Chapter 9
Techniques of underground quarrying: 2. Transport and materials handling

Cartways and associated shafts

The well-organised and mechanised system of transport from the open quarries via the Allen railway was not extended below ground, perhaps because distances were much smaller and more dispersed with frequent route changes. Instead barrows, carts and four-wheeled wagons were used, and in most areas they were moved independently of rails. Where there was an absence of cart-ruts or barrow-ruts the method of transport for the block-stone from the working face to the surface was unclear, though dragging by winch and crane or on sledges or even wooden rollers were possible over short distances. It is possible that the absence of cart-ruts was more generalised than was apparent from the limited areas of floor that were open to investigation for this study.

Cartways were purpose-driven, fairly level routes (ideally slightly sloping toward the entries) within the underground quarries. They were used by a two-wheeled quarry cart or four-wheeled wagon with solid or spoked wheels. These left evidence of their use by ruts and hub-wear marks. Horses generally leave tread marks within the centre of the cartway but apart from one possible example (Fig. 9.1), these were absent at Combe Down, though their use was envisaged in a lease of 1804 (LL. A01/18/5/30). A small number of horse-shoes were found in the workings, and it is possible hoof traces were obliterated by later usage. Overall, however, the impression remains that horses were not commonly used and that the carts were moved by the underground workmen.

The cartways were the primary transport routes within the underground quarries, mainly used for

Fig. 9.1 The only example of a cartway where likely traces of horse-hoof impressions were noted, north-east Byfield Quarry (505)

the transportation of roughly squared block stone, rubble-stone for building and finished or wrought stone, either to the open surface quarries or a conveniently placed vertical shaft. There was also evidence of some cartway routes subsequently being used as barrow-ways, which often obscured original surfaces and filled the cart-ruts. The cartway system in the Combe Down Byfield and Firs quarries is shown in Fig. 9.2.

The earlier cartway levels had an unobstructed width of about 2.4 m between walls, pillars, packs or banks, rather more later, and a surviving height below the roof of about 2.4 m or a little more (typical of the earliest), to some 4.5 m later. Many had evidence of carts or wagon use in the form of ruts typically measuring internally 1.2 m wide and externally about 1.5 m wide. The ruts were left by the cartwheels which wore into the soft 'make-up stone' (fine chips or dust) placed on the floors to ease passage. The width is thought to reflect a cart width of the 19th-century type of about 4 feet as the earlier evidence for haulage of the 18th century (with one possible exception in the Byfield Quarry) was generally buried by later activity: This does not necessary preclude a similar width for early carts, but where earlier cartway sequences were recorded cart-ruts were generally absent.

The cartway routes followed headings developed from the surface entries. They were up to 4.50 m wide between walls or pillars, which was often the width of rooms worked, though often less for earlier examples. The method of driving such headings was very similar to that used on working faces (as described earlier) except that often one wall was not pierced, presumably for increased stability. Driving also yielded block-stone, helping the pay its cost, but near the entries some spoil would have had had to be removed outside for dumping. Cartway floors appear to have always been constructed on a thick layer of spoil. Some 2 m seems likely from occasional observations, but this could vary to allow construction of a slightly sloping cartway bed to help movement outwards of loaded carts. There was a trench or ramp at the inner or face-end up which below-floor bed-blocks had to be dragged, but the cartway level also allowed access to higher beds and, more importantly, reduced the height from which blocks from high beds had to be lowered. The height of the cartway above its spoil-floor probably reflected the total height of freestone and picking beds removed, so a 2.5 m average roof height above the cartway suggests a total of some 4.5 m of beds removed and greater heights may have resulted from deeper (and usually later) workings. Alternatively the height may have been adjusted to allow loading from the thickest bed, the top of which was two or three metres below the roof. It is possible that stone was dragged back from the face in working rooms, or barrowed back to the inside end of the cartway, perhaps up a ramp. In some cases, particularly in the late 19th century, cranes were used for both lifting and dragging of bed-stones along the floor and on to the cart or wagon.

The cartways seem to have been well-maintained. The ruts, though often visible, were normally only a few centimetres deep and often free of visible stones. The sides of the cartways were often sloping, covered in a fine dried sludge derived from clearing and maintenance of the cartway surface. The lack of deep ruts implies that the surface was dressed or made up with small stones and dust laid upon it to provide smooth surfaces. On curves within the cartway lengths the wheels of the carts had sometimes cut into the sloping bank, increasing the angle and leaving impressions of the wheel profiles; these were hard to measure, but suggest wheel diameters of about two feet (0.6 m) or a little more. Rub marks from the passage of carts and, perhaps, horses were found on the corners of the adjacent pillar faces. Haulage marks, including rope and chain grooves, were noted in places along the routes and at the vertical winding shaft locations which were positioned along them. This evidence assisted in the interpretation of types of haulage methods used and the systems employed.

The early to mid 18th-century cartways were driven from surface open quarries, and their routes were identified by the contemporary pillar types, generally apophygate with some corbelled elements, through which they had been extended. The Allen cartway routes were of this type and were all driven northwards from his surface quarries in the Byfield and the Firs quarries west of the Long Drung. Nearly all the cartways were re-used by later quarrying enterprises that succeeded Allen's direct management in the later 18th and during the 19th centuries. Consequently any clear early evidence for the use of the Allen cartway routes was buried or obscured by later transport activity. Because its use was abandoned before the end of Phase II and the area at the far end apparently not worked thereafter due to roof instability, the most likely un-modified Allen cartway was the western-most of the two driven in from Jones Quarry in Central Byfield, which exhibits very prominent cart ruts (Fig. 9.3).

In the Central Byfield Allen workings (Quarry 505) the length of his eastern cartway extended over 120 m from his surface quarry operation at Ralph Allen Yard to the northern extent of the contemporary apophygate and corbelled pillars. Later cartway development, known to be mainly 19th century in date, extended this another 120 m northwards and, despite running along a series of wide shafts, may still in part have been extracting block-stone over the former length used in Allen operation. Some other earlier cartway routes not re-used in the 19th century were also of considerable length, with distances of up to 120 m and more. This practice of using cartways was generally absent in areas to the east of the 'Long Drung' (with the

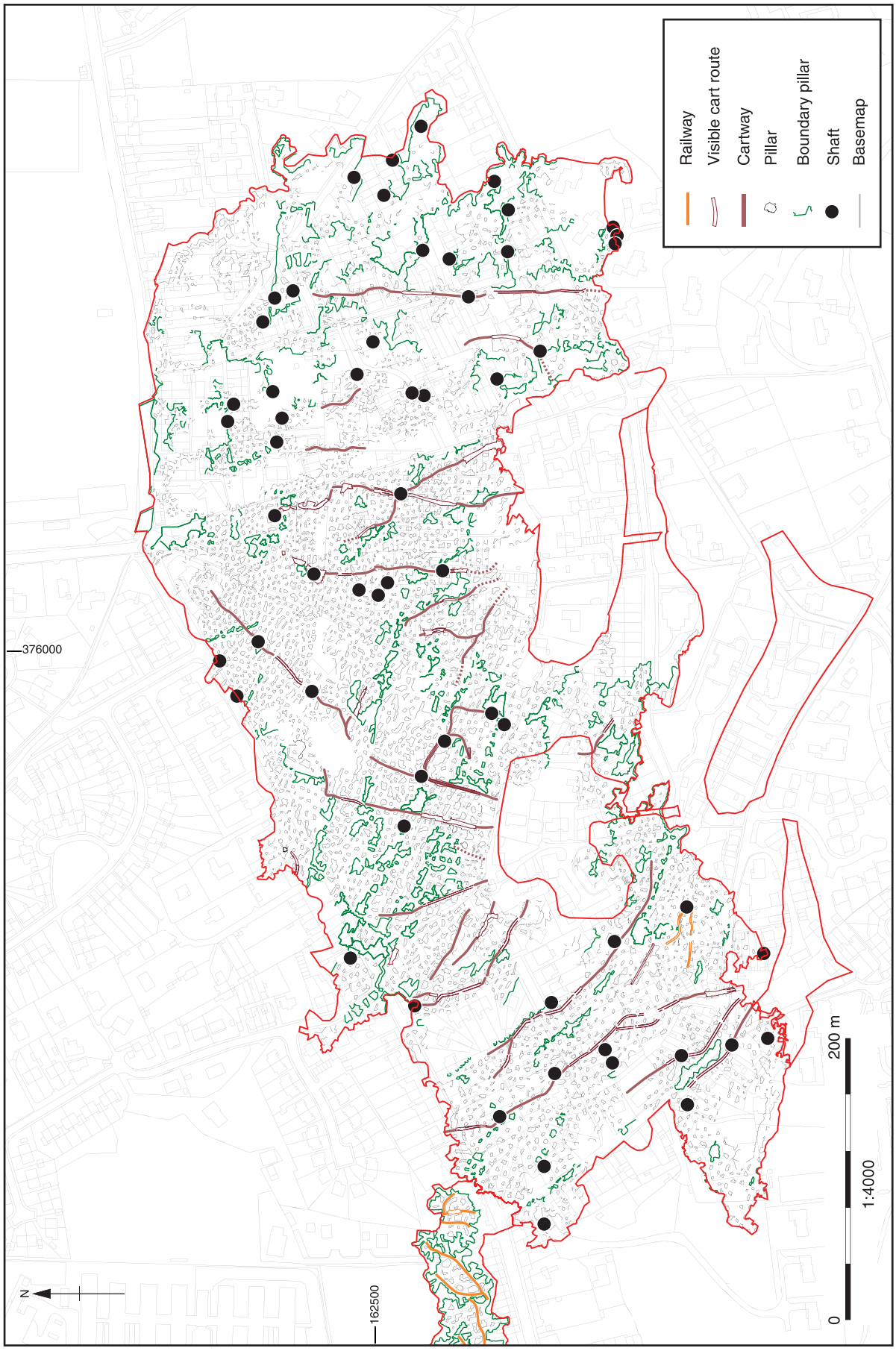


Fig. 9.2 Plan of known cartways in Firs and Byfield, also showing shafts

Fig. 9.3 Allen's western cartway in Central Byfield, near the entry. It appears not to have been used after abandonment in the mid 18th century because of bad roof conditions at its inner end, discovered after work restarted c 1803. The white reflection may be due to stone particles within the re-crystallising mud cleared to the side of the cartway

exception of The Brow cartways), where most quarrying areas were small scale and generally used winding shafts. Where cartways were used there, they tended to be in shorter lengths between the working face and the shaft, in some cases rendering the use of longer earlier-period cartways obsolete whereupon they became used as convenient dumping areas.

Allen period cartways

The Allen cartways (1730-1764, Phase II) were driven from at least two or probably three separate open or surface quarry locations, perhaps at a very early stage of the surface quarry development. The definite two were Jones Quarry at what is Ralph Allen Yard today and Sheeps House Quarry at Rock Lane. Other entries were probably located at the west end of the (later) quarry north of de Montalt Place, and the quarry behind Hopecote Lodge (later) worked by Burgess. A fourth quarry, located to the south of de Montalt Place 'Masons Crane House Quarry', was also operated by Allen and Richard Jones in his '*Life*' appears to suggest, using a simple sketch, that two parallel 'roads' were driven there (see Figure 5.6). As the roads cannot be any of the surface roads in the vicinity, Jones 'roads' can probably be presumed to be cartways. There was no corresponding archaeological evidence found to suggest that cartways were driven underground from there, though the possibility remains as much of the ground was later surface-quarried.

The initial Allen transport system seems to have used two cartways from each surface site, perhaps to provide better ventilation. In each case a surface crane was either definitely used or available (in sale details) for use above the entries to raise stone from the cartway level to the surface railway and down to the wharf at Dolemeads.

Allen cartways at Jones Quarry (Central Byfield)

At Jones Quarry the two original entries branched as a 'V' from the entries. They were each 3.6 m wide and both were driven for about 120 m on the eastern side of the Combe Road boundary pillar in Quarry 505, initially about 2.5 m below the roof. The western cartway (Fig. 9.4) was driven next to the almost continuous Combe Road boundary pillar and was that described above as abandoned in Phase II, and never re-opened due to instability. At the northern and the southern limits, high roof supporting packs had to be constructed. Instability also affected a wide shaft about 60 m along the cartway resulting in it being inaccessible to the survey team.

The eastern cartway had a much longer life after initially being driven in through an ashlar block, barrel-arched entry, then largely in rock for about 90m. Rope grooves were found on the wall near the entry, suggesting that, at some time cable haulage, probably from the crane, or if later, from a winch, had been used. Use of shafts further in may suggest cable haulage at the earlier time using the crane cable. It passed under a wide shaft at about 70 m inwards, but this was inaccessible due to partial roof collapse and a sub-circular pack built around it, so its possible functions could not be examined,

though ventilation would certainly be one of them and the enclosing wall was so wide as to suggest a wide shaft suitable for raising block or stone. The cartway had been extended stage by stage, eventually almost to the North Road, the staging partly indicated by changes in pillar morphology, with shafts at roughly 50 m intervals. The shaft to the north of the first shaft (the walled shaft above), just beyond the last apophygate pillars, showed evidence for haulage as rope grooves were found on the underside of the shaft at roof level and near the floor, and in a pillar at the side, back towards the apophygate pillar area. They suggest that carts (or blocks of stone, on rollers if very large) were hauled to the shaft by a cable, but again the shaft's alternative use for light and ventilation may have been important. The shaft was filled with post-quarrying surface-derived material. The collapse at the first wide shaft and the adjacent small area to the east necessitated the diversion of the cartway to the western edge of the shaft; the former length to the north of the shaft was also covered by collapse. As the stones had been cleared to the edge of the cartway, it was clearly a contemporary fall but there had also been post-quarrying roof collapse. The date of the later collapse is unclear, but two scappled blockstones abandoned on the eastern edge of the shaft and surrounded by collapse material can be assumed to have been left prior to the collapse.

Allen cartways at Sheeps House Quarry (Central Firs)

At Sheeps House Quarry (2200) two roughly parallel cartways were *c* 25 m apart (Figs. 9.5 and 9.6), widening slightly further in. The slightly larger western cartway was 4.80 m wide between the pillars (though also partially lined with heavy roof support packs) and a late 19th-century excavation in the floor of the western cartway revealed it had an excavated floor-to-roof height of 5.50 m, the only example of an early cartway where the full height was visible. Rooms appear to have been made from either side and between the cartways as they advanced which would considerably improve ventilation and quickly provide a large number of working places. The original gauge is unknown as evidence of cart-ruts at the lower extents of the exposed sections was very slight and not measurable with any precision, and the transport system into the rooms alongside the routes remains unclear as the sides were usually packed with stone and spoil.

The western and eastern cartways were driven northwards for about 70 m, where shafts were sunk above each cartway, both narrow, at about a metre wide, so probably for ventilation. Some of the apophygate pillars had been partially modified, the cartway widened and additional support by packs was provided, probably in the 19th century, to prevent (further) roof falls. The apophygate pillars

Fig. 9.4 Upper section of Allen's western cartway in central Byfield showing a roof-fall which is below a wide joint or "gull" in the roof. The seated figure is mine manager, John Lister

Fig. 9.5 Allen's east cartway in Central Firs. Note the remains of an apophygate pillar, on the left, the original roof destroyed by a fall. The heap is a cone of debris from the narrow shaft above. The passage with light from the left links to the west cartway

Fig. 9.6 Allen's west side cartway in Central Firs showing apophygate pillars and support packs alongside

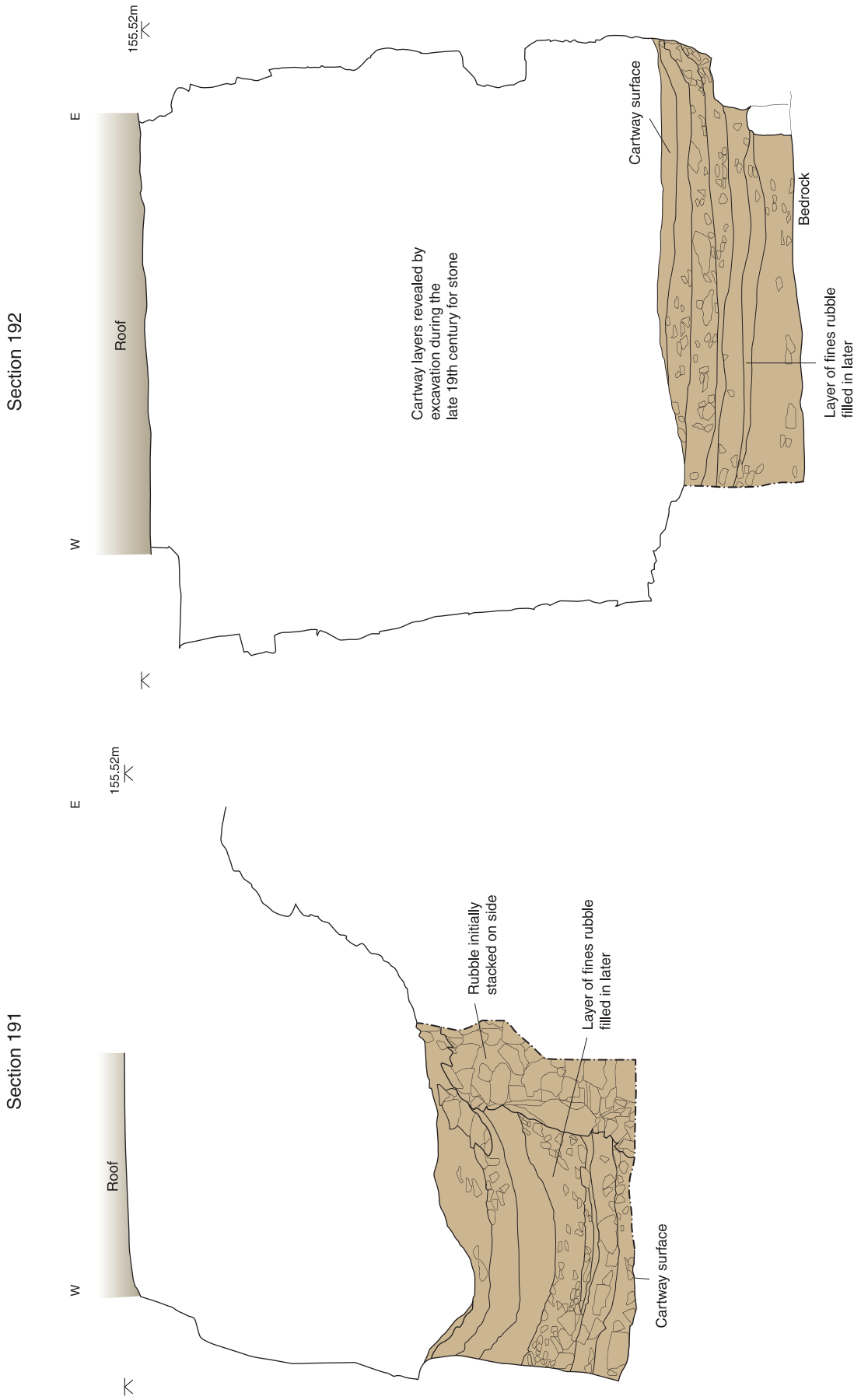


Fig. 9.7 Stepped section showing cartway and other development at the Allen western cartway in Central Firs

extended roughly to these first ventilation shafts, and probably indicate the limits of the first development phase. A series of east-west aligned large boundary pillars across the northern extent of Quarry Area 2200 where the shafts were located would also seem to indicate a northern worked limit. Beyond the shafts, alongside the cartways, the pillars tended to be corbelled, and probably belong to the later part of the Allen Phase II quarrying, extending probably just past the Firs Shaft used in the recent Stabilisation Scheme. The smaller depth of penetration of the apophygate pillars here suggest these workings were later than the Jones Quarry workings at Central Byfield.

The eastern cartway route was over 100 m long and 3.60 m wide between the apophygate pillars. The southern stretch of the route was re-used by a later cartway branching towards the east. A shaft thought to be contemporary with the early development of the cartway, located about 70 m from the entry (in an analogous position to that on the western cartway (below), was *c* 1.40 m in diameter. It was one of the few examples of a probable ventilation shaft and was also of a similar diameter to another located 30 m to the east above the branch cartway. The latter may have been contemporary with the later part of Allen Phase II Quarry 2200 or, more likely, was an early Allen Estate Phase III cartway, as it was associated with Long Room working and crane usage.

At a point 70 m from the entry shaft the cartway was extended northwards to close to the Firs Shaft and, judging by the corbelled pillars, probably just beyond during the late Allen Phase II working. This change was noted in the development of pillar type from apophygate to corbelled along the route. The shaft, though much modified by modern use, had Lewis holes positioned on one side suggesting a crane post support, and cable grooves were found on the pillars. Although no date could be confidently ascribed to these features, the areas adjacent to the shaft had Long Rooms similar to those further south-east associated with crane use, considered as probably Phase III.

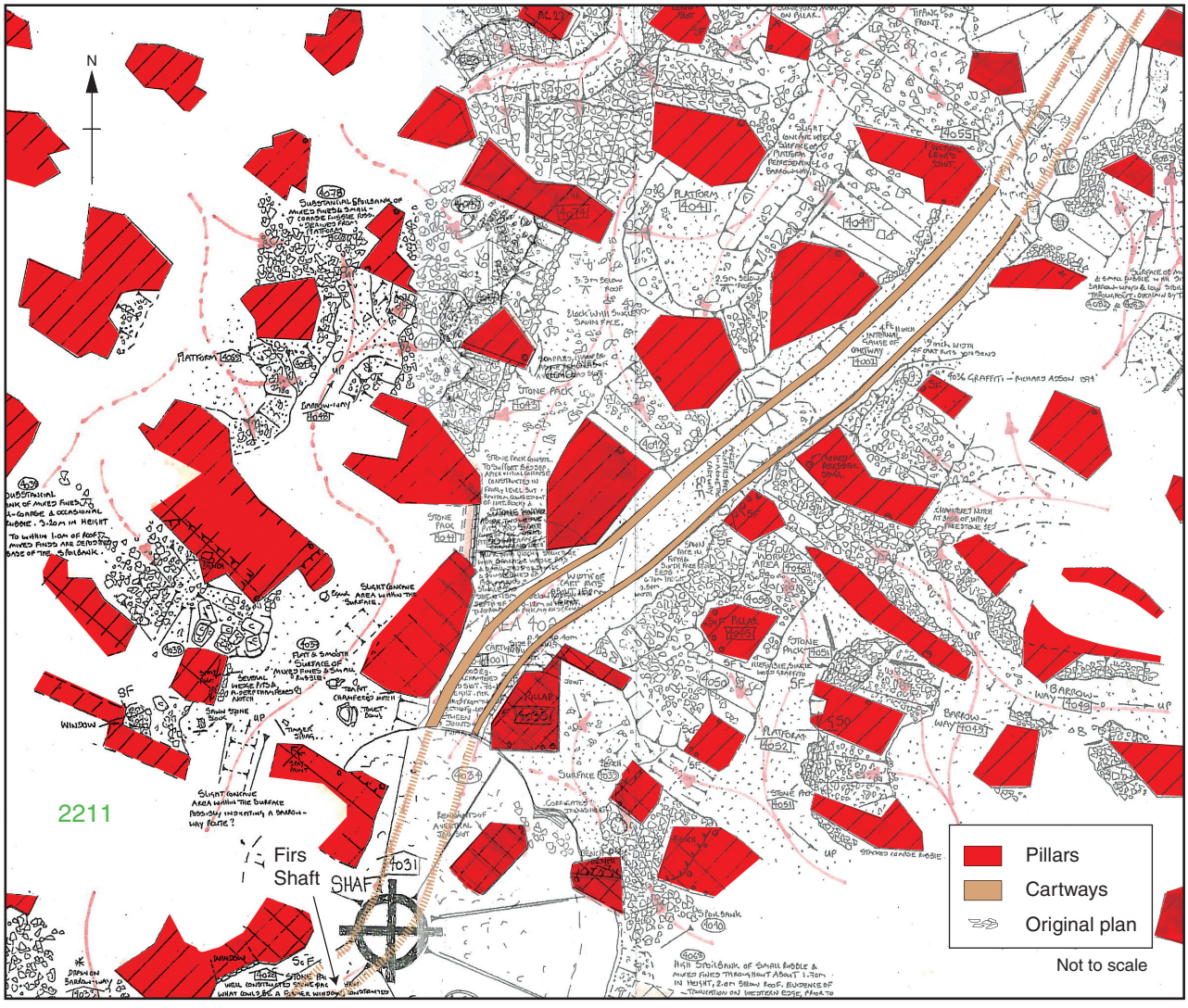


Fig. 9.8 Plan of cart ruts in the western Allen or post-Allen cartway at its north end near the boundary pillar

The western cartway was more fully investigated than the eastern, since the second shaft along it had been reused and the cartway excavated for stone in the late 19th century (Quarries 2367 and 2370). Uniquely this provided high stepped sections available for archaeological recording, extending halfway across the early cartway. Only the information directly affecting the Allen cartway is remarked on here, and the information revealed is more fully considered in Chapter 12, Case Study 15.

The southern extent of this cartway had passed, under a narrow shaft 70 m from the entry where there was no substantial evidence of cart-ruts. A 3 m-diameter shaft was located near the interface between the apophygate pillars and the slightly later corbelled phase of the Allen workings (Phase II, Quarry 2201), although several apophygate pillars were noted to the north of the shaft, abutted by later 19th-century stone packs. The shaft was probably used during the 18th century for winding stone out and was certainly used in the 19th century for localised Bath Stone activity associated with Quarries 2368, 2370 and 2344. From these northwards, later activity obscured the early cartway route.

The lower part of the stepped section (Fig. 9.7), records the lower sequence of cartway activity, with the uppermost cartway surface being the contemporary height of the cartway floor leading from this location southwards back to the surface entry. It is unclear how much further this cartway extended northwards beyond the section. However, it may have been extended during the Allen period to near the northern boundary pillar west of the Firs Shaft, and the line of the route was well-defined by the adjacent wider pillar alignment. A small area of cart-ruts were preserved close to the boundary pillar (Fig. 9.8) and a corresponding breach in the pillar suggested that the route may have extended to or even through this quarry boundary, into Quarry 2213 to the north. The workings hereabouts are Long Room and most likely Phase III Quarry 2201. The period of this breach could not be established archaeologically but the cartway alignment, covered with debris, had been noted – on one of the early visits to the site – as extending through the pillar face into two Long Room workings. By around 1800 the cartway was shown extending beyond the boundary pillar on a lease (LL. 91/18/5/30), which shows it then extending for about 30 m to the north-east, about 20 m north of the Firs Shaft. It was not possible to ascertain if there was post-1800 development beyond.

Apart from the ventilation shafts serving the cartway routes, the wide shafts that served the levels were of substantial diameter, in the order of 2.5 to 3 m or more. Precise diameters were difficult to measure because of walling and surface derived infilling, as well as access limitations. They were only *c* 6-7m deep to the top of the working. Any or all of the wide shafts may have been originally constructed to supply ventilation for which the metre width was adequate. If they were made wide, or later were widened, then undoubtedly this was to draw stone out vertically. The position of shafts probably indicates the distance dug before subsequent ventilation was required and they often seem to have been positioned at the interface between periods of quarrying activity.

Cartways east of the Avenue (East Firs)

Similar surface relationships as at Sheeps House Quarry at Rock Lane occur near Claremont on Church Road, with 'Quarry Lane' declining into a surface quarry (1851 Monkton Combe Tithe map), worked about 1810 by John Burgess. North of this in East Firs are apophygate workings with relationships that are very similar to those at both Sheeps House Quarry and Jones Quarries described above. However, very small workings, Quarries 2390, and 2346 displayed direct pillars and evidence of wedge-and-chip working under 89 Church Road occupying the ground between the Phase II Quarry Lane workings and the (later) outcrop-type Masons Crane House Quarry. Thus the entries to the Quarry Lane workings were not from Masons Crane House, so Richard Jones' sketch must remain a mystery, the probable ground involved having been later quarried away. Instead the entries must have been at the bottom of Quarry Lane. There are several possibilities, though these could not be explored because of safety restrictions.

Apophygate pillar workings in Quarry 2331, were located underground just beyond the north and north-eastern limits of the surface Burgess Quarry. The two parallel cartways, separated by *c* 25 m of quarried area in between, seemed to be typically Allen and are just within the area of surface tree planting that probably defined his quarrying area. The route of the easternmost cartway was located a few metres west of the Long Drung. It and the parallel westernmost route were accessible northwards for 25 m from close to the entry, though the southern stretches were buried by later barrow-way activity and spoil. The easternmost cartway had no discernible cart-ruts, only a smooth surface of fines, probably developed through later barrow-way activity. It was *c* 3.5 m wide and lay *c* 3.3 m below the quarry roof. The length of both the routes was estimated by measuring the plan distance from the surface quarry edge to the northernmost extent of the contemporary apophygate pillars, approximately 40 m. Unlike other Allen cartways recorded, there was no ventilation or larger vertical shaft at the northernmost ends.

Workings of a similar type also occurred at the western end of the same quarry. The area has been much affected by roof-falls, but the Hawkins (1994) plan suggests at least two other entries were physically feasible and probably likely. The apophygate and corbelled pillar association was observed in a similar association to two wide shafts seen in areas

Fig. 9.9 Shaft cap above cartway (2194) viewed from the underside, associated with Allen Phase II workings in East Firs (Quarry 2206)

west of The Avenue, but full details were not recordable due to collapse within much of these workings. The two shafts involved were capped by a particularly fine shallow-arched domes formed of roughly cut blocks (Fig. 9.9).

Pre Allen cartway (south-east of Sheeps House Quarry)

There were, however, examples of early workings with possible or certain cartway routes considered not to be Allen's but close in time to his. Quarry 2338 had a single apparent cartway length located on the southern extent of a Quarry (2347) which appears to have been driven southwards from the surface Sheeps House Quarry. It was exposed for a length of only 11 m as it had been tipped into at the northern and southern limits by later barrow-way tipping fronts. It was 2.50 m wide between flanking low stone pack walls and 2.5 m below the roof. A clay pipe of 1720-1725 was recovered from stacked rubble retained by a stone pack on the northern side. It is representative of the period during which the quarry operated and correlates with an incised graffiti dated 1725. The workings and possible cartway is particularly important because it is pre-Allen, and, as it almost certainly extended back to the surface Sheeps House quarry to the north, it suggests a date for the surface quarrying activity on Sheeps House southern boundary of the early 18th century or before (see Chapter 12, Case Study 2).

Contemporary non-Allen cartways east of the Long Drung

Two further extant sections of cartways were also surveyed in Far East Firs east of the Long Drung, within apophygate pillar working Quarries 2339, 2350 and 2369. Quarry Areas 2339 and 2350 are thought to have been contemporaneous although they were separated by a fairly extensive boundary pillar with few openings. One of the few located gaps identified during the Stabilisation Scheme was the continued drive northerly of the easternmost cartway route. This pillar extent may have reflected geological weaknesses and was left *in situ* to support the roof, rather than an operational or ownership limit; the alignment, if projected westwards matches the northern limits of the Burgess surface quarry face.

Both the easternmost and the westernmost cartways there appeared to vary from the Allen cartways by their roof being one or two beds lower in the sequence (that is, the roof was below the picking beds). Therefore, access from rooms at the side descended via a slope into it. The roof appeared less broken than those in the Allen workings, which may explain the choice of horizon. The easternmost cartway was developed northwards from a surface quarry south of Church Road in the area of the new housing development (west of Ashlands Cottage), and extended roughly below Tyning Road for about 200 m. An area of apophygate pillars was found on the western edge, with the

cartway representing the eastern limits of the quarrying along most of its length and was located besides a fairly continuous pillar boundary. The northern extent of the cartway length was recorded in Quarry 2339 and the southernmost limits were surveyed in within Quarry 2350. The areas between were infilled with waste stone and/or collapsed roof materials and the location of a shaft could only be suspected to be at the southern limits of the northern open cartway.

The southern extent (Fig. 9.10) did not appear to have been extensively re-used in the 19th century, possibly because of poor roof conditions. It was open for about 16 m, otherwise sealed by roof collapse and accumulated surface- and roof-derived clay. The northern section was open for approximately 120 m and had been built over by a stone pack to retain waste stone. A masons' working area located 11 m to the south-west of this cartway length on the western limits of Quarry 2369, which is also thought to be roughly contemporary with Quarry 2350, contained a large collection of scappled and sawn blocks contemporary with the cartway, dated by graffiti on a block reading 'June 1730' (Chapter 12, Case Study 1). No cart-ruts were evident, as it had been re-used by later barrow-way routes and access for general spoil tipping. Several large shafts further along the route may have been either sunk or re-used for later quarrying.

The eastern cartway was 3.20 m wide between flanking stone packs, with the uppermost cart ruts recorded at a height of 2.30 m below the roof. The ruts had an inner gauge of 1.38 m and an external width of 1.76 m. The average width of the ruts at the base was 0.12 m, with a depth of 0.20-0.30 m depending on how deep the wheels had cut into the fines surface. The cartway sequence (Fig. 9.11) was recorded to a depth of 1.70 m below the uppermost exposed cart-ruts. An earlier set of ruts noted at 2.60 m below the roof and directly below the upper ruts represented the same cartway activity where the westernmost wheels had bedded into the soft floor level. Several small stones had been placed in the upper set of ruts, presumably to provide a more stable base for the wheels. The ruts represent the later use of the cartway route, possibly for the northernmost area of extraction.

The section exposed below the ruts showed no evidence for the use of carts. There were three compacted surfaces, possibly representing barrow-way use prior to extension of the cartway. The surfaces consisted of compacted fines with small lenses of clay in between. Below this a layer of larger rubble and fines included large blocks up to 580 mm in size. This overlay a very level and compacted floor of mixed fines and small rubble 3.40 m below the roof level, which represented the earliest of the surfaces on the route with no cart ruts. It resembled the deposit located within the lowest sequence of the western Allen cartway in Central Firs. This floor could have been used for the dragging or sledging of blockstone as it was very level.

This cartway had a possible length within associated apophygate pillar areas of approximately 200 m and was thereafter further extended to the north in

Fig. 9.10 Southern end of the cartway east of the Long Drung

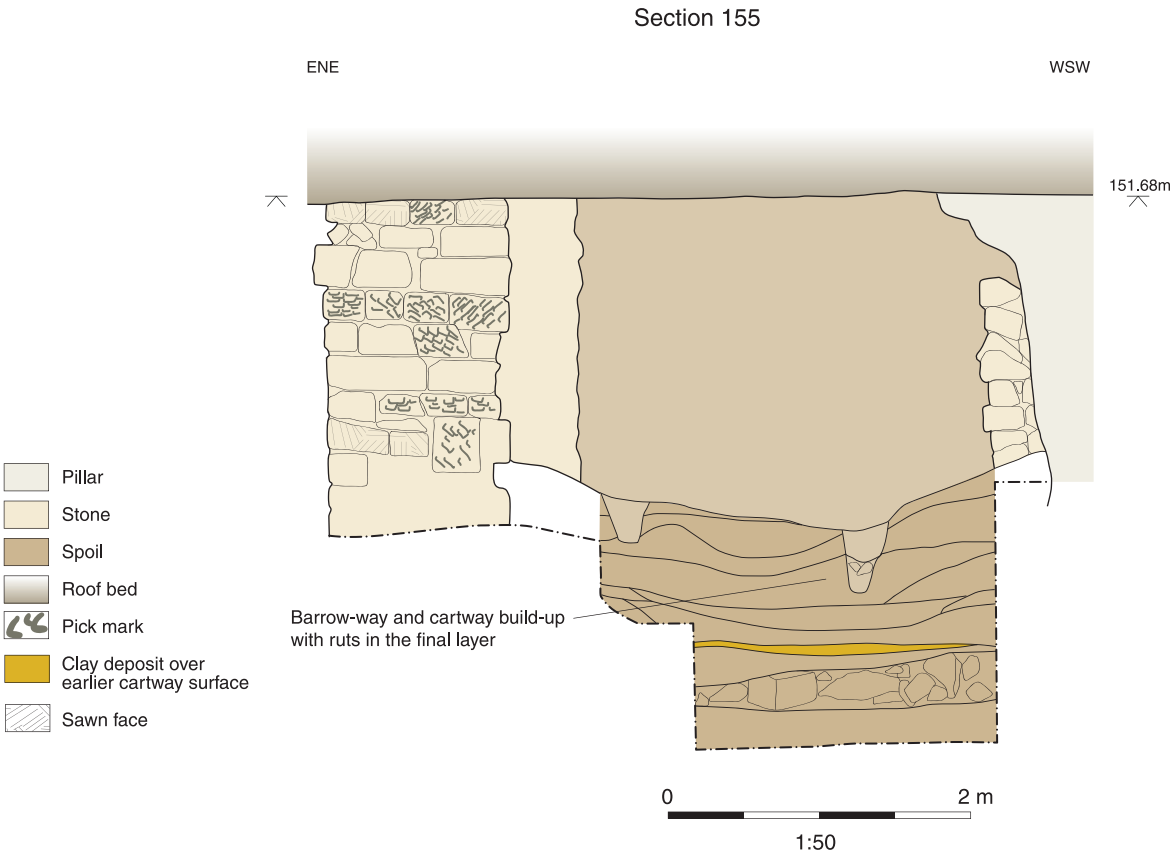


Fig. 9.11 The sequence of deposits in the easternmost cartway, east of the Long Drung (Section 155)

Fig. 9.12 Curving cart ruts cutting deep into the surface of the westernmost cartway east of the Long Drung

the 19th century within Quarry 2363. However this extended length was largely obscured by collapsed roof material. It was by far the greatest single length of cartway recorded at Combe Down. Its length may suggest that this form of pillar was retained much longer than in Allen's quarries, though eventually it was succeeded by just the same forms as used elsewhere at Combe Down.

It may be partly attributable to Milo Smith (who owned parts of Combe Down-Greendown just before Allen started there and worked there for a few years) and/or the Greenway family who were quarrying in Combe Down in the early 18th century through to the early 19th century, somewhere probably east of the Long Drung (see Chapter 5). The cartway system seemed, by its length, to have been the main transport for the Quarry 2339, and also the eastern part of 2350, which were probably part of one quarry reflecting its full period of operation. The cartway was well laid out, and although the former shafts along its length were inaccessible, their locations suggest that shafts were positioned at regular intervals of about 60 m, the first being *c* 60 m from the surface quarry at the interface between Quarry 2339 and 2350.

The westernmost cartway was developed northwards possibly from the same surface quarry as the easternmost cartway, to the south of Church Road. However, it had a definite curve to its course, extending at its southern limits towards the west, possibly towards the eastern edge of the open surface quarry behind Hopecote Lodge (Burgess Quarry). The cartway was associated with an area of apophygate pillars on the southern extent, with corbelled pillars on its northernmost observed stretch. The northern limits of the route, close to Sydenham Place on the surface, had largely been overlain on both edges with stone rubble, with about 1.5 m remaining open in the centre, or had been flanked with shorter sections of stone packs. Other high lateral deposits of mixed fines were representative of finer materials being cleared during maintenance of the cartway surface (Fig. 9.12). Where a short section of the cartway was open, curving cart-ruts had cut into the surface to a depth of 0.40 m. They indicated a gauge of 1.30 m apart and were at a level of 2.30 m below the roof.

Post-Allen late 18th- and 19th-century cartways

Cartway development undertaken by perhaps a dozen independently operated quarries continued after the death of Allen and the break-up of his monopolistic control. The existing cartways seem in most cases to have simply continued development northwards, the change apparent largely in the adoption of direct pillars replacing corbelled as the dominant form, and the height above the cartway floor becoming greater at around 4 m to 5 m, possibly reflecting a greater depth of stone being worked. This increased the recovery of stone, as becomes apparent in later leases (Chapter 6), within the same rental and royalty regardless of depth per superficial area. This was not an instant transition across the area, but a definite trend by the beginning of the 19th century.

Further cartways appear to have been started at the Sheeps House Quarry, with one on the western side of the earlier workings (near the steps on the footpath through to The Firs), and one at the Jones Quarry (Ralph Allen Yard today) passing through a stone arched entry and through the Combe Road Pillar and a short distance (some 20 m) of much earlier apophygate pillars under the William IV yard.

The new Jones Quarry cartway was carried through and along the western edge of the Combe Road Pillar to a shaft offset to the west side about 50 m from the entry. Once through the pillar, the cartway was driven within a 5 m-high, very open Long Room and was notable for distinct jad slots and use of wedges. It had very limited workings off. It appears to have been the only working in the Byfield area before the 19th century. The name Jones Quarry may tentatively suggest that it was worked by Richard Jones and his son, after 1764.

A third cartway was developed in the late 18th century on the western side of the two originals at Sheeps House, again through a small section of (again, much earlier) apophygates, modifying an existing entry (Quarry 2342). It was substantially higher than earlier cartways and had only limited development, penetrating about 20 m in 1800 according to quarry leases. There were faint traces of cart ruts on the surface. Leases also show substantial development took place in the north west corner of Sheeps House Quarry, which must have included the cartway there. This must have taken place in the late 18th century, as soon after 1800 a lease (Chapter 6) noted almost half the distance from the entry to the Turnpike Road had already been worked. Much of the area on this western side of the Firs and between there and East Byfield was inaccessible due to instability and backfilling with spoil, so archaeological examination was very limited.

The first decade of the 19th century saw very considerable development of new cartways in both Byfield and Firs, this time under new ownership but with only limited change of quarrymasters (see Chapter 6). In Byfield cartway development and quarrying had probably stopped before the end of Allen's life. In Firs it had continued, but in the older areas development was coming close to the Turnpike, nowadays North Road. In these cases, and probably also east of The Avenue, shafts and cartway development seem to have been integrated. The landlord, after initial reluctance, agreed to shafts specifically 14 feet (4.25 m) in diameter being put down as was reasonably necessary. Two lines of shafts shown on the first and second edition OS large scale maps ranged northwards in Central Byfield (to what is now Westerleigh Road and north east in Central Firs (over what is now Firs Field from Firs Shaft to the Hadley Arms.

An example of the type of cartway system that operated in the 19th century, and fairly representative of many other examples in form, was located on the eastern edge of Byfield Quarry (514). The cartway was driven northwards towards North Road from the south-western edge of the Sheeps House Quarry, from about 1808 onwards, as the quarry developed. Graffiti dates of 1818 recorded at the northern extent are indicative of the final stage of workings. The cartway extended for 120 m, with an average maximum open width of 5 m, at about 5.71 m below roof height. It was only possible to measure the cartway track on the northern limits of the workings. Here it had an internal gauge of 1.27 m (4 ft 2 in) with the ruts measuring 203 mm (8 in wide).

Fig. 9.13 Nineteenth-century cartway in East Byfield, showing rub marks caused by a cable on the right side pillar, and wheel ruts on the floor

Fig. 9.14 Cartway near Firs Shaft leading towards the Hadley Arms. Note rub-marks from a cable on the left side-pillar and a corbel with a post-working fracture on the right-side pillar

However, this cartway was possibly untypical in that it appears to have used cable haulage of wagons. There were no crane positions along its length, but there was evidence of horizontal haulage from cable grooves and other rubbed and eroded pillar faces (Fig. 9.13) where cable (rope or chain?) haulage is believed to have been used, and several other pillars were trimmed to allow better access for carts. The wear marks led back to a probable shaft location, suggesting a down-the-shaft cable from a surface windlass of some type. A rare example of a loading dock was also located at the northern limits. It consisted of a low stone pack wall constructed of roughly coursed rubble, measuring 3 m in width at the base of the structure. The cartway level had a surface of mixed fines and was loaded from a height of 0.94 m above its floor. A length of iron chain (SF 188) recovered from the edge of the loading dock may have been used for haulage or lifting, although there was no evidence of a crane location. The structure was noted by David Pollard when full access to the dock was possible. He records that the structure had 'accompanying tyre marks on the floor suggest the wagon was a low flat trolley or dray, with a fore carriage that enabled the front wheels to turn underneath the wagon bed. Certainly the fore carriage was able to negotiate a very tight turning circle around and almost touching a single pillar' (Pollard 1994, 42).

Besides the loading dock the main cartway had a secondary spur cartway on the western edge probably representing a turning area for carts. The carts may have been hauled by horse to this point as it was, unusually, large enough for one to turn so as to be facing the correct way, with the wagon in the loading bay structure for loading of the stone prior to the outward journey. This suggestion was by the late Mike Desmond, lead miner on the Combe Down Project, whose own coal mine in South Wales was the last to use pit ponies underground. David Pollard (pers.comm. 2002) had also independently suggested the same operation of the horses.

In Firs the major 19th-century development, other than the completion of older routes, was that driven from near Firs Shaft to near the Hadley Arms, under the north-east area of Firs Field, part of what has been (later) called the Three Acre Quarry. It was operated by John Burgess and son between about 1810 and 1838. It was some 5 m high and 4 m wide and passed next to or under four wide shafts in what was clearly a planned and integrated development. The section near the Firs main shaft cut for some 20 m across older Long Room workings, linking to the northern end of the quarrying area known to us as the Grand Canyon – Quarry area 2209, part of Quarry 2211. Smoothed sides of the pillars close to the Firs Shaft (Fig. 9.14) showed rope wear and it was evident, from cart ruts in the floor turning into it, that the first section last served the Grand Canyon (2209). Cable grooves on the shaft pillars may reflect another down-the-shaft haulage system, though these were destroyed before full recording was possible.

Past that junction the cartway ran in a deep cleft, formed on the south side by roof-high rubble stone packs and on the north, by 2-3 m high packs extending some 7 to 8 m over a platform approximately 2 m below the roof, and to a further flanking line of roof-high stone packs. This may have been an area associated with the cartway for storing or working on stone. The cartway then passed directly under two wide shafts. The first, known today as

Fig. 9.15 The arch supporting the shaft on the Firs-Hadley Arms cartway

the Chestnut Tree Shaft close to the War Memorial on Firs Field, was entirely filled with rubbish, and apart from determining this, its width could not be examined. The next shaft was clearly the main haulage shaft, more or less central to the Three Acre area (and was used by the Stabilisation Scheme as the Materials Shaft). The shaft (Chapter 12, Case Study 9). had been heavily reinforced by stone arches and rubble and block pack walls, apparently from the true floor of the excavated working to the roof and, on one side, to the surface (Fig. 9.15). The cartway on the north-east side had been blocked off and the cartway backfilled, suggesting that the north-east area was worked first, and in comparison to the clear floor from the Grand Canyon to Firs Shaft, the cartway floor on the west of the (arched) shaft had been allowed to deteriorate, suggesting the Grand Canyon section was among the last sections to be worked within the quarry. It was not possible to examine the cartway north-east beyond the arched shaft, but there is documentary evidence of a further shaft near the Hadley Arms and another was found in the area between the Long Drung and The Avenue, also worked by Burgess, so the cartway may have continued that far.

Barrow-ways

Throughout the workings there was an intricate network of barrow-ways used by single-wheeled barrows. These were used for transporting both rubble and blockstone en route to the quarry entry for sale, and for transporting waste material (spoil) to suitable locations that were more than handling- or throwing-distance from the working face. The type of wheelbarrow used, from the limited evidence of one survival-shadow (Fig, 9.16) and a few wrought iron wheel rims was similar to the usual builder's barrow, with the single front wheel running at one end between two long timbers with the handles at the other end. In between was either a flat bed for carrying blockstone or a bed with sides, called raves, for carrying spoil. In some cases the raves could be removed to convert to a flat bed, though specialised use of each type would have been simpler. As barrows often had to be operated under low roofs, causing the barrowman to stoop, shortened rear legs, in comparison to the builders' barrow, would have been advantageous. It is possible a 'mining barrow' (see Figure 9.17), with the body slung below the long timbers may also have been used (Derek Hawkins showed such a mine-barrow surviving at one of the Wiltshire Quarries at the 2010 NAMHO conference). Wheelbarrows could probably carry loads of up to 250 kg in favourable circumstances. Beyond that, two-wheeled quarry carts or four-wheeled wagons were probably necessary for all but short distances where dragging or rollers might be used.

The virtue of the wheel-barrow lay in its economy in first cost and in use, manoeuvring ability, and ability to move substantial loads with a single labourer. It required only small and narrow openings and could be used with low roofs (even below a metre were recorded, though these must have made for great difficulty) and can turn right-angled corners or worse with ease. It can be tipped over its front end, projecting material some height off the floor, with further height gained by using a small planked or spoil incline. Alternatively it can be tipped with great ease over the front corners or side, with care maintaining a fairly level floor with

Fig. 9.16 Wheelbarrow 'shadow' in East Firs, close to the Long Drung

tipping slope beyond. It was almost certainly the most used vehicle in the quarries. Its needs are few, but a level flat floor without even pebbles projecting make it much easier to use, and a reasonable roof-height above the floor (just less than human height) assists greatly, though the barrow with a willing operator could overcome almost any disadvantages if required (Fig. 9.17).

The extents and orientation of the barrow-way routes were recorded during the archaeological survey and plotted in relation to associated components, including cartway routes, shafts, spoil tipping fronts and tipping platforms and other deposits of spoil along their routes. Fig. 9.18 shows an example of the annotated drawn plans prepared during the archaeological survey with the barrow-ways and the pillars highlighted against the detail of surrounding features in Quarry Area 2332 in East Firs. Where possible the barrow-way routes were phased and related to the quarrying areas in which they appeared, and also recorded in relation to adjacent earlier or later sequences of routes. The direction of the tipping fronts and the use of the barrow-ways was recorded on the synthesised drawings of the quarries, and these were also used to relatively or absolutely phase some of the quarrying enterprises. The widths and the heights of the surfaces below the roof were recorded in order to interpret how easily

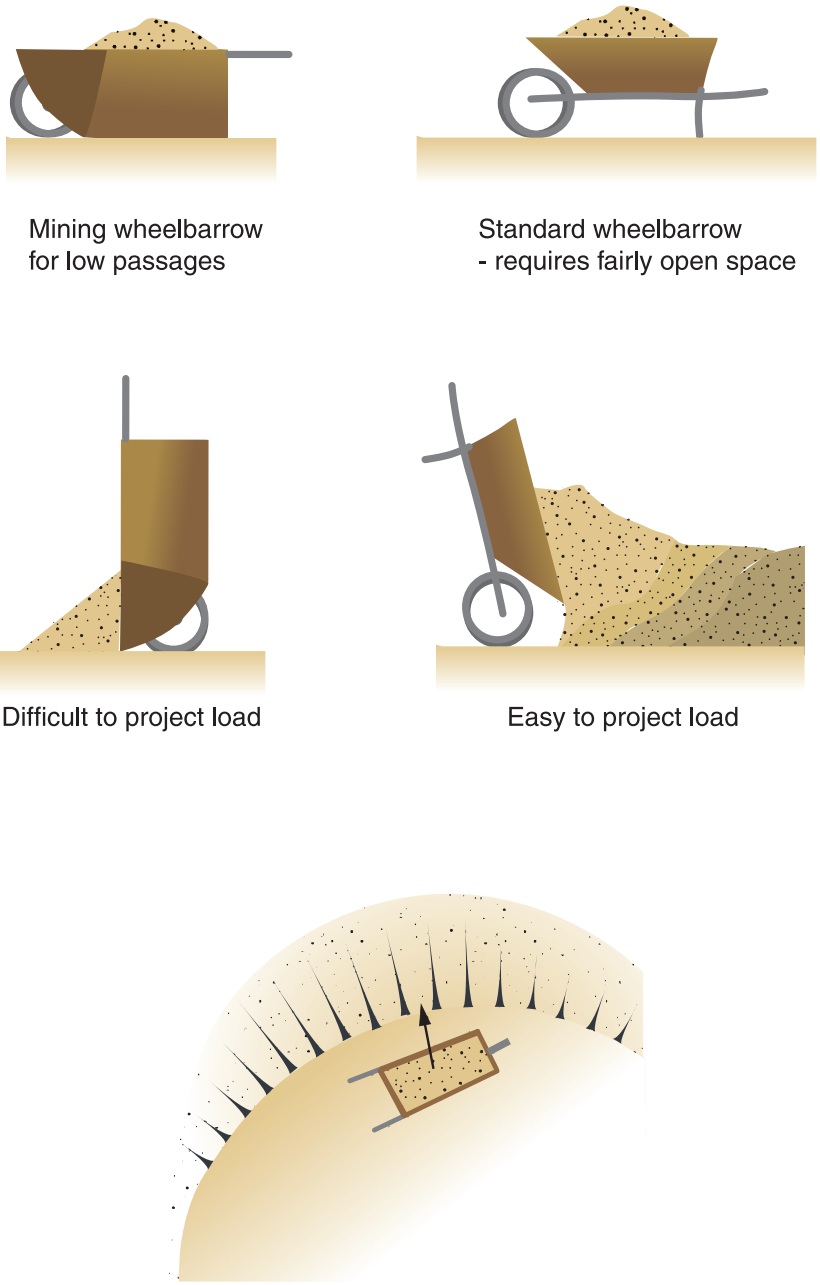


Fig. 9.17 Types of wheelbarrow and their use

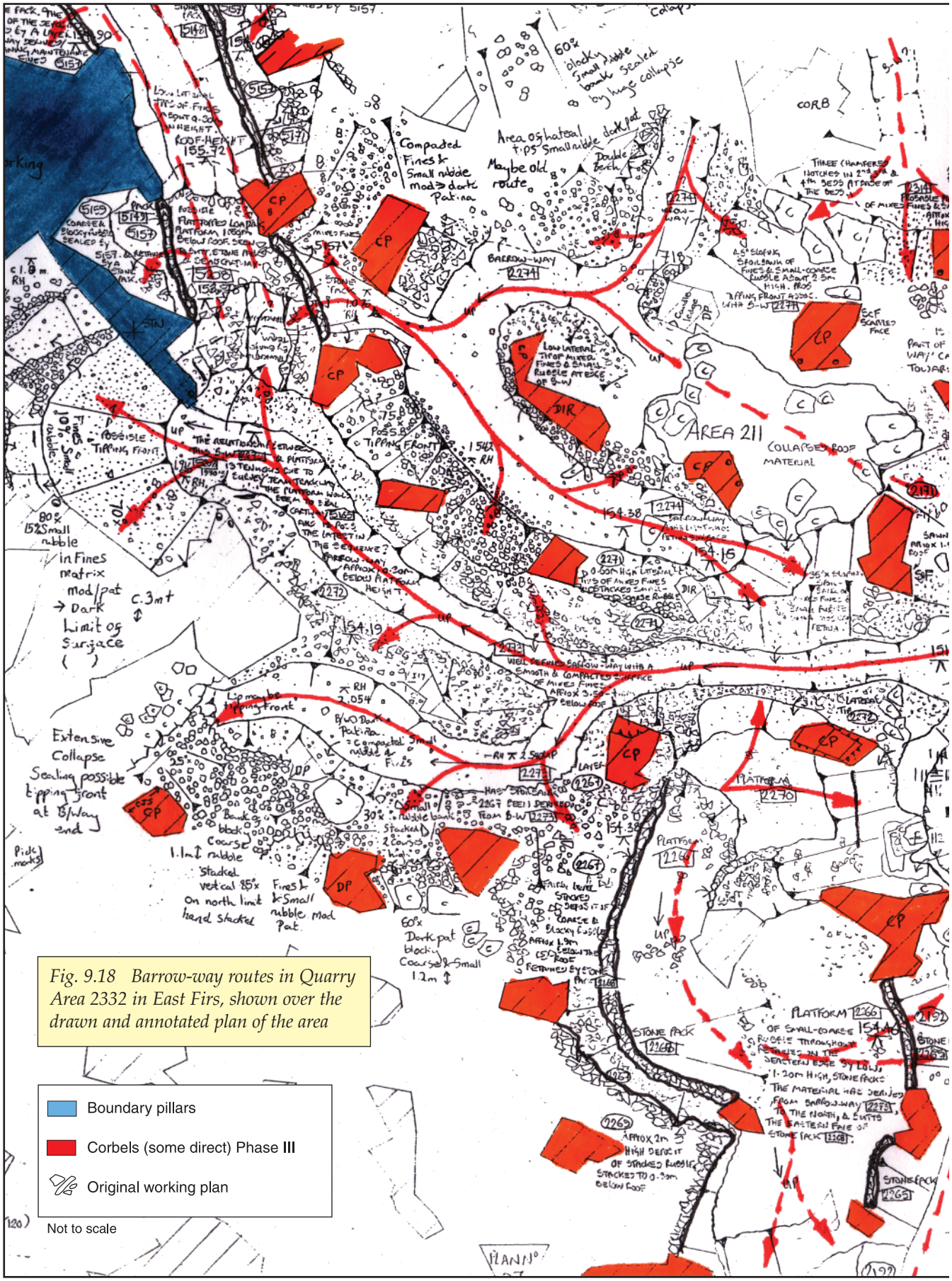
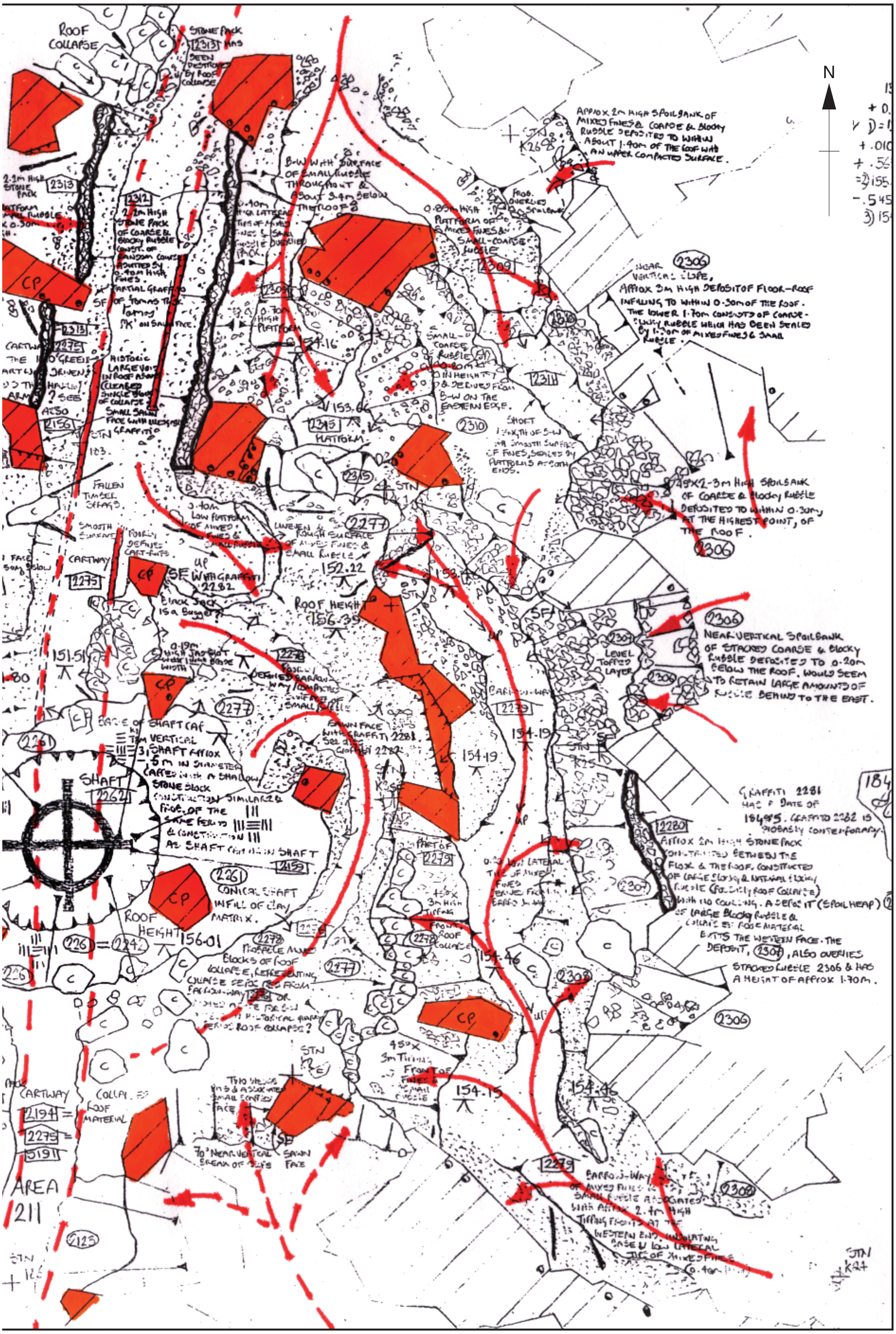


Fig. 9.18 Barrow-way routes in Quarry Area 2332 in East Firs, shown over the drawn and annotated plan of the area


N
ROOF COLLAPSE
STONE PACK 2313 HAS BEEN DESTROYED BY ROOF COLLAPSE
APPROX 2m HIGH SPOILBANK OF MIXED FINES & COARSE & BLOCKY RUBBLE DEPOSITED TO WITHIN ABOUT 1.40m OF THE ROOF WITH AN UPPER COMPACTED SURFACE.
NEAR VERTICAL SPOILBANK OF STACKED COARSE & BLOCKY RUBBLE DEPOSITED TO 0.20m BELOW THE ROOF, WOULD SEEM TO RETAIN LARGE AMOUNTS OF RUBBLE BEHIND TO THE EAST.
GRAFFITI 2281 HAS A DATE OF 1845. GRAFFITO 2282 IS PROBABLY CONTEMPORARY.
SHAFT 2262
ROOF HEIGHT 156.01
AREA 211
CP
152.22
154.19
154.46
154.15
151.51

they could have been traversed by the quarrymen pushing loaded barrows.

Barrow-ways varied immensely in both form and use. Some cartway routes were probably used for both carts and barrows at various times and were frequently adapted to barrow-ways in later use. In open-working areas, the whole flattened floor area could have acted as a barrow-way route. Some barrow-ways functioned both to remove stone and spoil, though usually not both over their whole lengths – it was not always easy to differentiate the purpose, except where the barrow-way leads directly and only to a spoil dumping area or heap. Spoil-dumping barrow-ways had a particular value in that they may reflect opening-out of areas, so their position may indicate where work started: dumping from one area to another yields stratigraphic relationships which can indicate sequences and even allow derivation of dates or phases of working.

Barrow-ways used for access and stone extraction

In quarrying areas not directly served by the cartway network stone was transported either to the surface level entry or to a vertical shaft equipped for winding. Many of the longer (measured in a few tens of metres) barrow-way routes for stone extraction tended to be located in the quarrying areas to the east of the Long Drung, where smaller quarrying enterprises were established after about 1830. Access to the quarries was restricted to vertical winding shafts, with a reduced, if any, dependence on the larger cartway transport routes. Such barrow-ways became the main routes for the transport of the finished project, and usually were also used for the disposal of spoil. Within these quarrying areas where stone was sometimes quarried only for the construction of houses above, less of the total depth of commercially viable freestone was extracted and as little as 2 to 3 m taken. The routes often connected a working face at one end and a vertical winding shaft at the other. Such barrow-way transport routes often had flanking stone packs on either edge to protect the barrow-way from dumped rubble (of which a higher proportion was likely with lower depths of extraction) and for additional support for the roof.

A good example of probably the longest of this type was a barrow-way noted in Quarry 2356 (Fig. 9.19). It extended for at least 75 m, with floor to roof flanking packs on either edge. It was between 0.86 m and 1.20 m wide and had well-maintained and compacted floor surfaces. Several phases or sequences of barrow-way were noted, with the heights of the compacted barrow-way surfaces recorded at 1.50 m, 1.90 m and at 2.40 m below the roof level. Often several stone packs had been constructed on either side of the access routes. Sometimes they directly abutted the face of the previously erected pack and sometimes a thin deposit of mixed fines and rubble was stacked between successive builds. This barrow-way route and other examples of longer barrow-ways acted as access routes for the quarrymen and used, as conditions were adequate, to carry the finished stone, but they were also maintained for the lateral disposal of spoil in the flanking packs. This made them semi-permanent routes.

Fig. 9.19 Barrow-way in Far East Firs (Quarry 2356)

Fig. 9.20 Barrow-way in Far East Firs (Quarry 2365)

A shorter barrow-way of this type was recorded in Far East Firs in Quarry 2365 (Fig. 9.20). The barrow-way was initially 25 m in length and 0.80 m wide and was 1.80 m below the roof level, later developed to a length of over 50 m. Access was good throughout with level and compacted surfaces of fines. It had flanking packs along its length which retained discards on either edge, with adjacent rooms filled with spoil. The route linked the working face on the boundary pillar on the eastern edge of the Firs complex to a shaft in the north of the quarry.

Barrow-ways and spoil dumping

These showed the greatest variety, the workmen using any convenient strategy or tactic to minimise the effort of dumping worthless material. They utilised existing ways where available, sometimes on long disposal routes which took on a semi-permanent character with well-defined flanks, but in other cases, particularly in substantial areas available for dumping, they adopted a distributary (diverging branches) form (see Chapter 12, Case Study 7 for detailed plan of these). Often, however, they seemed less organized, dumping at any place in which spoil could be placed. Very often the distributary areas were formed on top of the spoil dumped or stacked directly, by hand, behind the face and gullet, and it was common for them to use adjacent quarries. Once open spaces had been utilized (possibly by several layers of spoil over successive barrow-ways amounting to several metres depth), the barrow-way routes were themselves filled in as a final act on retreat (Fig. 9.21). The barrow-ways often followed the former routes and were formed and built up over successive barrow-ways totalling several metres depth. This process of dumping over old cartways, spoil dumps and old barrow-ways led to very complex systems of barrow-ways one above the other, sometimes requiring inclines. What was actually visible was the last phase of barrowing over the immediately previous stage of dumping. Nearly every excavation (a near continuous process over 15 km of supported roadways) carried out by the Stabilisation Scheme that cut through spoil revealed sections of former barrow-way routes running below the visible surface.

One of the more simple sequential series of barrow-way activity was noted within the Central Firs Quarry 517 where three separate barrow-ways were recorded in section (Fig. 9.22). These are thought to date to the early 19th century, as the latest in the sequence at least had abutted adjacent sawn pillar faces, which would have needed to be clear of the floor in order for them to have been worked. The barrow-ways were probably all employed for deposition of spoil from the quarry workings of the earlier adjacent Allen period Quarry (505). The uppermost barrow-way had a compacted surface with low lateral tips of small rubble and fines. It was about 1.30 m below the roof, and sealed two earlier phases, located at 1.90 m and 2.10 m below the roof respectively. The lowest barrow-way exposed was seen to abut a rubble pack on its western face that had been constructed from an earlier unexposed barrow-way or quarry floor. The height of the uppermost barrow-way to the quarry roof was rarely below about 1.10 m, which provided a low but relatively normal (though undoubtedly uncomfortable) height to adopt a

stooping posture while pushing a loaded barrow. This changed near the final deposition end of the barrow-way, which was a spur where the height was sometimes reduced to as little as 0.80 m, probably implying hand-stowing at this point.

A slightly more complex series of barrow-way routes, and representative of many of those investigated, was noted within a section (Fig. 9.23) exposed in the Firs Quarry (2347). The barrow-way was used to transport spoil from the main quarrying area to the west to deposit it in a Long Room. The barrow-way sequences were all attributable to the same phase of workings. The earliest deposit in the sequence was a surface of mixed fines located at 2.40 m below the roof. It also formed the point at which a lateral stone pack was constructed on the northern limits of the Long Room. A more extensive barrow-way or floor surface was also

Fig. 9.21 Barrow-way filled in on retreat in Central Firs. The rubble pack rests on the former barrow-way (Quarry Area 2347)

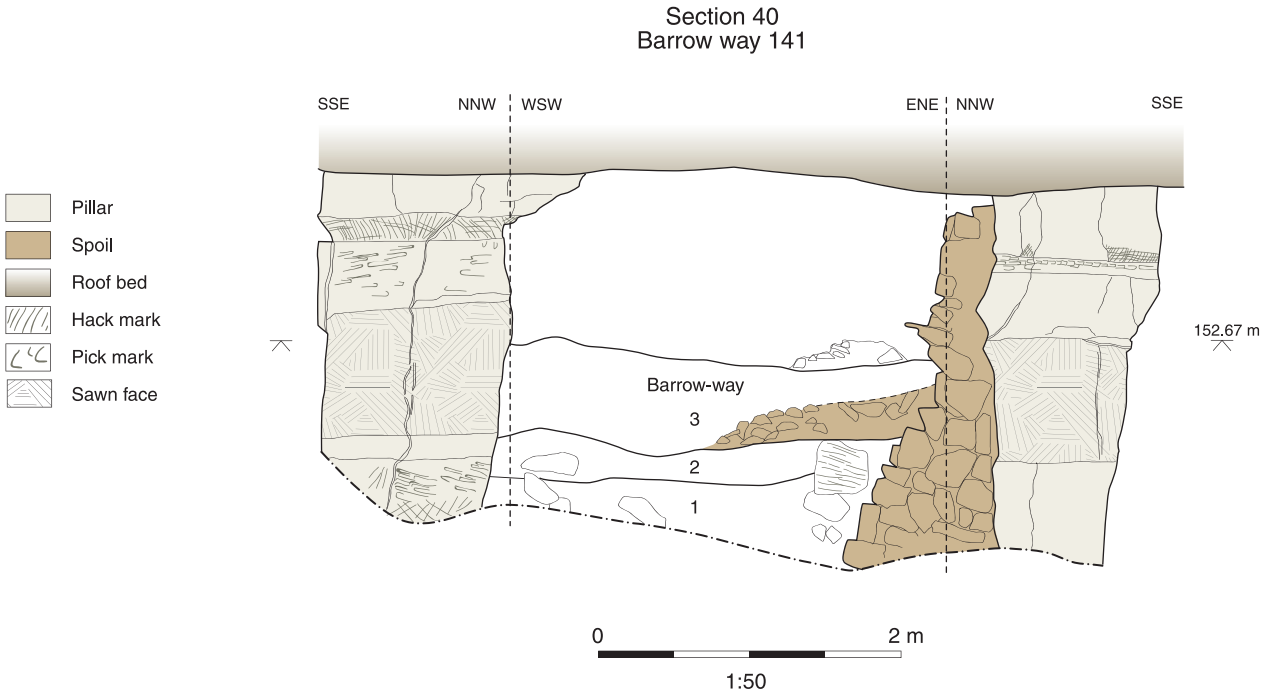


Fig. 9.22 Section showing the sequence of three filled-in barrow-ways in Quarry 517, East Byfield

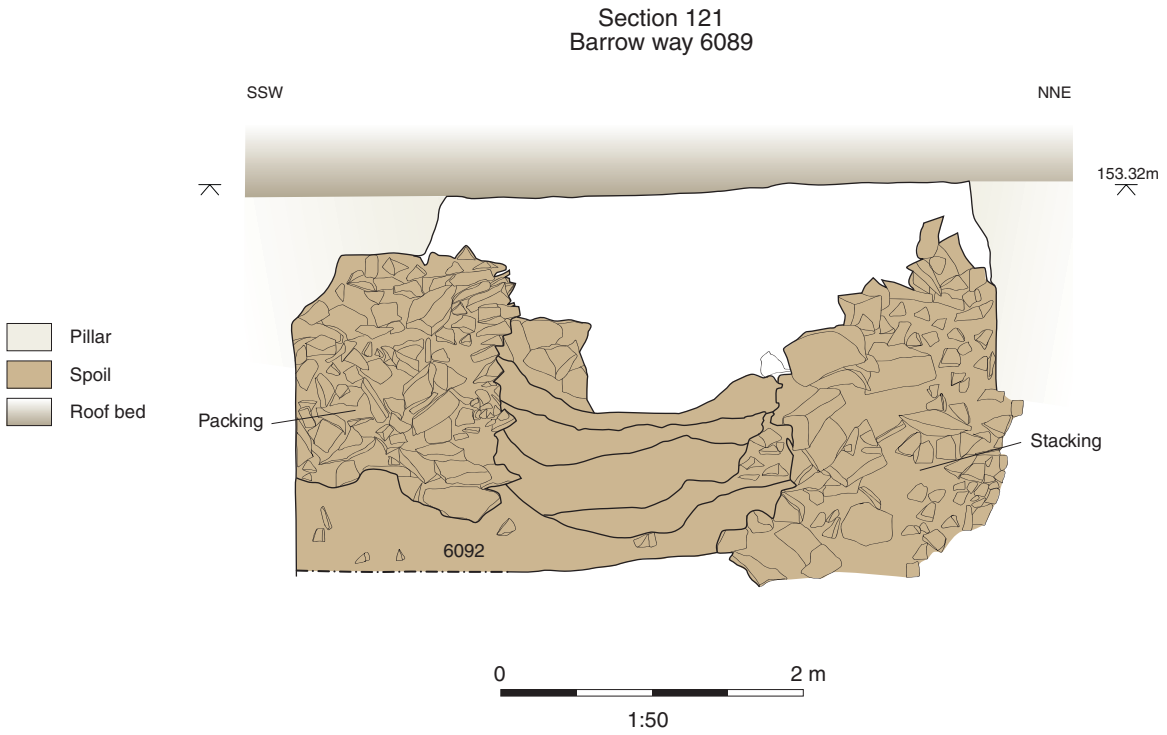


Fig. 9.23 Section of barrow-way in Central Firs (Quarry 2347) with lateral rubble-stone packs and stacking

noted at 2.40 m below the roof, from which a stacked rubble deposit on the north side was built. The floor was sealed by an undulating deposit of fines and small rubble 2.24 m below the roof, upon which lateral rubble was stacked. The uppermost barrow-way, which abutted both the stacked rubble deposits, extended another 15 m to the end of the room, and had four distinct compacted barrow surfaces located below the uppermost surface, at 1.42 m, 1.50 m, 1.72 m, and 2.04 m below the roof level. The deposits within the barrow-way sequence gave approximate depths for the deposited fines and rubble of between 0.20 m and 0.30 m, apparently fairly standard throughout.

A further example of barrow-way complexes is included in the case study of the Grand Canyon (Chapter 12, Case Study 9).

Features of barrow-ways

Barrow-ways averaged about 1 m in width, and had well-maintained surfaces of compacted fines or small rubble on the uppermost, often slightly depressed surface kept free of obstructions so as not to hamper the access by barrows. The quarryman had to navigate between the roof-supporting pillars, which thus always affected the routes. Especially in wider spaces, the orientation of barrow-way changed over time, which was sometimes the result of side tipping and subsequent wheeling over the later dumped material and sometimes from deposition of overlapping successive surfaces, or from raising the floor to deposit another spoil layer, perhaps at a late stage in the life of the barrow-way. These resulted in successive sequences of the barrow-way surfaces and their constituents, and also the lateral tips of fines and rubble deposited at either edge. The latter could include remnants of flanking stone packs.

Some barrow-way surfaces contained specific evidence for the use by wheelbarrows, though this was fairly rare with only eight examples of wheelbarrow grooves, all 19th century in date, recorded within Byfield and Firs. Such features were rare because they were prone to damage and easily filled with fines and clay washed in by water egress, or were trampled by quarrymen and later visitors or buried below later barrow-way sequences. Finds of iron tyres, and the impracticability of small wooden wheels subjected to such battering and wear make use of iron tyres almost certain on barrow-wheels.

In Byfield Quarry 514 a series of broken lengths of curving and straight barrow-ruts were preserved in the top of tipping platforms. They were 50 mm (2 inches) wide and represent the width of the wheels' tyres. The platform also had a centrally located groove where barrows had repeatedly traversed the same part of the barrow-way. This groove feature was also noted on barrow-way surfaces in the Byfield Quarry 510, and Quarry 2344. Barrow ruts 25 mm (1 inch) wide were also noted on the surface on the north-eastern edge of the Grand Canyon (2209). These linear ruts had were preserved in the centre of the barrow-way in wet, slightly clayey conditions and were attributable to one of the main phases of spoil dumping from the eastern end of the Canyon. Another feature seen near to the Firs Shaft showed the ruts curving up the lateral spoil dump

Fig. 9.24 Barrow rut preserved by calcitic flowstone Eastern Firs (Quarry 2337)

alongside the barrow-way, preparatory to tipping the barrow over its front corner. The survival of barrow ruts was assisted in some cases by calcitic deposition on the softer surface, noted, for example, in the centre of a barrow-way in the early 19th-century Firs Quarry 2337 (Fig. 9.24).

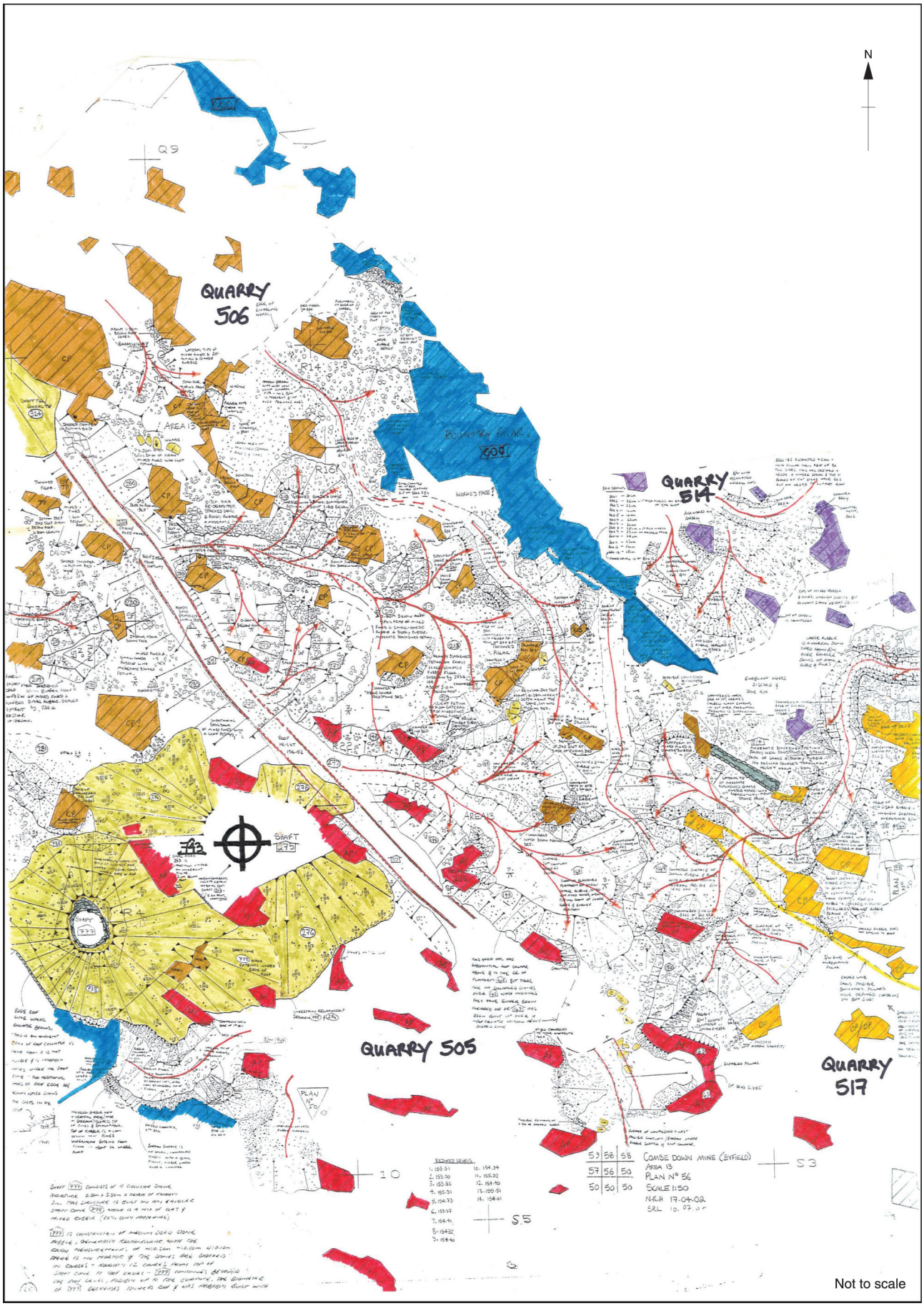
The make-up of materials within barrow-ways could include small and coarse fines (up to 5 mm) and rubble and coarse rubble 50 to 500 mm in the longest direction, with a thin layer of fines and small rubble (5 to 50 mm) forming the uppermost surfaces, which were compacted by regular barrow activity. The make-up materials could also be composed of larger pieces of rubble and even blocks (over 500 mm) or with clay deposits disturbed (usually in gulls) during the extraction of the stone. Clay was not a good material to barrow over and so tended to be deposited on the end of the routes on the tipping fronts and platforms. An example of this was contained in the tipping platforms in Byfield Quarry 514, where platforms contained a high proportion of clay-derived deposits buried below, while the barrow-way surface itself was relatively free. Where clay was deposited along the barrow-way routes as a sub-floor, it was overlain by a layer of fines to provide a more suitable surface. This method of using fines and/or small rubble for the uppermost surface to level it and provide a better surface for barrowing was also noted where larger rubble had been deposited in the make-up surfaces. (The floors of the Stabilisation Scheme roadways were prepared in a similar manner even though the tracked machinery was capable of dealing with far worse surfaces than a wheelbarrow).

Barrow-way routes were generally fairly level or had only very slight inclines or declines; understandably, severe inclines were avoided where possible. Where steeper inclines were recorded they tended to be in the areas with greater restriction of space. This could occur during the initial opening up of an area, for example, before the gullet moved forward to allow for spoil disposal behind. Inclined barrow-ways tended to be longer, again reflecting local shortage of space, while the longer travel distances would be less economic in time and effort to dispose of a barrow-load. There were thus few examples, perhaps less than half a dozen, of the steeper inclined barrow-ways of around 1:5 or 1:4 inclination.

An inclined barrow-way, recorded on the interface between Quarry 2202 and 2340, probably developed in the early phases of the quarry. It was about 38 m long and 1m to 1.30 m wide. It branched into two distinctive tipping platforms and other smaller barrow-way spurs and tips. One platform was formed by tipping into the deeper earlier quarrying area of (2340) and was *c* 5 m high. The barrow-way and tipping platforms may have been created when the initial northern extent of a cartway was developed at the position of the base of the inclined barrow-way for the disposal of spoil. The room in which the cartway was driven at this point may not have been much wider than the cartway, and of a similar width, about 4.50 m.

Another good example of an inclined barrow-way, which was carefully examined during the archaeological survey, is discussed in Chapter 12 (Case Study 9) at the Grand Canyon. It illustrates how spoil derived from different heights at a quarry

Fig. 9.25 (facing page) Barrow-way system linked to a cartway in Central Byfield (Quarry 505)


N
QUARRY 506
QUARRY 514
QUARRY 505
QUARRY 517
AREA 15
AREA 13
SHAFT
Not to scale

face was removed on the level to different spoil dumping areas, thus avoiding unnecessary effort in dropping spoil down only to have to raise it again via an incline. It is clear that the steep and long incline there was only used for spoil produced at the lowest levels, perhaps at a final stage of further deepening of the quarry, when nearby space was either exhausted or inaccessible. At that point the stone packs had risen to over 4 m high at the sides of the barrow-way.

Evidence for the contemporary use of barrowing from active cartways was recorded in the Byfield Quarry 505 where the mid 19th-century cartway had barrow-ways developed from the northern edges of the quarry, linking to tipping platforms (Fig. 9.25). The cartway continued in use as the primary transport route for stone leaving the quarry, for later quarrying at the north of the area, and transported stone past the barrow-ways. Some of the cart-ruts were partially filled with fines where the barrow-ways were active across its path.

A vertical sequence of barrow-ways in relation to earlier cartway sequences at what was originally Allen's western cartway was investigated in Central Firs in Quarry 2200 (Fig. 9.26). The sequence was in a vertical face of spoil where later quarrying activity in Quarry 2370 had truncated the barrow-ways and cartways and presented a high, free, stepped depositional profile. The barrow-way activity was associated with later deposition derived from a small scale 1860s scavenging operation at Quarry 2368, which included activity in the northern and central end of an adjacent cartway. The barrow-way activity within the former Allen cartway consisted of nine distinct barrow-ways of mixed fines and small rubble with occasional larger rubble and blocks. The uppermost

Fig. 9.26 Vertical section in Central Byfield (Quarry 505), showing successive barrow ways

barrow-way was 2.80 m below roof level and the lowest in the sequence was 3.90 m, directly overlaying the uppermost cartway surface. All the barrow-ways in the sequence abutted an earlier stacked rubble or stone pack on the eastern edge of the cartway surface. The surfaces varied in depth from between 0.08 m to 0.28 m and were fairly typical of the barrow-way depths noted elsewhere (see Chapter 12, Case Study 15).

Unusual forms of barrow-way

The main passage within the lower of John Scrace's unusual two-level workings in northern Byfield Quarries 508 and 512 contained a carefully maintained barrow-way. It was *c* 1.80 m wide and 3.30 m below roof level, and had an extraordinarily clean floor, devoid of debris, with an appearance of being literally swept clean. The route was used to convey stone from the working area at the northern end of the quarry to a possible entry to the surface open quarry west of Combe Road and south of the Bradford Road, which was active in the early 19th century. Low lateral packs had been constructed to retain varying sizes of waste rubble either side of the principal barrow-way. The rubble was well-sorted and neatly stacked. The quarry is considered below (Chapter 12, Case Study 8).

Haulage and winding

Much of the movement of materials was by hand, by use of iron bars (levering), lifting, carrying and throwing or by sliding, sledging or use of rollers, and, as described above by using carts, wagons or barrows. In order to move stone to surface, or in the case of spoil, to a distant dump, some form of mechanical equipment was used. The only firm evidence of manual equipment useful for these were finds of bars and two very long and wide and substantial timber planks and the shadow of a wheelbarrow noted earlier and what was most probably the handle of a two-wheeled cart. There was some evidence in wheel marks for wheelbarrows and in ruts for the four-wheeled cart or wagon, In the few later quarries there was use of narrow-gauge railways, in the form of sleeper-troughs, and for cranes, most commonly in anchorage points, cable grooves and impressions and in crane bases and chog holes in the roof. Winches were mentioned in early 19th century documents, and evidence of their use has been found in spigots, chains on pillars, a pulley, and floors over which stone appears to have been dragged.

As noted above, the wheelbarrow was capable of shifting loads of up to some 250 kg, though less was usual. It was cheap, effective and very manoeuvrable. For heavier loads the quarry cart or some type of wagon was required. The two-wheeled cart (Fig. 9.27) was available at least by the 19th century. It had a single long handle and effectively used its axle and wheels as a fulcrum to raise the stone from

the floor prior to moving off. It consisted of a level platform mounted above the wheels and axle, fitted with a long and very strong handle with a cross-piece to facilitate pulling. To load the stone, the platform was placed vertically next to the stone, which was secured to it, probably by chains, with the handle raised vertically. By chocking the wheels and then pulling on the long handle the platform and stone was rotated to a position above the wheels and the cart and load could be pulled across a level floor. Typically only some 0.7m wide, based on Wiltshire examples (Pollard, pers comm.), the two-wheeled cart was capable of operation in narrow spaces such as the gullet, as well as on wider cartways. The device was capable of handling a ton with two or more men to pull it. The handle of such a cart was found underground near the Arched Shaft in Central Firs, worked by Burgess 1810-38 (Fig. 9.28). It was about 2 m long and some 150 mm square, heavily protected at the top, or handling end, by iron strip reinforcing, presumably to protect against hitting the roof.

The quarry truck or wagon, as used in the Wiltshire quarries was a four-wheeled, flat-bodied vehicle, with spoked wheels and a swivelling front axle. The width of cart ruts at Combe Down suggests a body width above the wheels of about 4 feet (similar to those used in the Wiltshire quarries) or slightly smaller, and it was probably about twice as long. No remains were found, but facilities were

Fig. 9.27 Example of a two-wheeled cart at Beer Stone Quarries, Devon (photograph by David Pollard)

Fig. 9.28 Shaft from a two-wheeled cart, found near Burgess' Arched Shaft in Central Firs

provided at a loading bay in north-east Byfield (see above). It could be fitted for either horse-haulage or be pulled by men. The evidence for horse haulage underground is scanty. A few horseshoes were found, and one of the cartways within the Byfield Quarry 505 had what appeared to be horse hoof prints on the surface (Fig. 9.1**).** There was no evidence of facilities provided underground for horses, though in such small quarries this would anyway be unlikely. It may be that horses were occasionally used, but human haulage was the normal mode, as in many mines with small distances to cover.

A 1751 illustration of a large stone being hauled shows a carriage of heavy timbers with axles on which were solid wheels of up to 2 feet (0.6 m) diameter, without any form of steering, being hauled by use of a cratchet winch (see Fig 5.11). It would have been suitable for very heavy blocks of stone such as those seen at the Priory Park Gates, but although associated with other Combe Down equipment in the article, it is not certain that it was used there.

Railways

There was no archaeological evidence for the use of timber rails underground in a similar way to those used at surface. Evidence for use of narrow-gauge railways was very limited in the Firs-Byfield area of Combe Down, with use only apparent at James Riddle and Son's Allotments Quarry (518), linking the working area with a shaft in the early 20th century. It was possible to observe the track bed with timber-sleeper voids of about 0.85 m (2 feet 6 inches) gauge here and several dog or brog nails were found, of the type used to secure flat-bottomed rails to timber sleepers. It probably used a pre-existing cartway route, as it cut into existing spoil deposits. The working area was served by post cranes, which would have been used for loading the flat-bed wagons. Several chog holes from the cranes remained in the roof reflecting their shifting positions and probably that of the railway (see also Chapter 12, Case Study 14).

Railways were used in the areas at the Foxhill and Shaft Road sites that were archaeologically investigated, again in conjunction with post cranes (Chapter 12, Case Study 13). Illustrations of stone quarrying show a simple bogie with four wheels and a flat bed, and probably those at Combe Down were of a similar pattern (Fig. 9.29).

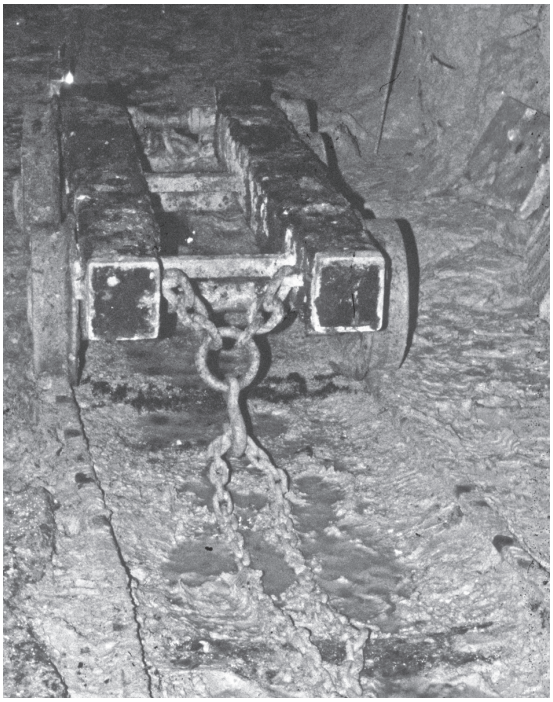


Fig. 9.29 Flat-bed four wheel bogie stone wagon (photograph by P. Wooster)

Capstans and winches

Various forms of capstan (vertical axle and drum) and winches (horizontal axle and drum) were used at surface to lift blockstone by means of cranes, both

Fig. 9.30 Grooves in the side of a pillar at Allen's east side entry at Jones Quarry (Ralph Allen Yard), the nearly horizontal grooves suggesting the crane cable was diverted up the cartway to draw-out carts or wagons

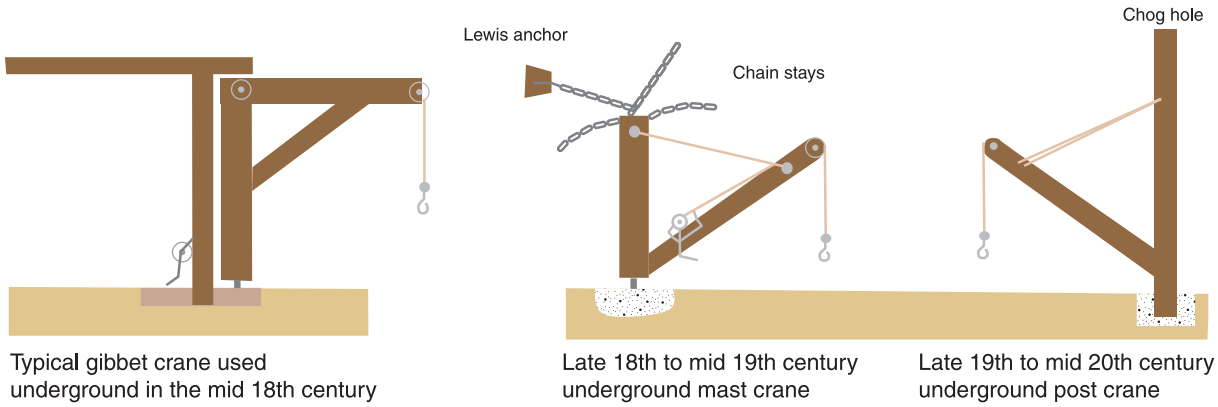


Fig. 9.31 Types of crane used underground

Fig. 9.32 Crane-cable grooves in the branch cartway out of the east Allen Cartway in Central Firs

Fig. 9.33 A Lewis in situ in north Central Firs, used to hold a crane stay

man-operated and, from description, horse-operated. In all the likely Allen Phase II quarries and later workings, there is evidence in the form of cable grooves, of the cable being extended down shafts to either winch stone or to haul a wagon along a passage (Fig. 9.30). In one instance west of the Long Drung (Quarry 2361), the cable was clearly drawn up the shaft (see Figure 7.6), to pull blocks of stone from some metres away from the shaft bottom, where they were presumably stored.

The capstan and possible early forms of wood-framed winches or windlasses probably gave way in the mid 19th century to the winch (crab-type) with a geared cast iron barrel with ratchet, wound by one or two men using chain or, later, iron or steel wire rope. The sparse evidence of this type of mechanism is in a sale of John Scrace's quarry (508 and 512), in the corner of the junction of Combe and Bradford Road in about 1809, which included a share in two windlasses (Pollard 1994).

Lifting and cranes

Cranes were introduced by Allen, to the design of the engineer Padmore (Chapter 5) from *c* 1730 at surface. These used a capstan and a rotating gibbet and raised stone from the entries to the cliff top and railway. It seems likely that these, or parts from these were mounted over shafts when they were first constructed, perhaps late in Phase II (late Allen period). The only surviving detail is cable grooves at the bottom of shafts worked at that time. Cranes of perhaps a similar but smaller type appear to have been used underground in the mid or late 18th century, probably early in Phase III. They were clearly, from anchorage evidence, of a stayed mast type, but it is unclear whether these were jib or gibbet types. In either case there must have been some form of bearing stone for a pivot, though none was noted during the survey. The variety of types is shown in Fig. 9.31.

At least three fastenings and chains for each crane would have been required, but, by analogy with later surface cranes, there may have been more in case one stay broke. Traces were found of Lewis holes from anchors on pillars, grooves from cables wrapped around pillars, and, in one instance, of the chain impressing a negative mould of itself in a pillar face in the Allen Estate Quarry 2201(Fig. 7.14). The use seems to have been an experiment, used only in one area on the east side of the Allen cartways in Central Firs, where they seem to have lined the cartway. Blocks were probably dragged from nearby Long Rooms and loaded on to carts. Cable grooves at an angle indicating an origin near the roof are characteristic evidence of their use (Fig. 9.32).

Crane anchorages

No complete examples of cranes survived at Combe Down, though examples survive in some Wiltshire underground quarries. The usual evidence for their

Fig. 9.34 A post crane base-stone, with a pillar behind and a chog hole in the roof with a Lewis slot

use was the crane stone or base stone, the chog hole or anchorage points (usually Lewis or wedge holes), cable grooves, or haulage grooves and rub-marks from the movement of the jibs.

The Lewis (Fig. 9.33) is a keystone shaped three prong iron or steel lifting and anchoring device that fit into a 'dovetail'-shaped Lewis hole in a stone block or pillar. It was often referred to as a pair of Lewises. The dovetail hole in the stone can be cut easily and quickly by the quarryman, using a holing pick, after which the two outer prongs are inserted and fixed in place by the third, central prong and fastened in place using a U-bolt to which a cable is attached. It can withstand a direct pull. The simple straight-sided wedge hole was also used as an anchor, often placed around the back of a pillar so that the pull on it was at right angles to the wood or iron device in the hole. Its virtue was probably to lessen the length of chain otherwise needed to wrap right around a pillar, a method that was also used.

Both mast and post cranes required a basestone, on which the post could pivot. The only basestones found related to the later post cranes were located in the early 19th-century Riddles Quarry (518). The example (Fig. 9.34) was formed from a substantial block of stone up to about 0.9 m square and 0.4 m or more deep. In this a slot of the width of the post was cut, leaving the rear of the stone intact. This allowed

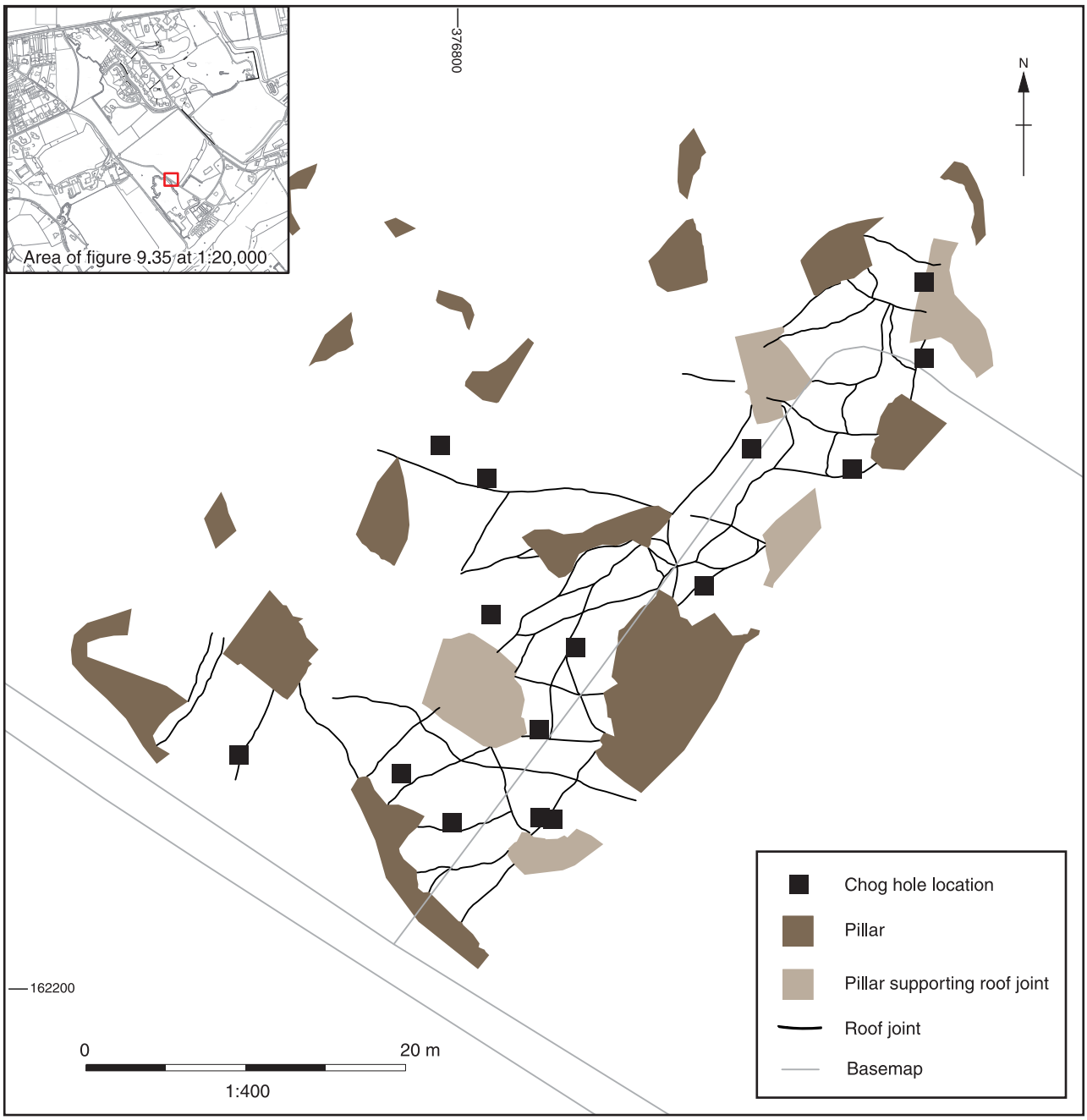


Fig. 9.35 Chog holes and their relationship to roof joints at the Mount Pleasant underground quarry

a wood bearing holding the iron pivot at the base of the post to be slid into position, while grooves in the sides of the stone slot allowed an iron plate or keeper to lock it into position. The post could be sunk into the floor or, as at Shaft Mine (2372), was supported on a coursed pile of rubble stone, presumably to accommodate a short post.

Mast cranes had cables or iron rod stays to suitable anchor points or around pillars, to hold the mast. There was a jib, rather like that sometimes used on ships, fixed near the bottom and held in position by an iron brace from near the top of the post. They were used before 1880 in Quarry 2215, where a Lewis anchor point was found *in situ*. It seems likely these cranes were similar to the standard quarry cranes used at surface, with a central mast standing on a pivot or basestone, anchored by four or five iron stays to anchor points (Pollard, 1994, 47). The mast had a jib on which was mounted a two-man winch, normally using chain cable at that time. Such cranes could both drag and lift blocks of stone and might even employ a 'muck box' to move spoil. No evidence of this is known from Combe Down, though Pollard (pers. comm.) reports the use in other Bath Stone quarries.

On the post cranes, the post was secured by being let into the roof using a chog and chog hole. The chog was a square block of elm, which would be particularly good at resisting damp conditions. It was bound with two or more iron strips fastened to the external face, and a central hole to accept the metal pivot pin projecting from the top of the crane post. The chog hole was a corresponding square-sided hole cut into the ceiling or roof to accept the chog and was placed immediately over the centre of the basestone. The post was hauled up into position using a Lewis let in adjacent to the chog hole. Occasionally two slots were found, which may indicate the failure of the first hole. Where no Lewis was found in the roof besides a chog, there was generally a corresponding Lewis in an adjacent pillar face. The crane had a post attached or pivoted at both a basestone on the floor (crane stone) and at the roof, where it was fixed into a square recessed chog hole. The jib was fixed near the base of the post with a barrel winch or windlass mounted on the jib with an iron tie-bar located to close the hypotenuse. A number of post crane sites were found in James Riddle's Allotment Quarry of *c* 1910 and also at the off-site underground quarries at Foxhill, the Tankfield Quarry/Coxes Vertical Shaft Mine, (Chapter 12, Case Studies 13 and 14) and the Shaft Road and Mount Pleasant Mines (Fig. 9.35). All these had associated cable-haulage grooves from wire rope or chain and marks from where a block of stone may have rubbed against a pillar face. Those recorded were all either very late 19th or early 20th century in date.

Fig. 9.36 Preserved underground crane at Combe Manor Hotel

The early types of mast crane were located along cartways and, in at least one example, appear to have been positioned a little way back from the cartway in 'crane holes' between pillars. Ideally a minimum space of some 4-5 m width was necessary for jib movement, but the example cites probably had less, which was perhaps one reason why the use was later abandoned. Later mast crane sites were within open-room working systems where there was substantially more space available. The general form of these crane types is known from other locations where some are still *in situ*. Examples of post cranes are on display at the Bath at Work Museum and outside the Combe Manor Hotel, neither apparently from Combe Down, but of a similar type (Fig. 9.36).

Archaeological evidence of the cranes

Mast cranes

The locations of mast cranes were determined from Lewis hole group distributions (Fig. 9.37). Several locations also contained wedge holes for anchorages, but these were less common and represent only a small fraction of the anchorage types. One of the earliest known locations of the mast-type crane was identified alongside cartways in Central Firs, probably associated with the eastern development of Allen Estate Phase III quarrying within Quarries 2201 and 2202. The latter was developed along a

Fig. 9.37 Probable mast crane position inside the Firs Shaft indicated by wooden slats projecting from an arrangement of Lewis slots

branch cartway out of the original eastern Allen cartway, the furthest extent of which has been partially blocked by a substantial fall. Both quarries are associated with Long Room developments and remains were found on both sides of the fall.

Evidence for at least two crane locations was identified at the eastern end of the branch cartway (Fig. 9.38). The northernmost of the cranes had several wedge hole anchorage positions and was associated with incised chain groove impressions on the adjacent pillar faces, suggesting that mast-cranes were used. A later stone pack was constructed, probably in the mid 19th century, to support a collapsed roof at the eastern crane location, isolating the former crane position from its contemporary cartway length. Similar wedge and Lewis holes were found the other side of the fall from here, and a chain under compression had left moulds of its links on a rock face (Fig. 7.14), illustrating the stresses imposed on it. The southernmost crane location was associated with the same length of cartway and must also have facilitated the lifting of blocks on to carts for transport either to the east (where there was a wide shaft) or to the surface quarry at Sheeps House. Several anchorage wedge holes, similar to those noted in the crane location above were noted, along with a 25 mm wide chain groove. There is evidence for several Lewis anchorage slots in the vicinity also, which probably relate to the crane locations. These, therefore, represent some of the earliest recorded Lewis holes in the Combe Down complex, although the Lewis itself is known from medieval if not Roman times.

Later mast crane sites are both believed to be attributable to the mid 19th century are also located in the Firs quarry; found within Quarries 2213 and the south side of 2202. In both these areas there is an absence of the crane base stones in the floor, possibly obscured by later waste stone fines on the floor and from barrow-way activity, and the primary evidence for the locations are the surviving anchorage slots in the pillar faces. Quarry 2213 contained about a dozen individual Lewis anchorage slots that are associated with mast cranes, in the sawn and natural pillar faces throughout the extracted area. In contrast to Quarry 2202, not all the pillar faces were accessible to survey and thus, probably, not all the anchorage slot locations were seen and these and other related haulage marks may not also have been measured. The marks are likely to be attributable to crane anchorage because of their close proximity to the quarry roof with an average distance of 1.0 m below the roof. Several wire rope haulage grooves, measuring 25 mm in diameter, were also noted on the pillar faces, with many angled grooves on the faces aligned between the quarry floor, from where a block had been hauled. They were projected towards the roof, which may illustrate the locations of the end of the crane jib, or perhaps a single pulley block used to divert the cable.

Quarry 2202 contained over 75 individual crane Lewis anchorage slots in the sawn and natural pillar faces throughout the area, though some caution is needed since for as well as anchorage points, Lewis's anchors were also used to change cable directions and also to fix winches in position. Most of the quarry was easily accessible to the archaeological survey and most of the pillar faces were investigated for anchorage slots and other haulage features. The majority of slots were located at varying heights between 0.28 m and 1.40 m below the roof, and were often found either in pairs in close proximity to each other on adjacent pillar faces. The pairing and close proximity would suggest that more than one slot was used to anchor the same crane stay. The cranes in this area were likely to have been moved and re-located as the

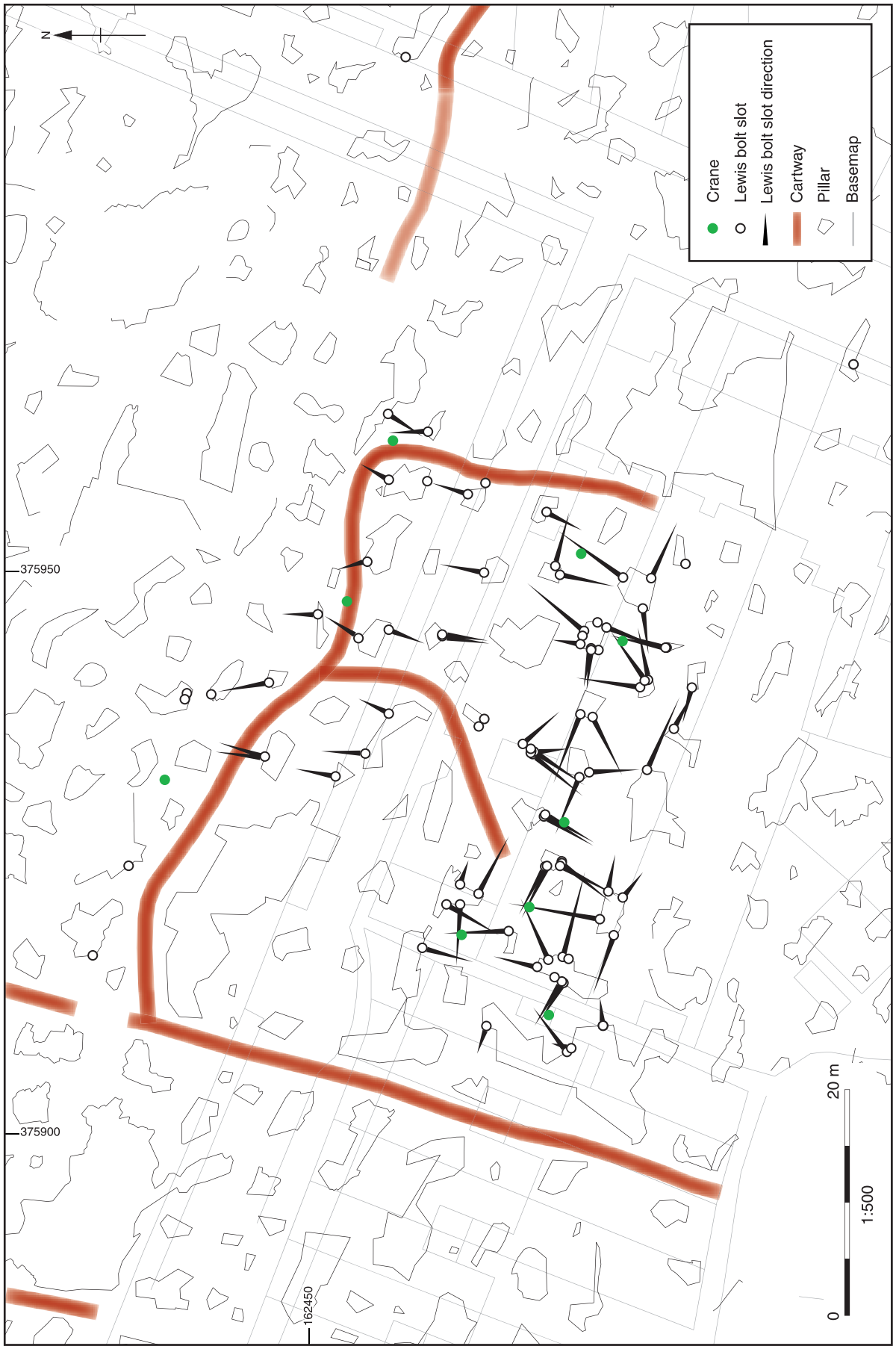


Fig. 9.38 Crane positions in Central Firs (Quarry 2202) indicated by positions of Lewis anchorages

quarrying operation was extended westwards and southwards and as the former locations were superseded. It is not known how many of the cranes were being operated in the area during the same period or how often they were moved during the quarrying operation.

Placing of the anchors was probably done in the early part of the development of working faces, when the benches were high enough. This suggests a reasonable degree of prior organization was necessary, and of course, geological conditions were also a constraint. A projected line from the mouth of each of the Lewis holes in some locations was also plotted in order to ascertain potential crane positions, though the exercise met with only limited success. This may have been due to contemporary problems and caution in their placing so as to avoid a direct pull on the anchor.

Quarry 520 in West Byfield had several crane locations along the length of a single cartway ascertainable from Lewis holes. They may have been used both for dragging and lifting extracted blocks of stone and possibly for haulage of carts along the length of the cartway.

Post cranes

Quarry 518 in Allotments Quarry had Lewis slots and crane anchorage associated with use of post-type cranes. Six crane locations were identified from chog holes and another two suspected but not accessible for survey. All were associated with two lengths of railway used to haul extracted stone to a vertical haulage shaft. Other features relating to the operation included rope marks or grooves on pillar faces, illustrating their use for dragging as well as lifting blocks

Crane locations had the top of the post anchored in a square-cut chog-hole with a Lewis slot beside it, and both cut into the roof. Beneath the post location, a single large stone crane block or basestone (SF 670), was found half buried and fixed in the floor of the quarry (518). This had an entry slot and slots for a gate. It was the only recorded crane basestone within the Combe Down Mines (though another was distantly seen in the Shaft Mine) and was recovered and videoed as part of the underground survey (Chapter 12, Case Study 12).

Chog hole dimensions varied throughout the quarries, reflecting the size of the chog and were (in contemporary measurements) half an inch to an inch (13-25 mm) larger than the chog dimensions. The hole depth varied from a minimum of 7 inches (170 mm) up to an inch or two (25-50 mm) deeper. The external dimensions of the chog hole had a greater variation and the recorded sizes ranged from 9 inches square (225 mm square) to $10^1/_2$ inches (265 mm), and the most common dimension was $12^1/_2$ inches (313 mm) square. All examples were recorded from within quarries started or operated within Phase VII (1867–1938). They were seen within the James Riddles Quarry (2202), the Foxhill Quarries (2382 and 2383), at Shaft Road Quarry (2372) and in the Mount Pleasant Quarry (2373). At the latter up to 15 chog holes were recorded in the roof, spaced at shorter intervals than noted elsewhere.

Chain and rope grooves

Grooves were created by iron chains or hemp (later, iron or steel ropes) either moving against or cutting into a face or corner of a pillar. They indicate use of pulley blocks, winches or cranes. The use of chain 'cable' in the quarries long pre-dated the use of wire rope for haulage, and chains continue to be used for lifting operations today. Chains of probable late 19th- or early 20th-century date were recovered from the Foxhill quarry complex and those quarries located off Shaft Road on the western side of the Combe Down Quarry (Quarries 2372 and 2377) and a short length of another was observed high on a pillar in Quarry 2202) held in place by spigots driven into the rock. Its purpose was unknown.

Chains left different impressions depending on whether they were fixed or moving on the pillar face. Actual impressions and outline of the shape of the chain itself may be pressed into the face or, where the chains moved across the pillar face, the impression would be an intermittent line of smoothed grooves, where every other link within the chain length had made contact with the face. The general width of the chains at the quarries was about 1 inch (25 mm) in diameter. Examples of chain impressions were particularly noted at two locations within Quarry (2202) where Open Room working had allowed extensive use of haulage equipment.

Other types of haulage marks were recorded underground. A common feature noted in the Foxhill Quarry complex (Chapter 12 Case Study 13) were grooves and marks left where a stone block rubbed against a pillar face. The marks were more intermittent than the chain and the wire rope marks and more diffuse in appearance. A good example of this was seen scored into a face with graffiti in Foxhill Quarry (2381) close to the roof level. This type of feature may be associated with the use of the crab winch, which dragged the blocks horizontally and about 500 mm above the quarry floor (Pollard 1994, 47). Alternatively, the Foxhill examples attributed to use of the post crane may, be related to the use of crab winch. Similarly, two spigots at low level, inserted into circular drilled holes in Quarry (2202) may have been for a crab winch, though securing a diverting pulley is also a possibility.

Vertical shafts

Vertical shafts – both narrow, and intended just for ventilation, light or access, and wide, to lift extracted stone directly to the surface from underground working faces – were used in the 18th century onwards at Combe Down in and after the latter part of the Allen period. They may have developed from earlier 'light-holes' or ventilation

shafts and were used increasingly during the 19th century. They were circular or semi-circular in form, either sunk above or to the side of cartway routes for efficient transport of stone from cartways to the surface or. Those in east and Far East Firs were sunk independently of the cartways. Vertical winding shafts appear to have been employed throughout the 19th century in almost all areas, and it is possible even old cartways linking to them effectively replaced by them. East of the Long Drung from the 1830s, most smaller quarrying enterprises were accessed from the surface, perhaps because entry from the edge of the hillside was impossible due to restrictions due to landownership. Over 50 known shafts were constructed at Combe Down and were used until about 1923.

All open shafts were useful for ventilation and the first, fairly small diameter shafts – about 1-2 m diameter – were probably sunk for that purpose, for example to the cartways developed from Sheeps House Quarry by Allen, perhaps at points marking the extent of the initial development phase. The first

Fig. 9.39 Shaft (12062) capped with stone blocks

Fig. 9.40 Underside of barrel-arched shaft-cap in East Firs

shaft was located about 30 m from the southern end on the eastern cartway, at a probable spur. There was a similar shaft in the parallel, western cartway and another on the spur.

Some smaller shafts, notably in the eastern areas of the Firs quarries, could certainly have been used as man-access shafts, though no footholds or remains of ladders were noted. A few seem to have been used for haulage, again particularly in the eastern areas, which was evident from rope or chain grooves in the walls. This would have been mainly suitable for very small scale operations hauling small blocks or worked stone. These and all narrow shafts recorded, other than wells, were unlined and tended to belly-out where they passed through particularly weak horizons within the maximum depth of some 7 m of Twinhoe Beds. Apart from examples fill with rubbish or soil, all were capped using stone slabs, for instance shaft 12062 (Fig. 9.39), some supported with iron bars or timber (see Figure 7.9). Other shafts that remained inaccessible to the survey, were infilled with surface-derived rubbish, or were surrounded by collapsed roof materials.

Larger shafts ranged from around 2.5 m diameter to just over 4 m, perhaps widening a little as they passed through fragmented beds. With one major exception – the arched shaft in the Burgess Three Acre workings (Case Study 9, Chapter 12) – all examined shafts were unlined, though several had either solid faces or pillars left, or packs below for support.

Wide shafts were often referred to as 'light shafts', a term possibly first coined by Pierce Egan (1819) since from below they indeed were conspicuous for this. However, although effective at the shaft bottom the light falls away rapidly within a few metres and the contrast makes it difficult to see inside the workings. All of the earliest wide Allen shafts, typically placed some 70 m from his level entries, had rope marks below the shaft, indicating stone or carts being hauled to the shaft bottom, and from hence to surface. There is no evidence of the lifting mechanisms, but some adaptation of either the Padmore cranes (Chapter 4) or the usual mining horse gin seems likely. The shallow depth and weak rock made it simple to sink wide shafts, which allowed larger blocks or lengths of cut stone to be brought up horizontally, simplifying both lifting off carts below and on to carts at surface, sometimes of considerable loads.

Firs Shaft had Lewis slots about half way down, radiating to a common centre, suggesting some form of post had been supported. There were also cable grooves on a pillar. No clear use was determined, but some form of down-the-shaft haulage system is possible, to drag carts or stone to the bottom. The Firs Shaft, another shaft located beneath the Chestnut Tree, and a further shaft with a well were part a series of shafts located on a single cartway attributable to Quarry 2211. They followed a line across the north-east of Firs Field (the Arched Shaft and Chestnut Tree Shafts are others). Together they were associated below with a cartway, so were clearly part of a combined system of haulage and winding. A similar line of shafts and an underground cartway was seen in Central Byfield ranging north under the Westerleigh Road.

The only quarries apparently totally dependent on vertical shafts were those at the Foxhill Quarries, of the late 19th and early 20th centuries, which apparently used a steam engine for winding (Chapter 12, Case Study 13). In the early 19th century, leases began to specify the shafts should be fenced, apparently done with a circular wall some 3 feet (0.9 m) high. A recent small excavation of the Chestnut Tree shaft on Firs Field exposed a wall built about 3 feet back from the shaft edge. However, since that time most of the wide shafts had been filled, some carefully with quarry waste, others with domestic rubbish. Several had rubble or block stone caps; two in probable Allen workings in East Firs had splendid low arched domes, perhaps rising just over a foot in the centre, and others had barrel-arched variations (Fig. 9.40). Firs Shaft had concrete slabs, and another wide shaft under the garage on The Avenue had iron girders and concrete.