is possible the floor level was adjusted in height for this.

The probable advantages of concentrating on driving the cartway forward, as shown by the limited development sideways, were two. Rather

Fig. 8.7 Dressed block in situ showing use of a chamfered jad to assist removal. The use of the chamfered jad may be just the choice of the workman, but was probably mainly used for shallower depths

than 'fanning-out' the workings and utilising convenient rooms as a cartway, the cartway was purposely driven straighter, and, additionally, much greater numbers of working places were opened, though not necessarily being immediately worked. This was useful to cope with both the high production Allen aimed at and the peaks inevitable with the uncertain economic fortunes of the building industry. In the pre-Allen method the rooms were irregular and the route was likely to be far from straight. Under Allen, his fairly narrow pairs of fronts penetrated deep into the strata with straight cartways facilitating movement of carts from the quarry. The arrangement of two interconnected cartways provided much better ventilation through the quarry.

At some stage in Allen's time the use of picking bed removal was abandoned in favour of the face being holed at the top by the jad slot. This was not new, even at Combe Down, since the pre-Allen quarry 913 known as E4 Stub (Quarry 2347) and dated by graffiti and a clay pipe, had used this system before and after 1725. It is likely it was then familiar to Richard Jones, Allen's Clerk, as an apprentice there or nearby. The use of holing, locally called a jad, was an idea similar to, and possibly inspired by, coal mining practice. It involved cutting a long and fairly deep slot back to the next joint in one of the picking beds, perhaps two beds below the intended roof. This could be V-shaped notch or a slot with sub-parallel faces about 100 mm apart and could be up to a metre deep at Combe Down, depending on the joints. By inserting a wedge into the bedding plane below the bed below, the bed could be broken off back to the joint, or as far as the jad penetrated. The top bed under the roof was usually left slightly projecting, forming a corbel at the top of the pillar. This replaced the picking-bed-removal method, and also led to the rather laboriously picked out apophygate pillars being replaced with corbelled types with the projecting or corbelled top (Fig. 8.8). The corbel, like the supposed benefit of the apophygation, was probably considered to spread the load of the roof over a wider area, as did the apophygate pillar head. The freestone beds below could be then worked just as before.

This was probably a quicker method, and by apparently leaving one or two picking beds untouched in the roof, reduced the amount of spoil. Corbelled pillars were found either ahead of the apophygate pillars, or parallel to the cartway, but behind the (typically) first two rooms with apophygate pillars. Thus the side position shortened the travel distances back to the entries. The layout sequence was seen replicated in Central Byfield, Central Firs and in East Firs.

Adoption of new methods of organising the face layout

It is not fully clear why the system used in Allen's time changed, nor why two radically different systems were adopted. One possible reason is either that both the apophygate and corbelled pillars were defective in their design or that their

Fig. 8.8 Corbelled pillar in Firs Quarry (2201) Quarry Area 2211

design limitations were grossly exceeded, which will be covered in the chapter below on roof support. Several areas of the quarries with these types had either contemporary or subsequent collapse. The area east of the Avenue, for instance, with these pillar types had the largest number of 'High Hazards' found in the Hawkins survey (1994). A further reason may have been that after Allen died in 1764, the new lessees of the Estate included some who brought in new methods in an effort to increase efficiency. Both the Long Room and Long Wall with gullet-and-pillar systems had some clearly comparable features with methods used in coal mining in the 18th century (Flynn 1984, 82 *et seq*.).

Long Room system: Allen Estate Phase III working

This system was developed in Allen Estate times and was almost exclusively used in Central Firs east and west of the two Allen cartways and either side of the eastward spur (Quarries 2200; 2201; 2202). It was characterised by a Long Room developed along its length, rather like the cartway. However, unlike the cartway and its adjacent rooms, Long Rooms were developed in parallel with each other and their sides were often not completely divided into separate pillars, but had windows or doorways at a high level. It was a very systematic way of working, minimising the spoil-dumping problems. Particularly good examples were seen just west and north of the Firs Shaft (Figs. 8.9 and 8.10). Usually the rooms opened out from a cartway or a branch from it. The long sidewalls may have increased stability and led to improved spoil handling, but a disadvantage was the unworked stone found left in the side walls In East Firs, later 'pillar robbers' seem to have particularly favoured Long Room walls as the source of their stone, in one instance apparently removing the whole length.

The first Long Room in a sequence was developed just as a tunnel 4-5 m wide (Fig. 8.11). Because of the height worked it almost certainly used a stepped face with a gullet behind and a floor some 2 m deep in spoil at (or even higher to assist loading) than the outside cartway level. The next and parallel room used or formed windows and sometimes doors (rather like pitching holes in a barn) just below the jad-cut picking bed level, at intervals, into the earlier room, through which high level waste was thrown onto the former. already spoil-raised floor. Finally, as the stepped extraction system permitted, the windows were cut down between the new and old rooms, forming pillars between them. Accumulation of spoil may account for the windows found that were not created or fully developed into doors in the side walls to form separate pillars thus lowering the proportion worked. The process was repeated with the development of the next and adjacent Long Room.

Fig. 8.9 Long Room developed just west of Firs Shaft (Quarry 2200). Note the window in the left wall, and the almost continuous side walls and the end wall which would greatly assist stability

Fig. 8.10 Window used to dump spoil from the Long Room just beyond, north of Firs Shaft (Quarry 2201)

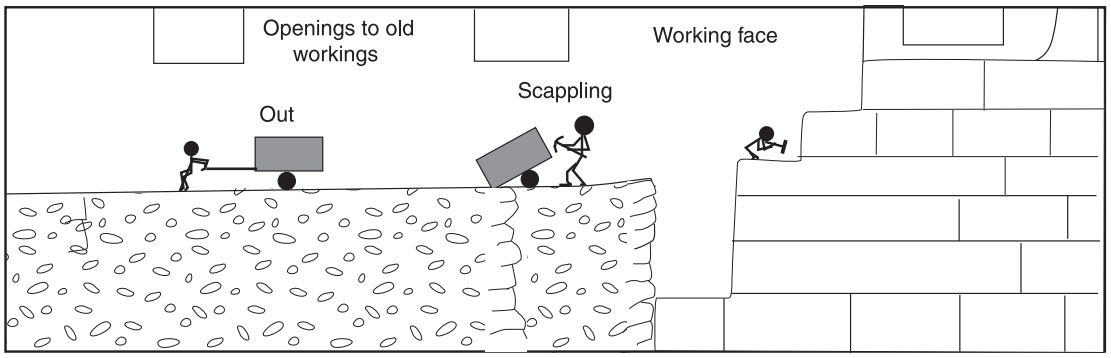
These Long Room areas seem to be associated with the use of cranes, and it is possible that the crane cable was used to drag stone from the face to the adjacent cartway or access. In Firs the cartway in the Allen Estate Phase III appears to have been somtimes at a lower level (with a greater height – 3-4 m to the roof), presumably to assist loading. The evidence for crane use was represented by the distribution of Lewis slots used as anchors and groove marks around and across pillars, used for the cables (chains) used to hold the mast. They are considered in more detail in the following chapter. The use of cranes, like the Long Room system, seems to have been limited, and it is possible the system did not fulfill expectations, perhaps because the space for cranes was limited and they required moving too frequently. The Long Room system seems to have been abandoned in favour of that described immediately below. However, in the late 19th and early 20th century a somewhat similar system was used with Open Room methods, and wider and higher rooms and with post cranes, leaving either solid walls alongside North Road or by leaving almost continuous 'boundary walls' between successive workings, as at Foxhill (see Chapter 12, Case Study 13).

Long Wall with pillars and gullet: Phase III to IV and later

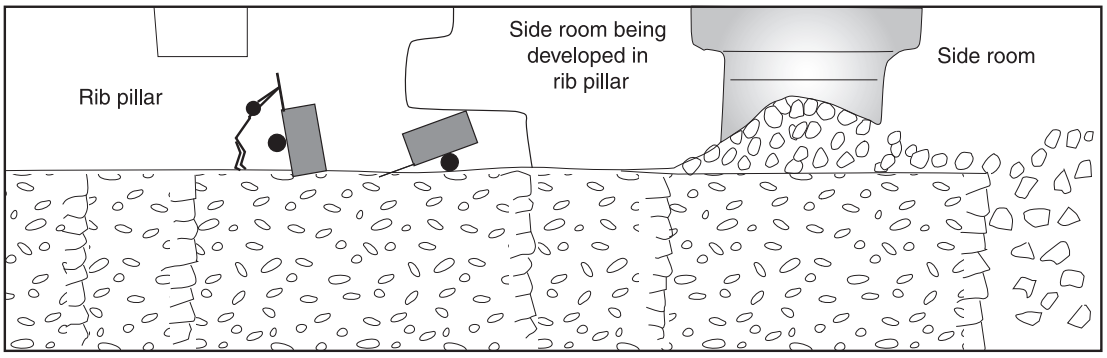
From its relationship with the Phase II workings, this system was apparently developed at almost the same time as the Long Room system, but at the western side of Central Firs. It has parallels in the hand-working of surface quarries where there was an advance along a long face, removing a thin strip of stone along the whole length, with only a narrow trench or 'gullet' between the face and spoil dumped at the back. A degraded surface example occurs in the 'rough' at the southwest corner of the Byfield area, close to Shepherds' Walk. Clearer examples survive near the northern end of the Isle of Portland. The difference underground was that pillars had to be left to support the roof so the gullet had to be wider to allow this. The 'type site' at Combe Down where this method was first identified was at a face in north Central Firs (Quarry 2224), though as usual at that point the face, at the apparent boundary pillar, had been worked to vertical (Fig. 8.12). The system minimised the loss of stone in pillars by their more regular spacing (and by leaving less stone between when compared with the Long Room system above) and both the distance of movement and manual elevation of spoil required was reduced.

The cartway or stone barrow-way into the area could serve both a four-metre-high gullet (the working trench area) and faces developed at right angles to either side, several gullets at suitable intervals as it progressed forward. In front was a stepped face with a jad slot continually being developed forward under the roof as the bed-blocks behind were removed. Pillars were formed between the

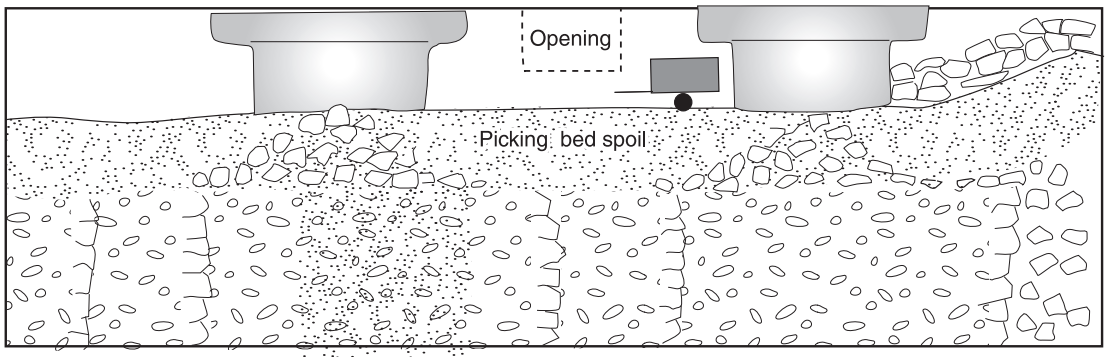
rooms being developed, using natural joints or by breaking using wedges, as distance and the joints required. Once beyond the pillar, the steps and removal of bed-blocks were continued behind the pillar as well, thus beginning the formation of the next room. The floor level in the gullet, at the same level as the cartway, was maintained using spoil from the working of the face. Thus blocks of stone from high on the face were slid or passed down, and those below the cartway had to be hauled up. Behind the gullet, which was kept wide enough for the barrows or carts used, along a length of some 30 to 40 m, was a continuously advanced bank of spoil, interrupted only by the rows of pillars left behind previously, and supported by a series of stone packs at the back of the gullet.



Long Room advances, rib pillar left at sides
Picking bed spoil goes into adjacent, former working
Working face and scappling soil forms advancing bank



Side rooms and pillar developed on retreat in rib pillar by older working
Side room spoil left in heaps across long room



Top layer area spoil from picking bed in adjancent, new working
Rooms are left nearly full of spoil, rubble thrown on top

Fig. 8.11 Reconstruction of Long Room working method

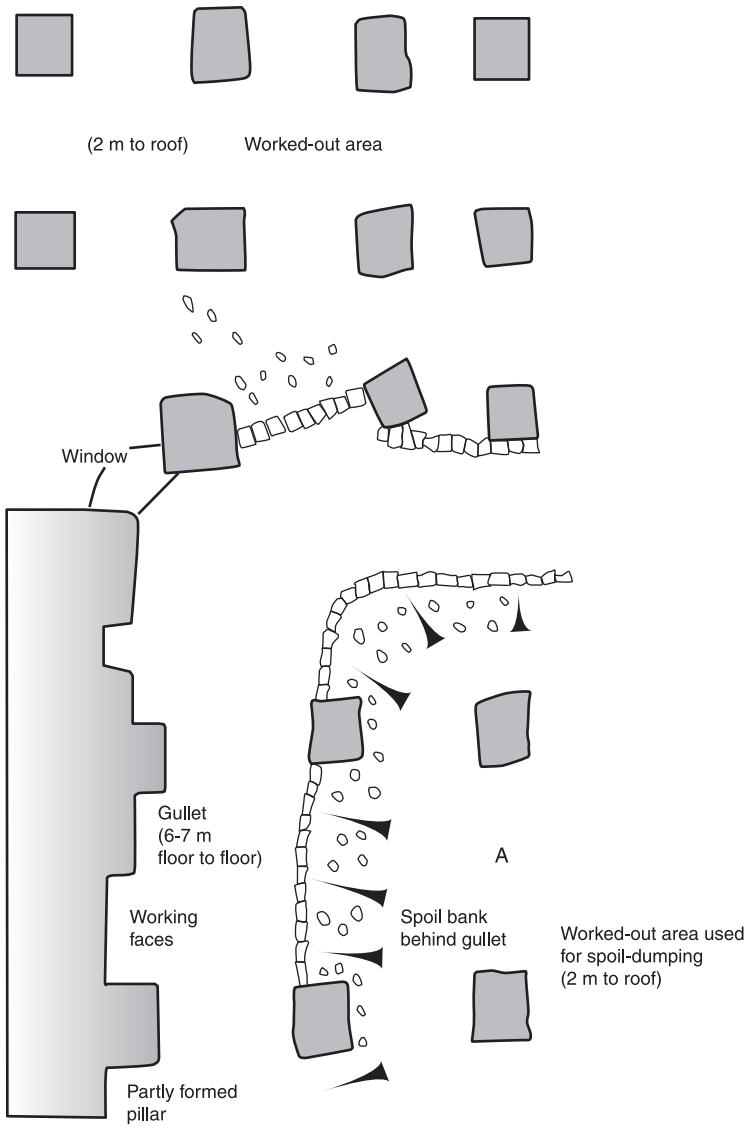


Fig. 8.12 Sketch plan of Long Wall, gullet and pillar working in Quarry 2224 in north central Firs. The area on the right (A) had been worked similarly, then was completely backfilled

Much of the initial spoil would have had to be removed as the long face started (into older workings elsewhere), until the first set of rooms had been formed beyond the gullet and pillars and the next set started. Then the set of rooms behind the pillars would form the new gullet and the old could be backfilled to a reasonable throwing-up height below the roof, typically 2 m or so. Thus a 6 m high face would have the lowest part some 2 m below the gullet, and behind the gullet spoil was stacked, contained by a series of advancing rubble walls to a height leaving 2 m or so open below the roof. High-level waste could be barrowed on planks over the gullet, or around the end on to the spoil bank behind the gullet, often being taken some distance away by barrows and dumped systematically to save space, but sometimes being just randomly dumped.

It was probably easier to work stone behind pillars by approaching from both sides and was substantially more economical in the labour cost of spoil removal by this systematic dumping, which involved some 40 % of the total material excavated. It also enabled easy supervision of several groups of men by a 'ganger', and made transport of the stone more systematic too as it was from the same area.

This multiple-face development was the dominant late 18th-century technique continuing into the 19th century and was, in slightly modified form, the technique used in the 19th-century Burgess workings in the Three Acre Quarry (2211), with continuous boundary pillars marking the end of each area of extraction and the starting position of the next, probably for stability with the high workings in such as Burgess' Quarry, which reached an extractive height of 8 m. This great height limited the capacity to throw material up the bank behind the gullet, and spoil management systems had to be developed to cope with lifting

the extra two metres or so. The width of the gullet tended to be wider as the ceiling or roof height increased and the stepped area necessarily became greater to maintain a safe angle, so that planks across the gullet became less practicable. However, barrows could be moved around the ends of the gullet and, by use of inclines from the bottom or middle, to gain access to the dumps. The complexity of this is discussed for the Grand Canyon area (Chapter 12, Case Study 9). This same area had a face worked high up with a bank of rubble which may have covered the steps below. It was, unfortunately, not entirely clear whether the blockstone was dragged down on the bank of rubble to a barrow-way at the bottom or if some other mode of moving it was used.

Open Room working: Mid and late 19th century, Phase V and VI

This mid and late 19th-century development was designed to accommodate the use of cranes and winches underground to handle stone. It was partly made possible by either a reduction or better management of spoil. This had begun with the development of jad slots and, as the depth of freestone worked increased, the proportion of waste fell and the overall space available increased, in addition to any left from a previous phase of working. Use of more precise cutting of pillar faces using rows of wedge-and-chip breaking and sawing of faces also contributed (see below). It is also possible that all mining areas of the main Combe

Fig. 8.13 Open Room working area in Byfield Quarry (518). Cranes and winches were used to drag stone away from the working face across the floor. (Photo by Paul Deakin)

Down complex by the mid 19th century had plenty of adjacent older workings to accommodate spoil outside the current working areas. The system still had to use stepped faces to gain access but these could be steeper with use of crane or winch cables to haul blocks up or down to loading level. Given more room, loading could be done well back from the face by a simple crane lift.

In Open Room working, the floor was still built up of spoil behind a gullet as before, to be at the same level as the cartway, and was kept level by maintenance and by the dragging of blocks over it. Wider spaces resulted from keeping the spoil further behind the actual working area, and, where possible by greater spacing between pillars. Initially, since these workings were all surrounded by older worked-out areas, it is likely most waste was removed into the older workings until the need for handling room exceeded the space available. Typically the width between pillars was increased, requiring large numbers of timber sprags (locally termed 'scorters'), positioned from near the tops of pillars to the roof to tighten roof blocks against each other and possibly to reassure the quarrymen. Boundary pillars may have been carefully preserved and even buttressed by leaving rock at an angle to them, to add stability to the local area. Substantial open areas of some 10 m or so across seem to have been possible, sometimes with such two areas at right angles (Fig. 8.13). Some spoil dumping could still take place at high and intermediate levels into adjacent areas, but with lesser amounts it seems to have been possible to barrow it up on smaller and gentler inclines to flat-topped, bench-type spoil dumps within the worked-out areas as they became available. In many respects, the working underground was again following the methods used at surface, where hand methods had for a long time been supplemented by the use of stayed or Scotch derrick-type quarry cranes. Standard cranes of both stayed (using cables and Lewis bolt anchorages) and post-types were used, the latter becoming the norm. Winches, probably of the cast iron crab-type were also used for dragging, secured by chains and iron pins back to the wall. Cranes and winches are discussed in the following chapter.

Later Long Room working: late Phase VI and Phase VII

At Shaft Road and at the Foxhill workings, post cranes were used in conjunction with narrow-gauge railways to handle the stone blocks produced. This was done in large, very Long Rooms, 10 m and more in width. The usual stepped face was used, with a gullet behind, and a bank of spoil forming the railway foundation behind that (Fig. 8.14). Other spoil was stacked at the sides, so the railway effectively ran in the trench between. The crane was sited on the spoil bank, with the post inserted into a heavy stone block on the floor, and into a square chog hole in the roof. Blocks could be dragged some distance from the face, so the crane could stay in a single location for some time. Other cranes may have been used in conjunction as stacking cranes or to facilitate the transport of the block further towards the surface with the aid of further crane haulage. The railway was brought up behind the crane. Previous crane positions were obvious from

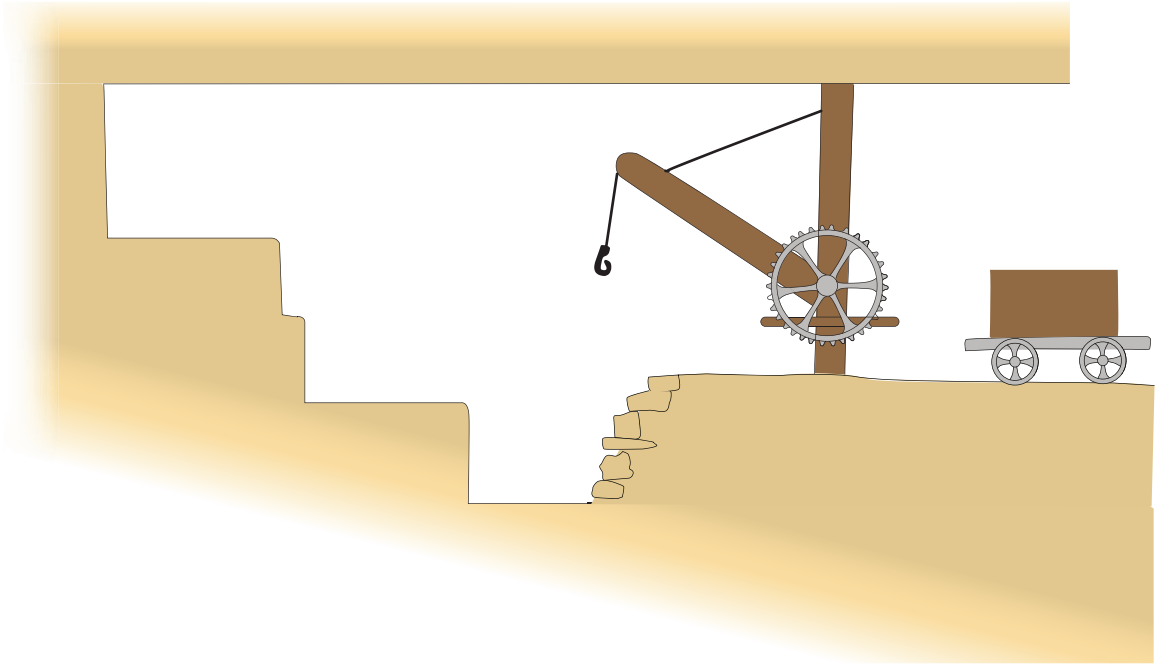


Fig. 8.14 Late period Open Room working method, showing use of a post crane to pull stone blocks off the face and load them on to a flat wagon (after Wooster 1978)

the chog hole in the roof. At Shaft Road two rooms ran parallel, a thick continuous wall between them except at a junction. At Foxhill, four separate Long Rooms (worked by three different ventures at different times) had boundary walls maintained between them. This method appears to be a modified Wiltshire practice.

Features on working faces

Picking bed removal

This was particularly used with forming apophygate pillars in Phases I and II. However the use of full picking bed removal continued until much later in some workings, notably in the quarry owned by Hulonce in West Byfield in the early 19th century, where it was combined with the jad slot, which more generally replaced it, in order to break into the picking beds. Evidence of its survival in the early 19th century was also seen on pillars in north Central Byfield, for example, some of which had been penetrated so deeply that they required stone packs or a timber props to support the roof (Fig. 8.15). In these later cases personal idiosyncracy of the quarrymaster involved was probably the key factor.

It seems possible that about a square perch of ground ($5^1/_2$ yards or 5 m square) was freed at a time as this was the common measurement used in calculating the value of stone recovered, but the actual size would depend on the weaknesses found in order to locate and leave the pillars. Though very few marks remained on the apophygate pillars, due to their tendency to spall, enough remained to show the intended pillar tops were carefully formed using picks with inch-wide blades, to either form an arch in some early examples, or alternatively to allow the top to bell-out, so as to provide a slightly wider area of support under the otherwise flat roof. It seems likely this particularly skilled work was done by a specialist part of the workforce almost certainly on some form of piecework since occasionally the area removed had been marked out by black lines indicating measurement.

Jad slots replacing picking bed removal

Jad slots were in use in pre-Allen workings *c* 1725, but the use then seems to have been isolated to one quarry under the south end of The Avenue. The advantage of the jad slot was that it produced much less spoil and generally only one or two of the picking beds was removed. The change was sometimes marked by an entablature between pillars at the transition between old and new methods, with the roof one or two beds lower on the newer side. The introduction of jad slots was associated with corbelled pillars (below), but they were later similarly used with direct pillars. In both cases the slot was driven in leaving a bed *in situ* below the roof, presumably to avoid damage to the workmen's hands, but in the latter case a wedge was driven in under the roof to bring down the upper bed so it was in line with the side of the pillar. The wedge often left a small mark where it was driven in (Elwyn Davis' observation). Occasionally wedge-and-chip splitting was used with roof beds stuck together with calcitic flowstone, the marks of which were seen in East Byfield and particularly in the underground Springfield Quarry workings.

The jad slot generally formed the first access close to the roof, what was, in later times at least in the Wiltshire Bath Stone quarries, referred to by the

Fig. 8.15 Stone used to pack up the top of a pillar where it had been intruded upon by the picking bed, east Firs

quarrymen as the 'breach' across the width of the room. In some cases, in what we termed chamfered jads, it was a wedge-shaped (flat-bottomed) or notched horizontal slot usually utilizing a bedding plane weakness and driven in until it met a vertical joint (Figure 8.16 shows working methods and terms used at the working face). Usually, the depth reached does not seem to have been large. The more conventional jad slot as used in 1725 (above) became routine after about 1750, usually by then with the more economical, parallel upper and lower surface. It was some 10 to 15 cm high and could be up to a metre or more deep although, at Combe Down, again because of the joints, it was generally substantially less. Vestiges of jad slots were mostly seen on pillars, but in a few areas, were found as continuous or semi-continuous slots across long lengths of a working face (Fig. 8.17). Variations in slot heights appear based either on local geological factors or personal preference, and perhaps the techniques required for extracting any given block efficiently, rather than development through time. Several different heights or types of slot could be used in a single quarrying area and across several periods. In later working, the jad slot was made wide enough to insert a narrow saw called a razzer,

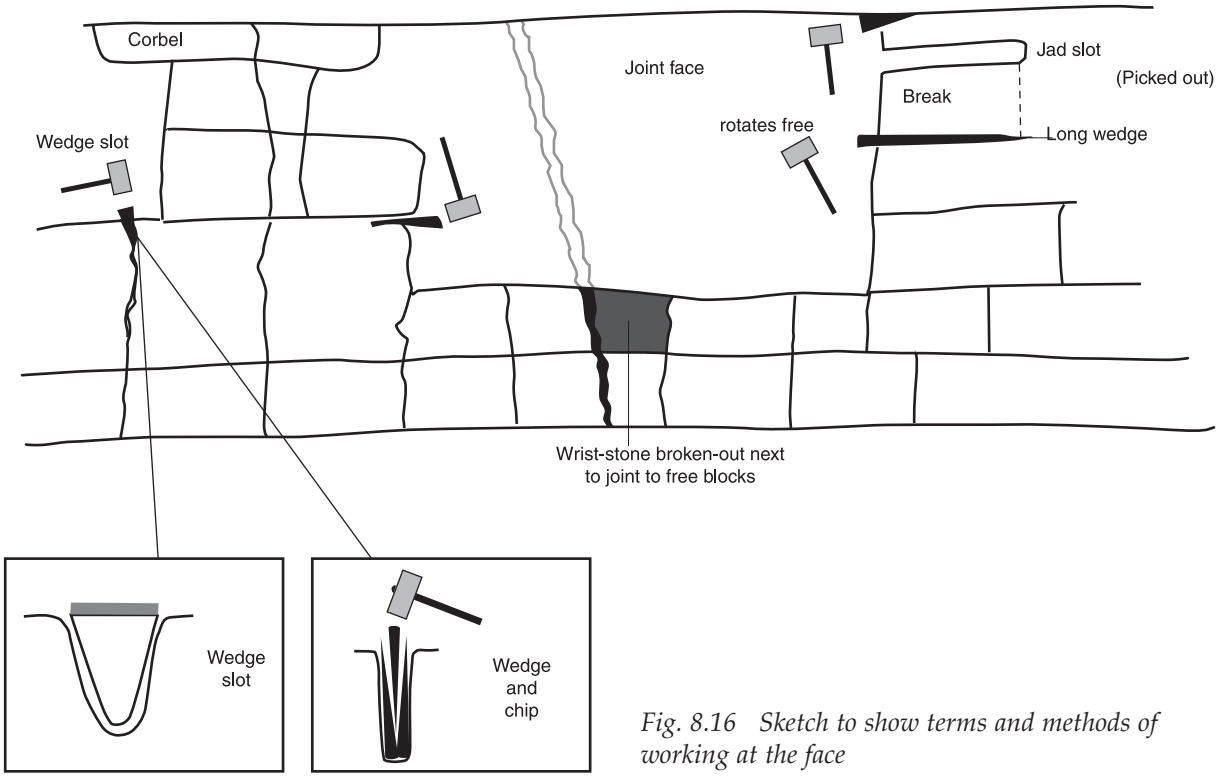


Fig. 8.16 Sketch to show terms and methods of working at the face

Fig. 8.17 Continuous jad slot across a face

until the saw cut allowed a regular frig bob saw to be inserted.

The jad slot was less labour-intensive than picking bed removal. There is some possible evidence, notably in southern Central Byfield that the two methods overlapped for a time with some pillars displaying one apophygate side and one corbelled.

The use of the term jad also refers to a tool, a 'jad' or 'jadding iron', a substantial bar with a wedge-like end. It was used to pare off upper or lower surfaces to keep them roughly parallel, or to square off inaccessible corners inside the back of a jad slot. The use of the term in relation to the horizontal 'jad' slot and the vertical or 'upright' jad or jad cut, within the context of the archaeological survey at Combe Down (so to easily distinguish the two types during recording) is somewhat anomalous in that most of the feature seems to have been cut by a horizontally swung blow of the pick in line with the length of the slot. The vertical rear ends of the slots, which survive on pillar faces, thus have rows of pick marks that can be attributed to the curved path of the pick blows. A description of this, as used at Box in Wiltshire, notes the long-handled pick, at the instant of impact, was dropped and then drawn out (Raymond 1870, 482), the dropping presumably to lessen the shock of impact on the quarryman. The tool-marks left by a jadding iron reflect blows delivered straight at the rock, usually on the underside of the cut, and have a different orientation, normally at right angles to the length of the slot (Fig. 8.18).

Price (2007), referring to quarrying near Cheltenham, cites a man as able to cut 13 square feet of jad slot a day (about 1.2 sq m) but in the context of the soft picking bed and shallower jad slots at Combe Down, substantially more than this would probably have been expected. The regularity of such work was probably an indicator of the skill and efficiency of the operator.

Cutting down the face

Cutting out of the stone either bed-by-bed using wedges or, especially next to pillars, by using long vertical cuts down through the beds was first done by picks or by wedges (Fig. 8.19 and 8.20) producing what we termed wedge pits to particularly distinguish this use. Later, in the early 19th century, within a very limited area of West Byfield, such vertical cuts (see Fig. 8.21) were extensively used and also termed jads (we used the term jad cuts to distinguish them), leaving curved pick marks on the full height of the pillar faces, and starting at about the same period, by use of saws (Fig. 8.22). Jad cut features, were sporadically evident elsewhere through the Combe Down Quarries. The earliest example was noted in the Stub E5, Quarry 2348, which is thought to have been worked contemporaneously to or just after the Stub E4 Quarry 2347, which was being worked in around 1725.

Fig. 8.18 Underside of a jad slot showing pick marks at the rear and jadding iron marks

Fig. 8.19 Wedge pits left in situ, East Firs

In the bed below the picking bed, between each pillar, either a natural weakness was widened by use of a heavy pick, or a wrist stone (Fig. 8.23), a convenient bed-block between joints, was removed by wedging and hammering to allow subsequent removal of adjacent blocks either side. Ideally a suitable joint could be located next to a suitable pillar position and the beds to be removed were worked from there. This continued until the whole exposed beds at a particular horizon were removed except at the pillars. At Combe Down the presence of wide gulls and joints sometimes made this particularly easy, especially near the outcrop.

Fig. 8.20 Wedge pit impressions left from cutting down a pillar

The substantial amounts of spoil produced by this breaking, and the subsequent squaring or scappling of the blocks, was removed and dumped as close to the working face as possible to minimise effort. Most of the stone sold (to judge by the contemporary buildings in Bath) was fairly easily-handled coursed rubble, but more substantial blocks had to be lifted, barred or dragged down onto or just above the gullet floor. Very large blocks, notably from the bed below about 2 m below the roof were slid or, sometimes, rotated out possibly directly onto a wagon positioned at the appropriate height next to it; scratch marks from re-working within Quarry 2202 show at least one example against the northern boundary pillar of an earlier Quarry 2201. After trimming of the smaller rubble or blocks, and squaring or scappling the larger, using a heavy scappling axe, the product was placed on barrows or carts for transport to intermediate stone storage or finishing areas or alternatively straight to the entry and onwards.

This somewhat crude system of block removal was assisted and somewhat refined by use of wedge pits using a wedge-and-chip technique and, in the

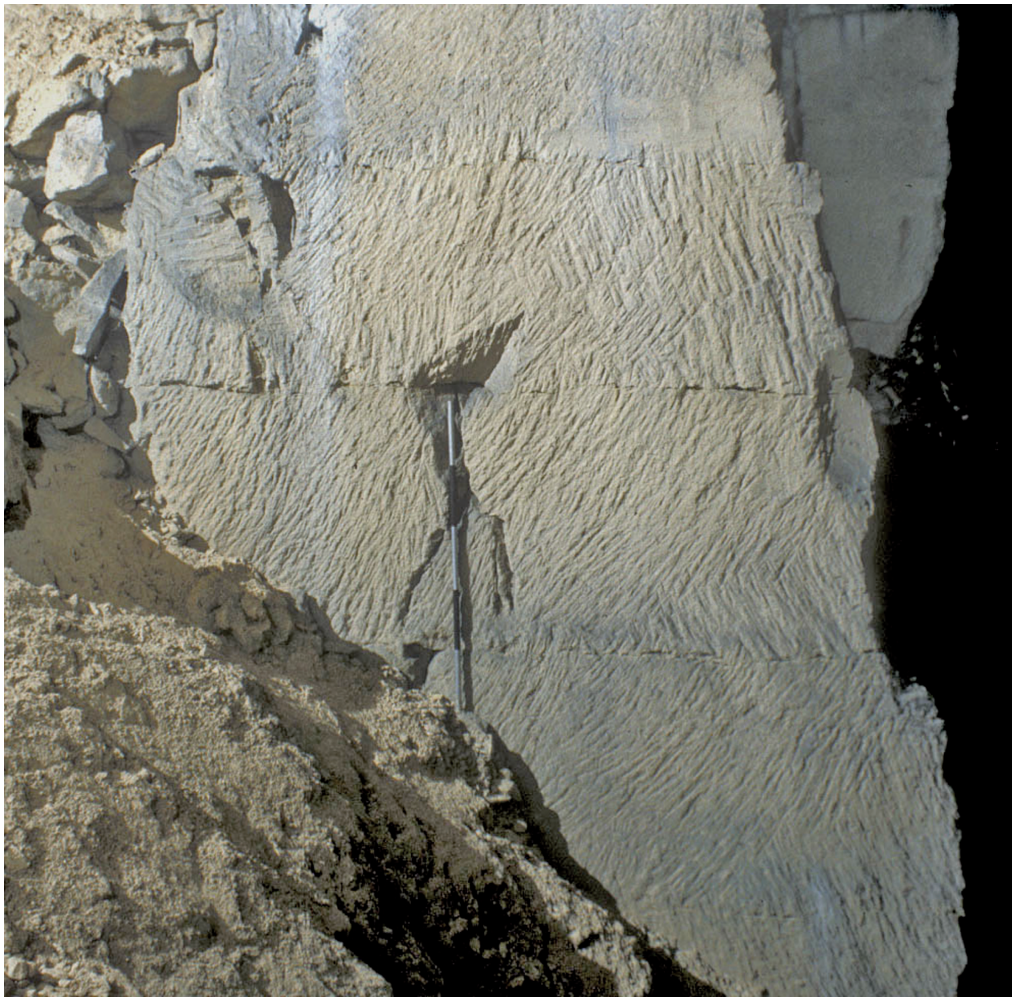


Fig. 8.21 The jad cut, used to cut down the side of a pillar, West Byfield

Fig. 8.22 A saw-cut pillar, mid-late 19th century, north Central Firs

late century onwards, their systematic use in groups was visible on pillars. By the early 19th century the efficiency of operation and the amount of spoil was also reduced by using either a jad cut or by using a saw, in either case usually forming one side of a pillar. Natural joint faces, however, remained common on other sides.

Working floors and storage areas

The existence of a flat and reasonably smooth floor, back from but still close to a working face and at the inner-end or next to a cartway, is an indicator of activity where either the crude blocks cut from the working face were trimmed or scappled with an axe

Fig. 8.23 The gap left by removal of the wrist stone, freeing adjacent blocks for removal. In this case the removal was probably part of the re-working of old pillars, Central Firs

Fig. 8.24 Stacked wrought stone, produced by a banker mason, East Firs

into squared blockstone or, in a few cases was used as dressing floor where stone was wrought or finished ready for building by banker masons. Stub E4 (Quarry 2347) and several places in east and Far East Firs, all quite small quarries had modest amounts of wrought stone stacked or on the floor and in these instances it is suspected the operator was primarily a banker mason rather than being a blockstone producing freemason (Fig. 8.24). Block stone was a rare find, with two sets of finds in Byfield and one in East Firs – the rarity suggesting perhaps it was usually trimmed near where found and it was then immediately carted out. It was perhaps because the Combe Down stone needed no drying before weathering, that the large over-wintering underground dumps of blockstone found in the Wiltshire underground quarries did not occur at Combe Down, though the space adjacent to the cartway near the Arched Shaft under Firs Field (Quarry 2211) may have been used for storage (Fig. 8.25). In later workings, using the Open Room method, much larger areas of floor were kept clear, but there it was probably for handling by winch and cranes.

Dressing areas for wrought stone usually had clear and well-trodden floors, sometimes with neat heaps of waste fines and chippings. All seem to have been associated with nearby working faces but again these were few. This waste, sometimes with broken carvings or mouldings, is termed 'banker waste'. Typical products were stone copings, but a wide range of mouldings were also recovered (see Shaffrey 2009). Effectively these were masons' workshops and at least two (adjacent to John Scraces Quarry (510) and Quarry (2219) under Stonehouse Lane, displayed an extreme neatness, quite unlike the rough and ready general working areas. Dressing floors as part of the working faces thus were unusual and all small-scale. For larger-scale operators the surface dressing floor appears to have had the advantage.

Toolmarks

Toolmarks provided important evidence for extraction techniques, and associations of toolmarks were often the best indicators, indeed, often the only way, of seeing how tools and other equipment were used. For the early-mid 18th century, however, the evidence (except in the E4 early workings) was slight. Hammers may leave curved shatter faces, but very few crush or prying marks were left from levering blocks clear, partly because, once the wrist stone was removed, the open jointing made other blocks easily removable. This lack of evidence was also due to the archaeologists never seeing the lower parts of early pillars and to the tendency of the contemporary apophygate pillars to spall, thus losing the original worked surface. The replacement of apophygate pillars with corbelled pillars and later, direct pillars left far more traces and from then onwards, tool marks were frequent and relatively easy to diagnose.

Fig. 8.25 Possible stacking area for blockstone in Central Firs (Quarry 2211)

Use of the scappling axe and hacks (and picks)

The scappling axe, of which an example was found, was a double axe, which took the form rather like the modern pick axe, but with the cutting-blade end in line with the swing of the tool. Scappling usually described the trimming of blocks to square them, forming blockstone. The scappling axe was, however, also widely used to roughly trim back the rock at corners of pillars to allow carts to pass, or to allow insertion of a saw or to widen or form a jad slot under the roof. They yielded characteristic wide 'chops' or blazes on the rock face (Fig. 8.26). Hacks were a similar tool except that the blade was at right angles to the swing, and left an indention cut the width of the tool on the surface. Although the term 'hack it back' remains even now in common use, the use of the hack, especially the narrow bladed (up to 2.5 cm) types, seems commonly to have been referred to as picking, though technically the pick is pointed. Many jad slots used the hack as well as the pick, though which can be easily identified. The most common form of pick type recorded at Combe Down was a flat-ended pick that had a width of 1-1$^1/_2$ inches, with the toolmarks often evident in the rear or the back of the jad slots. The narrow ended pointed pick was used in later quarrying after about 1870 and was usually still associated with the creation of a jad slot, but generally with a higher jad slot also for the subsequent insertion of a saw.

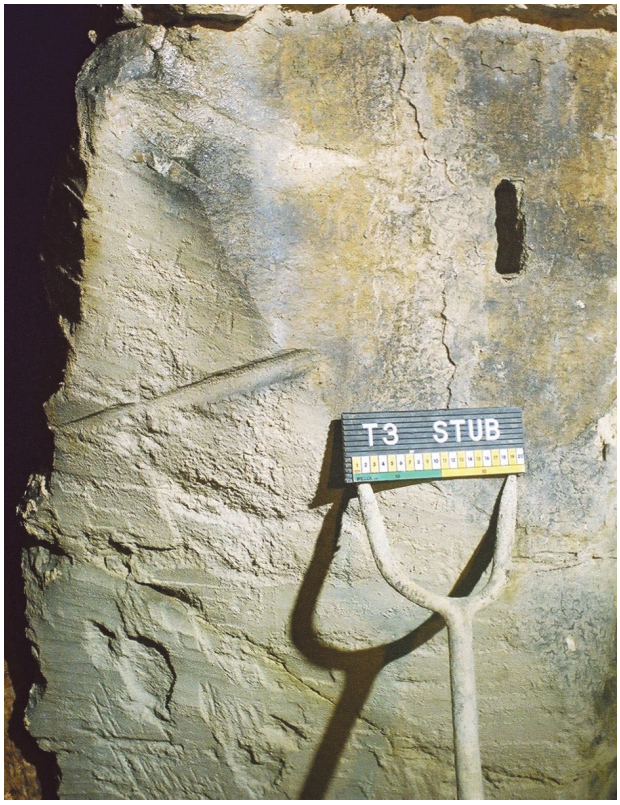


Fig. 8.26 Marks left by a scappling axe on a face, with wedge slots, south-east Byfield

Use of wedges

The wedge was either a fairly heavy, tapered iron tool (more sophisticated forms had a steel core) which could be driven using a sledgehammer into a joint or bed to lever them apart (above or below a jad slot), or the smaller more lightly constructed wedge-and-chip used in a pre-cut pit to split solid blocks. Various types of wedge holes (used as a generic term where a specific use was not determined) or pits (used with pit and wedge) or slots (used as anchors or to support a plank) were found with different uses. The terms for wedge pits etc. were necessarily used by us in absence of an established terminology to differentiate types, but as used here are not historically accurate and, for instance, Bath Stone quarrymen referred to the wedge pits as 'wedge holes' from the 19th century at least. A wedge hole is a hole made for a wedge and chips to fit into, in order to break out stone (Keith Palmer pers. comm.). As a young man Palmer worked with the last generation of quarrymen to use wedges and chips (Pollard pers. comm.).

The term 'wedge pit' was used during the archaeological survey to describe a triangular shaped slot, placed vertically or, more rarely, horizontally, into which two thin, trianguloid iron chips were inserted and a central wedge hammered in (see Figure 8.16) to break stone blocks from pillar faces, to lever a block from its bedding plane or to break ('rap') down the first bed of stone below the roof level and above a jad slot. The two slightly tapered chips were inserted in the pit with the thickest part at the base, then the thin wedge was driven down between them, exerting lateral pressure at the long sides. The pits were generally *c* 100 to 150 mm deep with parallel sides about 25 to 30 mm apart. These features were found in nearly all the quarries.

The use of chips, the commonest found iron artefact (see Scott, Chapter 11), was probably necessary because of the softness of the rock, spreading the taper effect of the wedge evenly over a much wider area. The slots were frequently recorded on pillar faces, mostly on the perpendicular faces set to the principal joint structure, and close to, but not aligned on, the secondary joint structure. They, along with many other tool-marks, are generally absent from the natural face of the principal joints, which usually required no additional working in order to extract the stone adjacent. Chip impressions left by this process were fairly common within the quarries but wedge impressions were less common because the wedges were placed between the chips and often had no direct contact with the face or the roof. However, in some places the wedges were driven beyond the limits of the wedge hole into the solid rock face, leaving a scar or impression at the base.

The evidence suggests that the wedge pit was not commonly used in the mid 18th-century Ralph Allen quarries (Phase II), an impression that is

slightly ambiguous, as in fact, very few tool-marks of any kind survived on apophygate type pillars in Byfield Area (Quarry 505) and were apparently almost entirely absent in the Firs Ralph Allen Quarry Area (2200) where the pillars were well-preserved and any such marks would have survived. They were used more frequently during the Ralph Allen Estate (Phase III) periods based on evidence from Central Firs between Quarry Areas 2200 and 2201. Examples of wedge holes were found on pillar faces, in one case several being used together to split a block from its bed (Fig. 8.27). Wedges in combination with jad slots and barring seem to be the primary extraction method used during the late 18th century at Combe Down leading to greater regularity in pillars. This continued in during the 19th century, only diminishing in importance after the use of the frig bob saw became routine.

Some more complete examples of wedge impressions were found on the quarry roof and regularly survived better than examples on worked pillar faces, because they were unaffected by subsequent quarrying as extraction progressed downwards, were less impacted by subsequent later scavenging of pillars, and more importantly were more visible as they were not covered up by dumped spoil. Wedge pits and chip impressions within them were noted in only two early 18th-century quarries in the Firs and a number were recorded on the roof of the 1725 period E4 Stub Quarry (2347), with only a single example on a pillar face. Wedge-and-chip 'rapping down' was, however, used extensively at the late 18th-century Entry Hill underground quarry (Fig. 8.28) where the orientation of the wedge pits, in combination with the orientation of infilling with waste, allows inferences to be made about the directions of working.

Isolated groups of wedge pits were observed where blocks were removed from awkward places – around the tops of the pillars and in areas where the roof was bonded to the beds beneath, usually by calcite. They were sometimes driven in tandem to remove the same block, or singly in a progression of working across a quarry. In places, wedge pits faced each other and seem randomly placed, in others they illustrate how a temporary supporting pillar was circumvented and subsequently removed.

Working between pillars would have destroyed countless wedge impressions created on faces during the initial stages of work, and the impressions left on corresponding removed blocks would have been removed during finishing by sawing and/or scappling. However, a number of blocks which had been discarded as unfit for use bore single or multiple wedge holes. These were recovered from barrow-way surfaces and noted in banks of spoil. A large block (SF 753) had been abandoned on a barrow-way in an early 19th-century Firs Quarry (2203). The block bears the traces of two $5^1/_2$

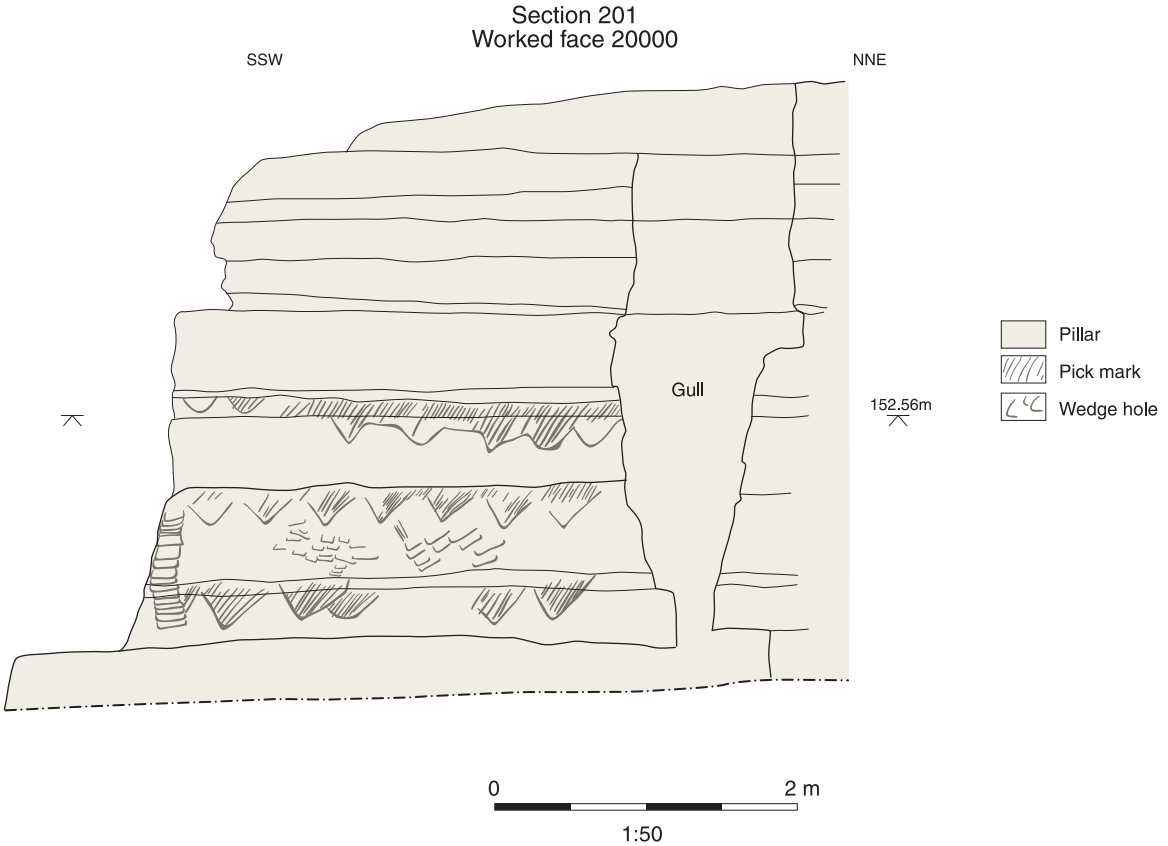


Fig. 8.27 Repeated rows of wedge pits on a pillar used to break successive beds

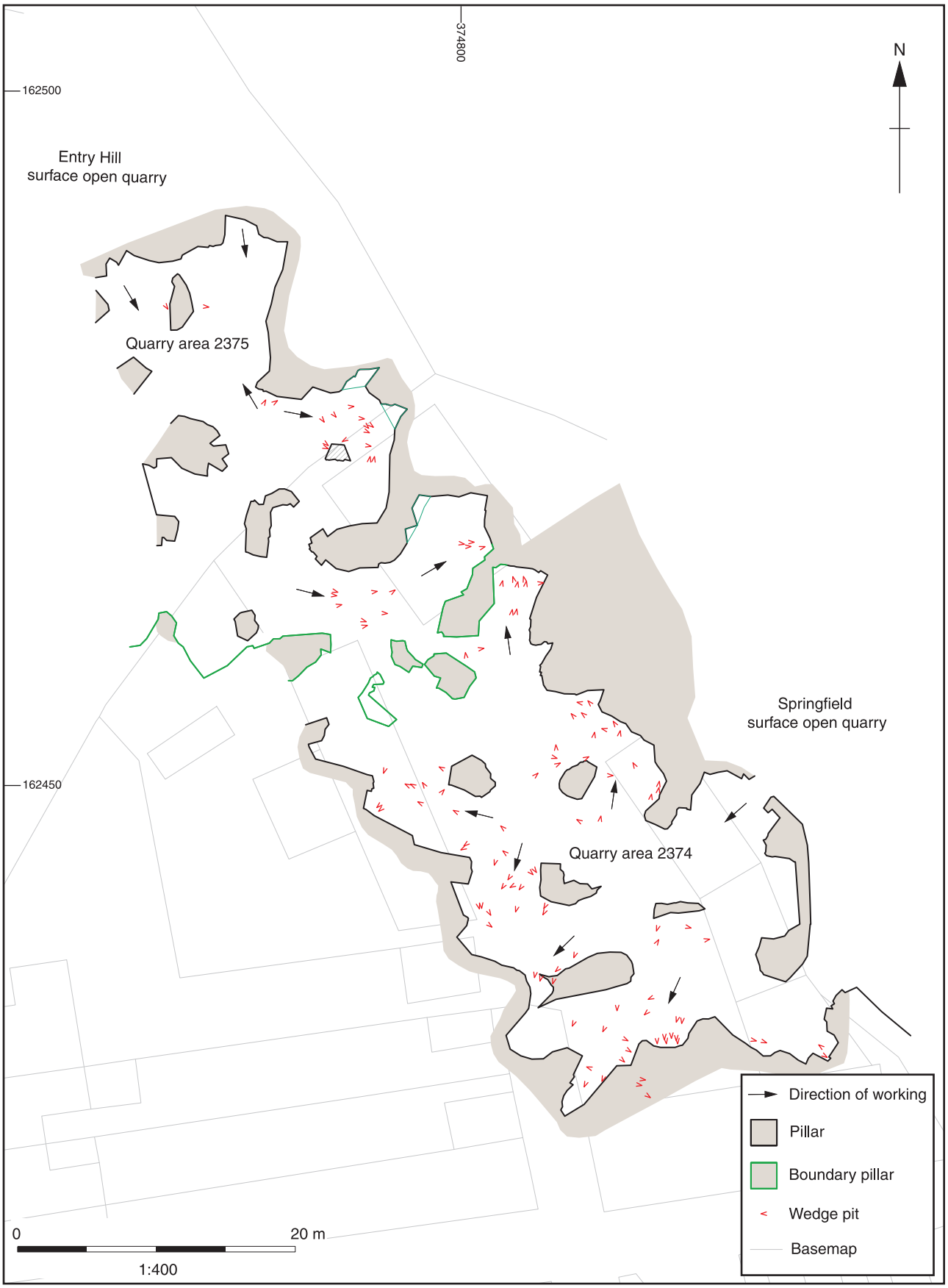


Fig. 8.28 Distribution of wedge pits in the roof of the late 18th-century Entry Hill quarry, allowing inferences to be drawn about the direction of working

inch (138 mm) deep wedge holes, spaced at 8-inch (200 mm) intervals, an example of what would have been a common temporary artefact of active quarrying.

The larger wedges found were probably only a small sample of the very many which must have been used which left little trace. These were not used with chips, but were driven directly either into joints or beds, or into the solid rock. These seem to have particularly been used to rap down a bed above jads, leaving the small impression noted earlier, and to lift blocks from their bed. Compared with the many chips found, large wedges (and hammers) were fairly rare finds, perhaps because they were less easily lost, or, possibly because they were part of personal tool kits.

Wedges were recovered from all quarry areas. Samples from Combe Down were all of a phosphoric wrought iron, easily available to a local blacksmith, and there had been no attempt to 'steel' them (Salter 2009). They can be classed as three basic forms distinguished by the shape of the base – rounded end; flat end; four tapering chamfered edges and reducing to a point. All types have relatively flat, broader, upper ends which received the hammer blows. Most of the wedges recovered had been bent or split by the impact of sledgehammers They are mainly 18th and 19th century in date, but one (SF1030) was recovered from the 20th-century Foxhill Quarry (2380). Their occurrence in the quarries can be attributed mainly to discard due to damage rather than accidental loss, and most of the 19th-century examples were recovered from spoil and barrow-way surfaces. Several wedges were found on pillar ledges, sometimes in association with chips. Some wedges and chips had been re-used to tighten the tops of timber sprags, or driven in at the base of the timber within the timber sprag recess on the pillar face.

The wedge slot is a superficially similar slot to the wedge pit, though was often larger. It is sometimes found at right angles to any feasible split, which does not always have an obvious purpose, but may have formed some type of anchor. Horizontal wedge holes survived less frequently within the quarries. These may also have been used to hold one end of a plank, either used as a cantilever on which to stand or for bridging the gullet. Lewis slots (see below) are easily identified by the 'dovetailing' or opening-out internally at the back of the hole and were used as anchors, notably for crane stays.

Jad cuts

Jad cuts was the term used in the archaeological survey to describe vertical cuts or long slots made by use of picks or sometimes jads, in order to cut out blocks or define pillars. Jad cuts were usually visible as repetitive, sweeping curved marks of picks on vertical faces extending from roof to floor. Their trace usually indicated removal of blocks bed-by-bed. They were not a common feature at Combe Down. Jad cuts were used within some of the earliest 18th-century Firs quarrying areas, including the 1725 period, Quarry (2347), in the Allen Estate Quarry (2201) and the Byfield Allen Estate Areas (913 and 506) dating to the mid-late 18th century. The largest numbers occurred in West Byfield in the quarry associated with Hulonce (Chapter 12, Case Study 7) and probably date to before 1830, though they may be by one of his sub-lessees. This limited use strongly contrasts with their use in underground Bath Stone quarries in Wiltshire, where literally miles of faces can be seen produced by this method, which continued in use there into the 20th century.

A 'doorway' next to the Irvings Incline had alternating use of jad cuts and sawing and splitting using triangular wedge-and-chip pits. Hacking and picking, or crude splitting with simple wedges also remained common in the middle areas of the same workings. This mix of new and old is hard to interpret as other than personal preferences of the workmen rather than strong management direction.

Subsequent to the archaeological survey a historically more accurate or apt term emerged for jad cut. A reference to them as 'not long since ... an improved plan of sawing the vertical – or, as they are termed upright jads became generally adopted' was found by Pollard (pers. comm. citing William Morgans 1871, 149). It may suggest an initial use of the technique, if only as an unsuccessful trial, at Combe Down at a much earlier date than used in the Wiltshire Quarries. The term 'jad cut feature' was also used during archaeological recording. Confusingly the term 'upright jad' may have been sometimes used contemporaneously to describe the vertical cut created by saws in the 19th century.

Use of saws

Sawing was a technique widely adopted during the later phases of quarrying and also often of reworking (see section below), involving cutting through individual beds or down the side of larger pillars. The evidence also indicates, however, that picks and jads or a scappling axe remained in use to clear away upper beds to allow saw access. The earliest use again occurs in the 1725 workings where sawn blocks and wasters (defective worked material) were found. It was of course a normal method of work used by banker masons at surface and the use in 1725 may simply be similar use underground. The use in a surface quarry was illustrated in an engraving by J. Hassall in 1791 (see Figure 3.12) with use of a large bow saw for cutting a block. It is clear that bow saws were also in use underground from occasional curved faces on pillars (Fig. 8.29). They were probably used for straight cuts also but the unwieldy frame must have made this difficult. The introduction of a cross-cut type saw, known as a frig bob would have made sawing a much more viable extractive

technique. It is likely that development took place in the first decades of the 19th century, from the availability of suitable steel (cementation steel) after demand for military edge tool materials had declined after the Napoleonic Wars. The first dated instance at Combe Down is an extensively sawn pillar in north Central Byfield with the date 1816 (Pollard 1994), and others followed in the 1820s and 1830s. Sawing as the primary means of extraction at the face was introduced, at Combe Down, about 1870 onwards and became common in the 1870s in several of the Firs and Byfield quarry areas with sawn faces extending the full height of pillars. At the end of the 19th and in the early 20th centuries sawn extraction was used throughout Long and Open Rooms, as in James Riddle's Quarry (518) in Byfield (Fig. 8.30) and Quarry (2213) in southern Central Firs. The pillars at the edges of these areas have multiple sawn faces and few natural exposed faces. The best examples were preserved in the Foxhill Quarry (2382) which had several sawn faces with hatching details. At the top of the same pillar was a good example of a picked jad slot created during the initial breach that allowed access for the razzer and then the frig bob saws.

Fig. 8.29 Curved face (at top) made using a bow saw, to allow access to vertical saw cut below. Probably part of a secondary working, pillar robbing activity, Central Firs Quarry (2203)

Fig. 8.30 Sawn pillars in James Riddle's Quarry (518)

The frig bob saw (Fig. 8.31) was available in lengths of between 5 and 8 feet (1.4 to 2.5 m) and, as used at Combe Down, was usually single-handed. The depth of the saw blade could be as much as 10 or 12 inches (25 to 30 cm) when new and the weight of the relatively thick blade (compared to the type used for cutting timber), was up to 56 lb (about 25 kg) providing additional pressure, which helped the sawyer to cut vertically downwards. A socketed wooden handle which was generally riveted to the blade could be maneuvered to project above or below the cutting blade to facilitate use in tight spaces. Sawing into a solid face was possible once the overlying bed had been opened far enough back. This could be, for example, below a jad slot made large enough for a smaller saw called a razzer (a worn down frig bob saw) to open it sufficiently for the high-backed frig bob to enter. The cut right to the back was maintained by a downward shift on the handle at the end of each stroke elevating the curved outer end of the saw. Cutting into a open joint facilitated this, and examples of utilizing such a joint were seen in James Riddle's quarry and at Shaft Road (Fig. 8.32). A narrow groove was left in the face beyond the joint. By making two saw cuts slightly angled inwards to a joint at the back, a wrist stone opening could then be created by wedging the block out (le Neve Foster 1901, 313). This meant a further reduction in waste compared with breaking out the wrist stone.

After the wrist stone had been removed, each vertical cut back to a joint would allow a block to be removed, but where the joint was too distant a saw cut had to be made parallel to the face from a somewhat awkward position at the back of the wrist cut. A rare example, because the joints were usually fairly close, with the last stone to be removed left in position, was noted at Foxhill Quarry (2283 see Fig. 8.33). An 0.9 m wide wrist stone at each bed was removed and the back face picked-back slightly to provide a hole for the quarryman to stand and to allow insertion of the saw behind the adjacent section of face.

Sometimes, leaving the trace preserved on pillars, each saw cut would be offset a few inches from the last, producing a characteristic zigzag-shaped or hatched face. Wedge-and-chip holes were also sometimes used in saw cuts to tilt the sawn block forward to lift it off its bed with least damage. The tilt forward of the bed was occasionally indicated by a curved groove where the corner grated against the remaining face. The cut produced was usually vertical or near vertical and it would not have been difficult to produce vertical cuts as was normal. However, in north Central Firs Quarry (2215) the pillars were sawn down consistently to

Fig. 8.31 A frig bob saw (late 19th century) leaning against a typical sawn face with graffiti

Fig. 8.32 Sawn face showing the slot left by a saw end penetrating into the rock at the far end (Shaft Road)

Fig. 8.33 Face in Foxhill Quarry showing picking-back behind the wrist stone to allow insertion of saw behind the sawn face on the right

have bases narrower than at the top, wedge-like. It is not clear why this form, sawn to a few inches wide in a few cases, was adopted, though no collapse seems to have taken place as a result.

When cutting stone from a pillar face, the sawyers would try to get as large a stone as possible and in order to insert saws the bed above was usually cut back by use of a broad-bladed scappling axe or hack (or occasionally sawn by a narrow-bladed bow-saw leaving a curved face). According to le Neve Foster (1901, 314) a workman could cut some 15 square feet (1.4 m2) of the softest beds in an hour. By our own experience, presumably on beds exposed so they were probably substantially harder, even allowing for our inexperience, the regular production would probably be substantially less.

Water was used to lubricate the saw and prevent it from binding with damp stone dust. In our own experience of sawing-out graffiti faces during the archaeological survey, water drips made the effort needed much less. Copious flows of water from a hose (unavailable to the original quarrymen) made it easier still. In historic times quarrymen used a variety of containers – tins/cans, glass bottles and even crucible-type vessels fashioned from Bath Stone to bring and hold water. Crude holes formed in benches on pillars formed basic reservoirs. Some tins were pierced with a small hole in which clay and a match stick were inserted to maintain a gradual flow. Water could be collected by placing the container or cutting a hole beneath a drip from the quarry roof. An example of water supply was

Fig. 8.34 A saw-sharpening stone in which the saw was held – teeth upright – for sharpening, Central Byfield (Quarry 505)

seen in parts of the Foxhill Quarry which became inaccessible after the 1940s. Here, four sealed glass bottles were recovered from the base of a vertical winding shaft in Tankfield Quarry (2383). These may have been bought down already filled from the surface, because no water was percolating through to the beds in this area. Several drip cans were also seen within the quarry, but consistent flowing drips from the roof were again not evident throughout the four quarrying areas.

Saw benches used for sharpening were a fairly common find, usually fashioned from a waste block of stone with a widened saw cut along its upper face. These were used to support inverted frig bob saws when the blades required sharpening (Fig. 8.34). Saw benches were sometimes also adapted from a larger block that was partially finished prior to the discovery of a fault in the stone. During the archaeological survey, the location of a saw bench often indicated the position of a banker mason's working area, in some cases where all other evidence of this had been buried or obscured by later waste deposition. The most obvious manifestation of saw sharpening, apparently done each Friday, were substantial numbers found of triangular files. These occasionally had been reused, their tang thrust into a crack or hole to form a coat hook, or, perhaps to sling their bait or lunch. Other tools required though not found would have included an opening hammer and saw teeth gauge to set the gauge and re-align the spacing of the teeth of frig bob saws. The correct gauge setting for each of the teeth, when accurately spaced, would apparently allow the passing of a match along the length of the saw blade down between the centres of the aligned teeth.

Blockstone was also sometimes cut by sawing into manageable sizes, which needed only single cuts to produce flat-faced building blocks or ashlar. The largest demand for blockstone must have been for ordinary stone-block sizes, which were more easily handled. Because of their fragile nature, these were sometimes supplied as 'double size' blockstone, before being reduced by banker masons on site.

Some insight into the tedious and heavy occupation of sawing is given by comments from Tanky Elms who worked at several quarries, including Springfield Quarry at Combe Down (Hall 1984, 99):

> *What we used to do was to get crooked handles instead of pulling the saw right tight which would rub the skin off your knuckles and arms. This gave you a couple of inches clearance from the stone. However, it made it more difficult to keep the saw vertical and so what he did was to get old bicycle tubes, cut off a length and wrap it around our arms tying it with a piece of string*

and with reference to taking a stone off pillars:

> *And you had to keep the saw moving all the time until the stone was removed. Was kept moving as the weight of the ceiling. What would happen was that the weight of the ceiling would come down on the pillar, the pillar would spread breaking the stone off to where ever you had reached with the saw resulting in half the stone being wasted . . . Two men would be put on the pillar stone, one would have to go and get the water and keep the bucket full which would drip continuously on the saws and the other would relieve him probably after half an hour.*

Reworking or scavenging/Bath Stone

Scavenging was an important part of the quarrying process. It typically involved removing thin slabs from pillars just before they were obscured by dumped spoil, or from those with easy access from cartways and entries. But there is also an abundance of evidence of later reworking, sometimes of a fairly substantial nature, usually involving saws to cut down larger pillars. There were also a very few small reworkings of blocks of stone for some reason not hitherto worked, perhaps left at the termination of a lease or depression in the industry,

Many of the widespread sawn faces that were seen resulted from reworking. The most commonly reworked elements of the quarries were the pillars located close to shafts and other entries or along major cartways. Pillars which bore the marks of older methods of working were found also to have sawn faces probably reflecting scavenging operations, sometimes by organised enterprises as the last stage in working an area, or in conjunction with working a nearby contemporary sawn pillar area, or individuals, local builders or other people making a small living. Evidence of subsequent dumping against the sawn pillars has been found, and in some areas the floor was dug out to gain access to the desired bed block and in others, filled back in again. Elsewhere dumping was clearly carried out as part of an adjacent major operation, and in a few cases in Firs, the sequence suggests very early use of saws apparently in conjunction with this.

Scavenging of the thick bed with its top some 2-3 m below the roof was an engineering problem. In the southern part of the East Firs area, this had often been done in a concealed manner, with spoil obscuring the true narrowness of the pillars below (Fig 8.35), though it was sometimes more blatant (Fig. 8.36). Colin Harris, site engineer for the Stabilisation Scheme (pers. comm.) considered it was possibly systematic Bath Stone at a late (retreat) stage of working. The apparent concealment may, however, have been an attempt to prevent lateral pressures causing pillars to topple, but if so, was not well done as substantial space was usually left under the upper, wider section.

The cartways often have pillars directly alongside which have been sawn on one face while most of the immediate area has an older system of working. Some of these surfaces are thought to reflect scavenging operations in conjunction with working a later nearby contemporary sawn pillar area, Many of the faces did not go below the spoil

level which suggests that many must be later, sawn after the spoil was dumped. Some beds below spoil level were also worked but not consistently, so it is possible that sawing was also done where a finished set of pillars appeared strong enough to allow some limited further exploitation. The bed below the common spoil level was the thickest (we saw) in the sequence, and in various locations the spoil appears to have been dug away to reveal this desirable bed for reworking.

The process of reworking often involved use of picks and jads or a scappling axe to clear away upper beds to allow saw access and in some cases faces were split off using wedge-and-chip. In a

Fig. 8.35 Reworked example of removal of lower block of the best stone. Many examples of this appear to have been deliberately concealed in both East and Central Firs (2201)

Fig. 8.36 The most extreme example seen of the reworking of a pillar, in East Firs (2203)

very few cases, narrow saws (probably some form of bow-saw) have been used to take off a higher bed, leaving a curved face to allow a normal, cross-cut type of stone-saw to enter the uppermost of the best thick freestone beds. It was, however, likely that some examples of altered pillars in cartways may relate to the need to facilitate better accessibility to cartway traffic and/or haulage operations, whether contemporary or later, rather than being scavenging.

A small, undated example of where the floor had been removed for access to unexploited blocks of stone occurred in north Byfield Quarry (514). It involved the excavation of a trench measuring several metres in length, a couple of metres in width, and dug to a depth of about two metres. It was located against the western edge of a pillar and would have produced very limited amounts of stone blocks. Three good examples of more organised scavenging enterprises occurred in seemingly near-contemporary workings in Firs Quarry associated with the removal of a sequence of earlier Allen cartway surfaces. In Quarries (2367) and (2368) and the slightly later Quarry (2370), the lower limits of previously exploited pillar faces and larger blocks of un-worked stone were reworked following the removal of the earlier quarry floor and spoil over it, and also two separate cartway surfaces, with the remaining open routes of the earlier cartways used to facilitate the removal of the extracted stone (see also Chapter 12, Case Study 15).

An example of the removal of existing quarry floors during the subsequent working of a remaining block can be seen on the southern limits of Quarry (912) by James Riddle and Son (518) in the first years of the 20th century. Here, about 1.5 m of the former quarry floor level has been removed for the construction of the northernmost of two railways used to haul the won blocks of stone towards the vertical extraction shaft. The enterprise also exploited smaller individual pillar faces and reduced the size of other formerly larger long or rib pillars within the earlier Quarry Area (915). Evidence for secondary working is evident on some of the pillars in that the earlier corbelled pillars have been modified by the later sawing techniques into direct pillars.

Lighting

The main form of illumination used in all but the few late 19th- and 20th-century workings were tallow candles, of which several were recovered. Little detail has emerged about them and how they were managed in use, but associated finds included candle boxes, rudely cut out of a block of stone and covered with a flat stone lid (to prevent the candle being eaten by rats and mice) and candle holders, either of crudely formed, sometimes spatulate stone (see Figure 11.23) or or of small balls of clay stuck on pillar ledges or stood on the remaining stone benches. Several individual clay holders were recorded within Quarry 2224, and were placed on adjacent pillars besides a barrow-way route to illuminate the path taken by quarrymen either to transport produced stone blocks or to barrow spoil away. Others candle holders, clay and otherwise, were commonly located on pillars adjacent to vertical shafts in areas that were presumably more often used during stone transportation operations.

In Firs a flare-type torch formed by oil-soaked textile wrapped around the top of a stick was found, but its condition suggested it may have belonged to a later explorer of the complex. Oil lamps, probably using kerosene, became fairly common in the late 19th century. Home-made forms from tins are possible but a fairly standard type was probably similar in appearance to a small watering can with a wick in the spout, which gave a fairly good light compared to a candle.

The first carbide lamps would have been introduced in the early 20th century. They were made of brass with a body partially filled with calcium carbide onto which water dripped from a screw-on top, producing acetylene gas. The lamps were probably designed to be attached to a cap, but could also be set on a ledge. The lamps were small and cheap and the inexpensive carbide lasted for about four hours and the gas jet gave good illumination. At Combe Down, no lamps were found, and no carbide residues were noted. Larger hand-lamps with eight to ten hours life came somewhat later. These were likely to have been used at the Shaft Road (Combe Quarry) and Mount Pleasant Workings, and at Foxhill.