Chapter 1
The stabilisation of Combe Down and its archaeological recording

Introduction

In the mid 18th century Combe Down saw the development of the first large-scale underground stone workings in England, which were fundamental to the creation of Georgian Bath.

In about 1730 Ralph Allen, with a fortune still being made from his famous reforms of the English postal system, bought the Down with its beds of freestone a mile south of the City as part of his growing landed estate. He introduced new techniques and integrated business methods to the quarrying industry. These increased the level of production and reduced the price of stone so effectively, that it permitted the vision of the architects John Wood and his son (also John), to be realised, removing the temptation to use materials other than the local stone, which has been so important in creating the cohesiveness of Bath's urban landscape (Fig. 1.1).

A century before the generally better known underground quarries at Box and Corsham in Wiltshire repeated Allen's success on an even larger scale, he systematised the methods of underground working and at surface introduced the use of cranes, a railway and roll-on-roll-off river transport, supplying both Bath, and via the Avon Navigation and coastal shipping, also more distant projects such as the St Bartholomew's Hospital in London.

This and later working at Combe Down left some 18 hectares of underground workings under the quarrying village Allen had established, which had gradually grown into the modern suburb on the southern outskirts of Bath. Located just a few metres below some hundreds of houses in Combe Down's central conservation area, the workings had become dangerously unstable and were considered to be liable to significant collapse within a decade. Between 2000 and 2008 they were stabilised by being infilled with foamed concrete.

Acknowledged as archaeologically of National Importance and of being Internationally Significant and part of the World Heritage Site of Bath, their effective destruction was therefore a major loss. Initial archaeological assessments had established the quality and variability of the extant underground features but also that they were poorly understood. Bath & North East Somerset Council in conjunction with English Heritage determined that a detailed archaeological examination to the highest possible standard would be the major part of the mitigation.

There are no precedents in the UK for such extensive and detailed archaeological work underground and the project offered a unique opportunity to study working techniques within a well-defined underground quarrying landscape and, in conjunction with documentary and literary research, to assess the economic and social impact on the village and on Bath. In particular, there was potential to examine in detail the technical equivalent underground, of Ralph Allen's well-known use of cranes and railways at surface. In the event, it was also possible to combine archaeological with historical investigation to assess the success of his stone business, which, though beneficial to the development of Bath, was probably less so to Allen himself.

The problems of archaeological investigation were complex, both in terms of health and safety and the archaeological methodology. The instability prevented access to many parts and close-up viewing of others and conventional archaeological excavation was not possible. It was thus necessary to devise suitable methods of recording and interpretation for these circumstances. It has also been necessary to determine a suitable terminology to describe and explain an underground landscape of which few people have any knowledge. Where possible we have chosen terms which are compatible with those used in mining and quarrying reports for the English Heritage Monuments Protection Programme: (Cranstone 1992; Willies 1993; Ashbee 1996; Chitty 1996). This report and the associated web site: (www.combedownstonemnesproject.com), and a proposed exhibition of the findings are the results which are an important contribution to the history of Bath and of significance for national and international research agendas for the post-medieval mining and quarrying industries.

This introductory chapter outlines the project history and administrative aspects of the report, along with the aims and objectives and the methodologies used to achieve them. A short note examines its place in the study of underground archaeology nationally and internationally.

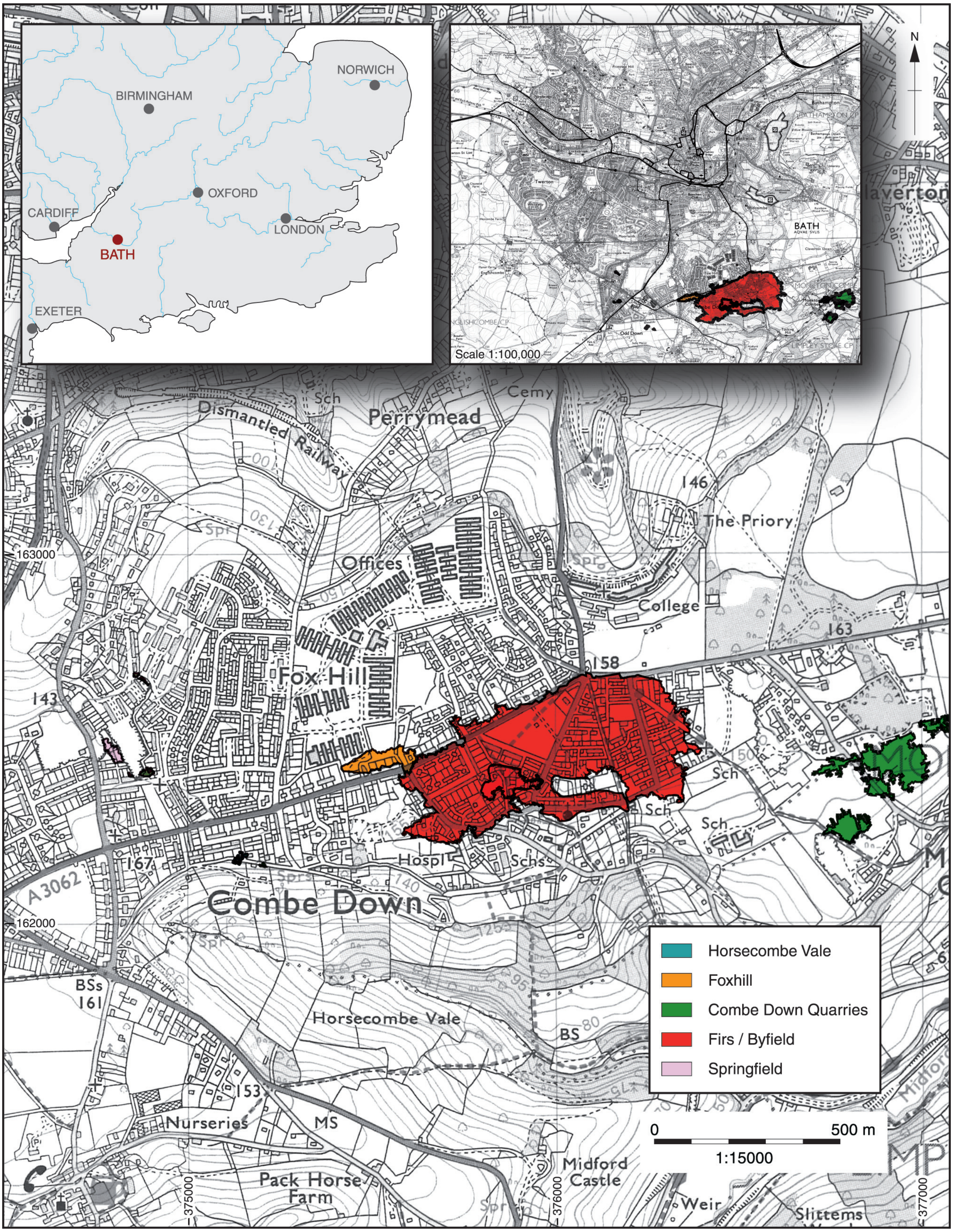


Fig. 1.1 Combe Down with the Combe Down Stone Mines site and other infilled underground quarries within the surrounding area. The centre of the main site lies at NGR ST 7662

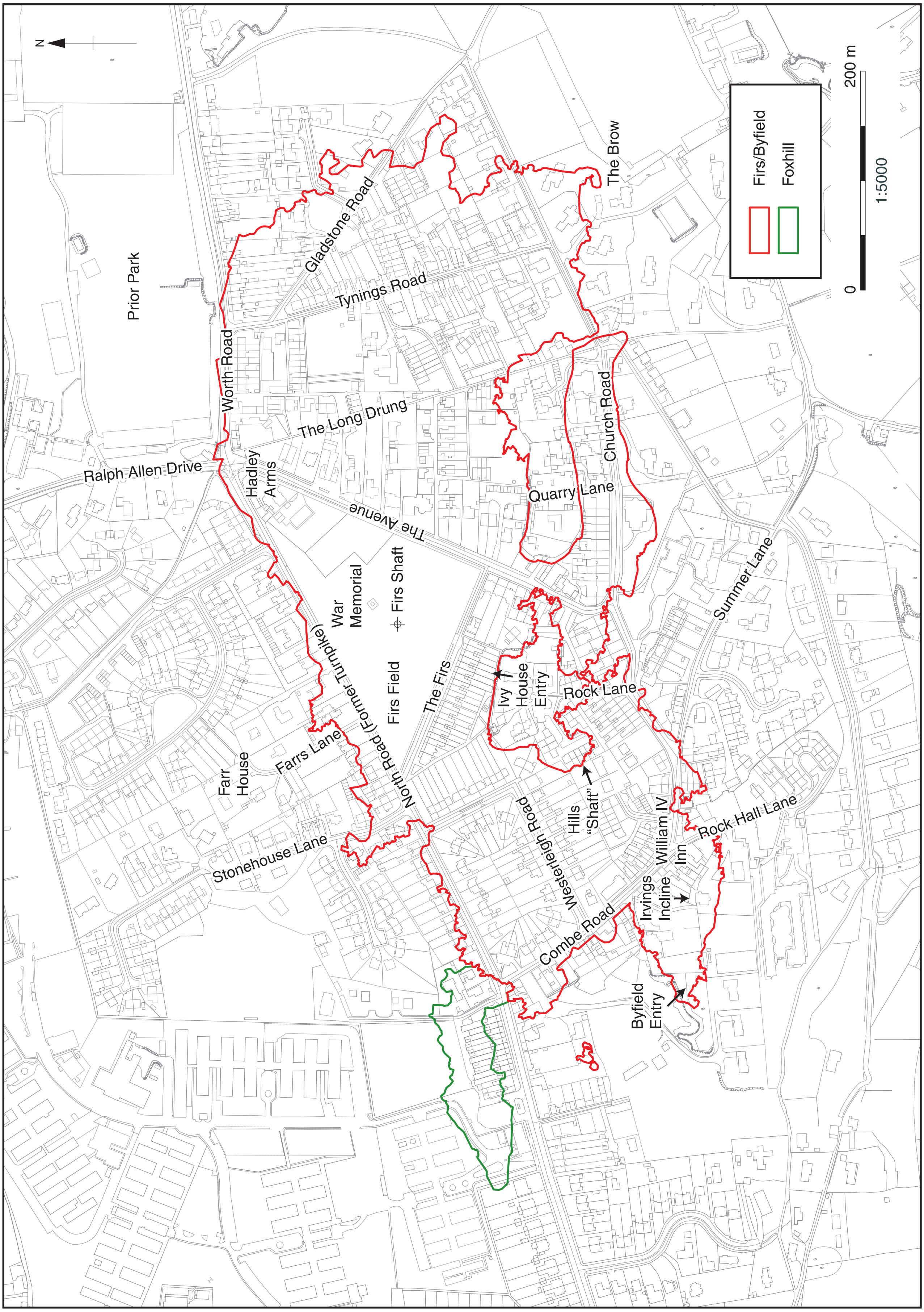


Fig. 1.2 Central Combe Down with named roads and paths and the Firs-Byfield underground quarries outline (this plan is also reproduced inside the front cover)

The Combe Down Stone Mines Project

The term Combe Down Stone Mines has been used to describe the 18 or so hectares of underground workings covered by the Stabilisation Scheme of the areas that had become known as Firs and Byfield 'Mines' in recent years, along with other outlying quarries in the local area, including those at Foxhill, Horsecombe Vale, Mount Pleasant, Springfield and Entry Hill, and Shaft Road, and The Lawns, St Winifreds and Freylings Quarries. (Fig. 1.2).

The Combe Down Stone Mines were in fact underground quarries – places where squared, dimensional, building stone was dug. Underground quarries have been legally classified as mines since the Metalliferous Mines Act of 1872.

Bath Stone, a similar stone to Combe Down stone, is still quarried underground today, and so is both a living industry and an ancient tradition which still uses the term quarrying to describe its activities. For the purposes of this report the traditional name is maintained and they are referred to throughout as quarries, as has been the local tradition (Pollard pers. comm.)

The structure of the report

The report is split into groups of chapters in four major sections:

The first section (Chapters 1-6) is essentially based on documentary and literary sources providing the geological and historical background of Combe Down and Bath, and the main features of the surface landscape including changes from surface quarrying. The concept of an underground quarrying landscape introduces some of the necessary terminology to understand the key chapter on Ralph Allen and his quarrying business and the following chapters.

The second section (Chapter 7-10) develops the results of the underground recording. Four chapters define and describe the broad principles and then the technical aspects of underground quarrying and its development over time in terms of methods of working, transport, and roof support and spoil management.

The third section (Chapters 11-12), following a summary of the specialist reports on finds, describes the geography and phasing of the quarries. The great area involved and the limitations of access into many parts of the quarries has led to the presentation, alongside the phasing, of a series of case studies representing each chronological phase of activity for areas in which a reasonably comprehensive picture could be reconstructed.

Finally, Chapter 13 presents a concluding discussion on the development of the stone quarrying in Combe Down, drawing together the archaeological and historical evidence, and seeks to evaluate the success of the project.

The archive

The project archive is currently with Oxford Archaeology, and will be deposited with Roman Baths Museum, Bath, under the Accession No. BATRM:2001.63. The digital archive will be available to view through the Archaeological Data Service (ADS – www.ahds.ads.ac.uk). Full artefactual specialist reports, plans and other contextual records of features etc, and a library of drawn and photographic images will also be available on the project website www.combedownstonemines.com.

A note on terminology

To aid the non-specialist reader Table 1.1 below lists a summary explanation of frequently used quarrying terms. More detailed explanations are provided at suitable points in the text.

Phasing of the quarry developments

The phasing of the quarries is discussed in detail in Chapter 12, but in order to refer to developments chronologically as they occur, the phases have been used throughout the text.

Phase I.	Pre-Ralph Allen – prior to his *c* 1730 developments
Phase II.	Allen period – *c* 1730 to his death in 1764
Phase III	Allen Estate period 1764 to *c* 1803 and the estate break-up
Phase IV	Early 19th century 1803-33
Phase V	Mid 19th century 1833-67
Phase VI	Late 19th and early 20th century 1867-1938

The phasing plan shown in Figure 1.3 is derived from a combination of the historical documentation and the archaeological evidence produced from this and earlier investigative work, and shows the interpretative sequence of underground quarrying by Quarry Area.

History of the Combe Down Stone Mines Project

The Combe Down underground quarries (legally mines during the Stabilisation Scheme), were situated below the central Conservation Area of the Combe Down Ward which lies between 1.5 and 2 km south of the historic centre of Bath. A large proportion of the Ward was subject to either quarrying underground or at surface over a long period, but mainly between 1730 and 1860, when the area provided the main building material for the 'golden age' of Bath. Quarrying in the outer areas of the parish continued, but the main supply of Bath Stone thereafter came from the much larger, rail-served Wiltshire quarries.

The principal area examined, known today as Firs and Byfield Mines, was centred more or less

Table 1.1 Glossary of frequently used terms

barrow-way		narrow pathway for a single wheeled barrow
cartway		cleared way for a two-wheeled cart or four-wheeled wagon
chog hole		square-sided hole in the roof to allow the top end of a crane post to be inserted
cockles		local term for vugs (see below)
cogging		modern term (derived from coal mining) in which layers of timber logs with a hollow centre are stacked up from the floor to support the roof
crane	mast crane	the mast (or post) was kept in position by stays or guys, and the jib angled out from the base of the post, secured by an iron bar at the top
	post crane	similar to the mast crane, but the top of the post was secured in a chog hole in the roof
crib		box formed with walls of rubble (or timber) and filled with rubble to support the roof
cross-bedding		geological feature formed in beds with a shallow sea origin formed by wave or tidal movements moving sandy particles on the sea bed. The sinusoidal fronts of the beds which cross the main beds are often made obvious by weathering.
crown hole		small hole at surface opening below to a much larger upwards collapsing fall of roof below ground
fines		spoil – waste rock – composed of fragments below 5mm diameter
gull		natural joint or vertical crack in the freestone widened by landslipping, sometimes filled with washed-in clay
gullet		gap or trench between the working face and the waste rock or spoil stacked a short distance behind the face
heading		the face or driving end of an underground roadway
jad		iron bar with a sharp wedge-end, used with a pick to cut and trim jad slots and cuts
jad cut		vertical slot made using a pick, often to cut out and define a face of a pillar
jad slot	.	narrow and deep slot cut horizontally by jadding or picking one or more beds out from below the roof to allow the beds above and/or below to be broken out using a wedge
Lewis		tool formed of wedge-like iron pieces connected by a bar and used for lifting. The pieces were placed in a dovetailed 'Lewis hole' in the stone to be lifted
Long Room system		method of working in which the face principally advances forwards in one room between two lines of pillars
Long Wall, gullet and pillar system		method of working in which the face advances across a number of rooms in a line
Open or Wide Room system		method of working in which the spoil is removed further away to facilitate use of mechanical haulage equipment, (cranes and winches)
pillar	long	rectangular in plan – the length 3x the width
	direct	has near-vertical faces from floor to roof
	corbelled	the top bed(s) of the pillar are left horizontally protruding as 'ears'
	apophygate	the top curves out, like an inverted bell just under the roof (as an apophyge on an architectural pillar)
	sailed	the vertical plane is inclined and the ends are much narrower than the centre. Usually the result of faulting
ridding		unwanted beds or material above the desired beds
saw		the stone-cutting saw was usually a thicker metal version of the timber saw
	frig bob	the equivalent of the cross-cut timber saw, but usually with a handle at one end only
	razzer	this was usually a worn down frig bob, used to start a saw cut where space was too small for the frig bob
scappling		breaking off the surface of the rock using a heavy form of axe
shear legs		pair of timbers erected in an inverted 'V' over a weight to be lifted by some form of winch
sprag (or scorter)		angled timber projecting out from a ledge or hole near the top of a pillar into the roof to increase the support
step(ped)-aside beds		beds displaced sideways because of faulting or local movement due to instability
stone pack		wall formed of rubble to either support a bank of spoil or to support the roof
tipping front		last phase of tipping from a barrow over, and forming the edge of, the spoil heap
vugs		natural mineralised cavities in the freestone
wedge slot		a triangular slot cut by a pick in the rock into which either a wood plank (for standing on, or as an attachment) can be inserted, or into which a wedge can be driven to break the rock out
wedge-and-chip		combination of a wedge driven between two triangular iron plates (chips), placed in the wedge slot to ensure a clean break in the soft freestone
whim		a form of capstan-winch with a vertical post or barrel, usually turned by horse-power
wrist stone		the first stone block broken out (wrested) from a bed exposed at the top of a face to allow the others to be wedged out whole

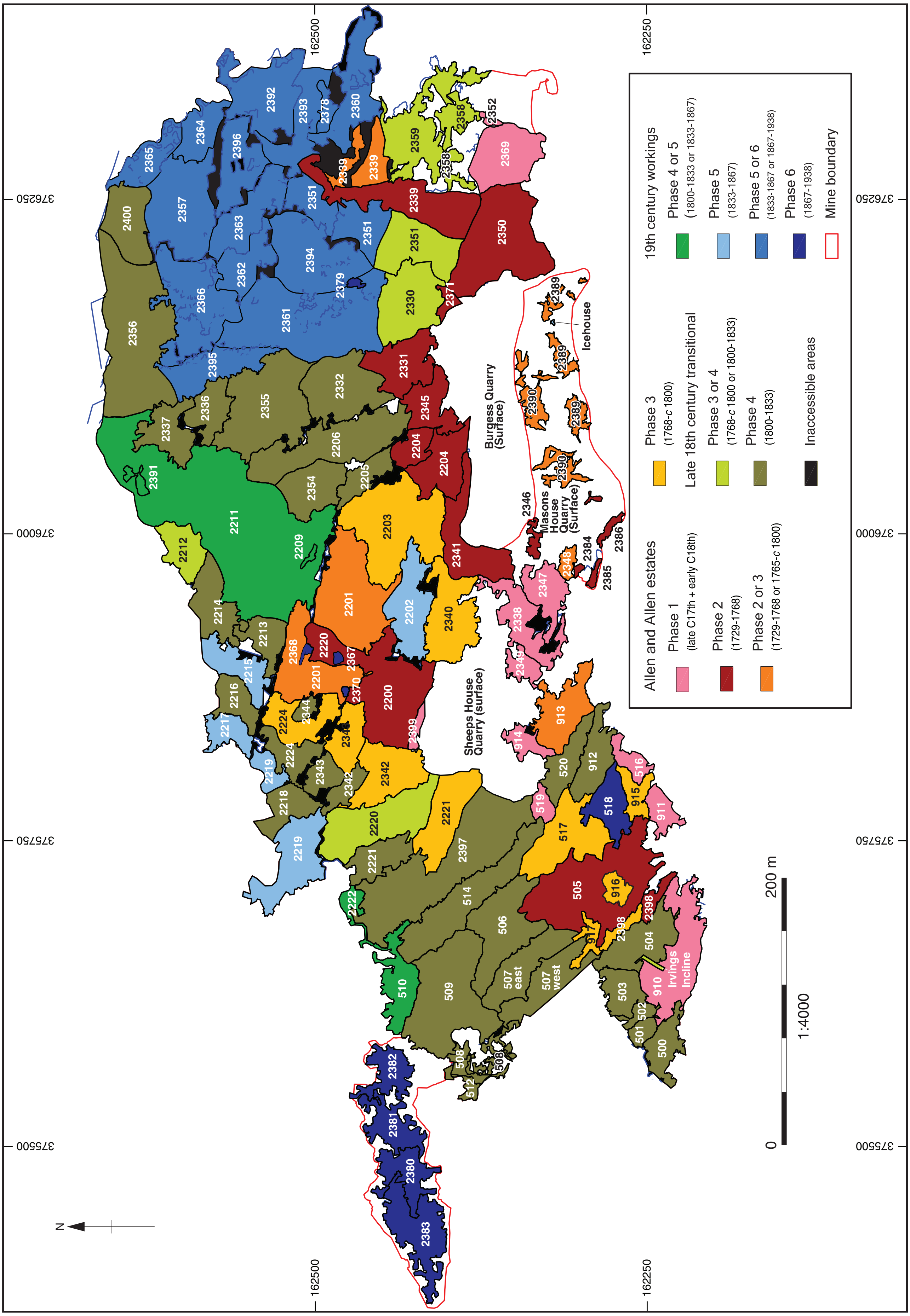


Fig. 1.3 Phase plan of the Quarry Areas within the Combe Down Stone Mines site (this plan is also reproduced inside the back cover)

around the reopened main access shaft (Firs Shaft) on Firs Field – at which point the surface infrastructure of the Stabilisation Scheme was established (see Figure 1.4) – and from the western side of Combe Road through a former surface quarry through the main Byfield Entrance. Their location in relation to the surface is most easily understood by their intrinsic relationship with the modern road system. Roads and paths formed the original boundaries for quarry leases or were developed either to serve the needs of the quarries or followed their working out and subsequent use of the areas for housing. The main underground quarry complex occupies the area south of the line of the North and Bradford Roads, roughly as far as Church Road. The western limit is a short distance west of Combe Road (the old parish boundary), and the so-called Byfield Mine there extends east roughly to Westerleigh Road. It is separated from what has become known as the Firs Mine by a largely infilled quarry (2397), with spoil which was previously inaccessible. Firs Mine extends east from west of Rock Lane across Firs Field (with the Firs Shaft), The Avenue, the Long Drung and over Tyning Road and Gladstone Road until the older area of houses ends.

Concerns about the stability of the mines were initiated by underground explorers in the 1980s. The quarry workings were normally within about 5 to 7 m of the surface and, in small areas, often less. Instability resulted from deteriorating pillar support and delamination of beds. Small collapses had taken place and engineering studies by Halcrow (*c* 1990) for the then Bath City Council, stressed the likelihood of major collapses within a ten-year time-scale. Planning permission was refused for the then proposed methods for stabilisation, but further work was carried out by Hawkins (1994) whose plans also showed floor and roof heights and high hazard areas, together with a report on stability. At the same time a report on the archaeology by Pollard (1994) established the presence of a large range of both typical and unusual features of underground quarrying, which, because of the dynamism of Ralph Allen, who entered the 'stone business' from about 1729 onwards with a wide range of innovations, was potentially of national significance.

Subsequently, Bath & North East Somerset Council (B&NES – the succeeding local government body) gained national government assistance for further investigations. This stage was carried out by engineering consultants Parsons Brinckerhoff and included access works from supported roadways, required by the Mines Inspectorate for safety, to assess the underground conditions. As well as some two kilometres of supported roadways constructed,

Fig. 1.4 Firs Field during the stabilisation project, view east. Firs Shaft is covered by the green circular roof in the centre foreground, and the Materials Shaft (the former Arched Shaft) is at the right of the long green-roofed building in the background (Image courtesy of Bath & North East Somerset Council)

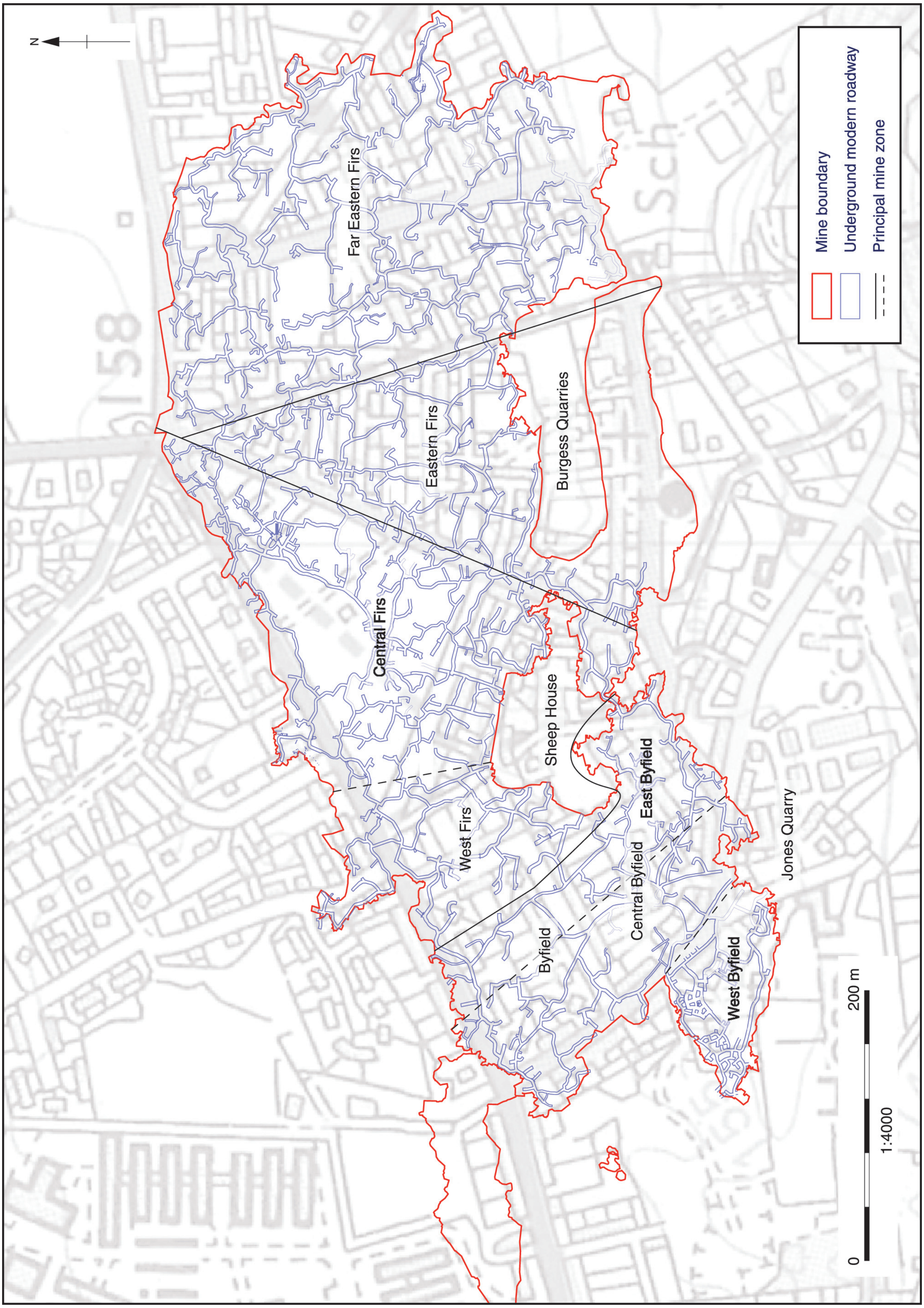


Fig. 1.5 Modern underground road network. Sheeps House, Jones and Burgess quarries were surface quarrying areas

further emergency works were carried out to remedy particularly dangerous situations and to support North Road. As part of this phase, in November 2000 Oxford Archaeology was commissioned to carry out the Environmental Impact Assessment for the proposed stabilisation works. The construction of the supported roadways inevitably resulted in damage to the below-ground archaeological resource and soon after Oxford Archaeology were asked to carry out an archaeological monitoring action or watching brief intended to monitor this process and record affected sites in advance of their destruction.

In 2003 a submission for planning consent for the stabilisation of the workings was granted. The work was put out to tender, with Scott Wilson appointed as the site engineers, and Hydrock, who had carried out the previous works, as the successful contractors. A number of archaeological conditions were attached to the planning consent in order to ensure that the mines were appropriately recorded as archaeological and historical assets, to allow preservation of features or areas of archaeological interest and to allow some aspects of the site to be displayed and presented to the public when physical access was no longer possible. It was agreed that analysis and publication of the results of the investigation and recording programme would contribute not only to the study of Bath and its post-medieval development, but also to national and international research agendas in mining and industrial archaeology.

During the main scheme stabilisation works, it became evident that the original archaeological mitigation proposals for preserving *in situ* some of the more significant areas of the mine were not feasible and the recording strategy for these areas was revised and a strategy focused on archaeological rather than engineering imperatives was implemented with time to allow more detailed examination. Five such High Grade Areas, accepted as being of national importance with features not available elsewhere in England, were recorded in as much detail as possible in late 2007 and early 2008. Additional engineered steel roadways were specifically driven to access these areas, were archaeologically led, and were used as recording platforms for the enhanced survey. Figure 1.9 shows these High Grade Areas and associated areas of enhanced recording where laser scanning and video filming were carried out along the archaeologically led roadways.

Monitoring of the main scheme works continued until August 2008. Work at three additional areas at Church Road, Horsecombe Vale and Foxhill was carried out between November 2008 and June 2009.

Aims of the archaeological project

The principal aim of the archaeological work was to preserve the archaeological aspects of the underground landscape by drawn, written, digital or photographic record, including the then visible remains and any which might be revealed in the course of the Stabilisation Scheme. The results would be presented in written and digital form, comprising the written and drawn record, along with finds archives, which would be suitable for presentation to a wide range of audiences including academia and the general public. In addition there would be a digital record of the underground archaeological landscape of a standard suitable to facilitate and create a 'fly-through' model and interpretation of the workings, including digitised photographic and video coverage which with advice and selection and interpretation could be presented in a visitor interpretation centre. It was also initially hoped to provide an underground visitor viewing facility, although this proved, for geological and engineering reasons, impracticable.

A further part of the aims was the provision of archaeological and historical advice during and after the duration of the project, and to assist in the preparation of the proposed display.

More specific objectives were developed both before and during the project, as possibilities unfolded. These included the location and planning of the full range of features, and would seek to understand the methods of working, the transport and handling systems including in relation to toolmarkings and artefacts found, and the methods of roof support and any constructions required, along with the disposal of spoil. It was clear that remains of underground working of wrought stone may survive, and that personal items would be found, relating to the lives of the quarrymen. It was also considered possible that the quarries may have had secondary uses and that evidence of these should also be recorded.

The completion of the physical recording aspects of the project allowed a reassessment, and in particular it was decided the provision of a Heritage Interpretation Centre programme should be separate to the output of the OA post-excavation and analysis programme, though material should be prepared with this original objective in mind.

It was also considered there was material evidence of quarry owners, quarrymen and children which should be presented, and that as the material culture of residents of Combe Down village was also represented in deposits of pottery, glass, bone and items such as clay pipes (domestic rubbish) in shafts and other entries and in graffiti, it too should be analysed and reported. It appeared also that the types of stone and architectural worked pieces produced by individual quarries could be analysed, partly in its relationships with the building of Bath, and where possible the wood resources and landscape of the area should be examined through species identification of wood used in the workings.

This present technical report has been produced with these aims and objectives in mind and is aimed at a wider audience rather than the very limited number of archaeologists and other specialists

Fig. 1.6 Timbered support on modern roadway 2 near Firs Shaft. The blue pipes delivered the concrete used for infilling

Fig. 1.7 Steel supported section of Roadway 2 in east Firs, after concrete had been emplaced

involved in mining and quarrying history. The main drawn, textual and image records which underpin it are digitally preserved and available on the web site for more detailed study.

The Stabilisation Scheme methods and archaeological recording

The former underground quarries had to be accessed through either timbered or steel-supported roadways. These and other working features are shown on Figs 1.5 to 1.8. Initially, the predominantly Welsh miners followed the familiar coal-mining practice of using timbered roadways about 2 m wide and 2 m high with side timbers slightly inclined inwards, with a roof timber located by notches on to the wedge-tops of the uprights. The sides were lagged as necessary with corrugated steel sheet, and the space under the roof made up by short timbers secured by wedges. Spoil was usually heaped outside the uprights to prevent spreading, and it or bought-in aggregate was laid to sufficient depth to bring the floor up to a level, and on which trackless vehicles could run. Steel supports used in the main scheme produced a 2.4 m by 2.4 m roadway, using 100 mm rolled steel joists sitting on a steel soleplate, and with a steel roof-joist chocked to the roof by timber. Sides were braced and lagged as necessary with the floor brought to level as above.

It will be appreciated that this roadway system, of which some 14 km were constructed, was most favourable with low roof heights, using cut-and-fill to bring to level where possible. Higher areas were best avoided. The exception to this was the area of Byfield designated for bats in which more complex high steel supports were used, concrete coated later. Thus most of the roadways cut through the original quarryman's backfilled spoil (which occupied about 50% of the original space) and for large distances the main visible archaeology was the excavation at the heading through the spoil. Since original working quarry heights were some 6 – 7 m, views of the lower third and even two thirds of pillars and of working faces, and along original cartways were very rare and often then difficult to get visual access to. Except for one instance no archaeological excavation was permitted. The roadways were pursued to, and often along the boundaries to ensure the limit of the workings had been reached, and boreholes were used to probe beyond for cavities. These and other surface and underground boreholes also provided useful data for the archaeologists. In the latter stages of the Stabilisation Scheme the boreholes were used as access for the laser scanning of inaccessible quarries at Church Road, a process which located several early eighteenth century quarries.

A team of miners advanced their roadway heading from 2-4 m daily unless the ground or roof was bad, either by hand methods or by use of a tracked excavator and belt-dumping into small tracked diesel dumpers. As the system lengthened, then branches were made and several headings, up to 23 at one time, were advanced. Surplus spoil was taken to the nearest open area suitable for dumping (ie preferably below the modern roadway level) where temporary timber support was provided. This gave access to more areas, and co-operation from the miners sometimes gave access for archaeological examination to a much wider area than the plan of supported roadways might suggest. Sometimes the number of headings meant that it was impossible to visit and record all headings and dumping areas daily, but again co-operation from the miners and engineers enabled significant finds or changes to be notified to the archaeologists. In particular cases work was held up to allow photography on the once-a-week visits by the consultant (LW). There was, of course, a corresponding need for the archaeologists to be as expeditious as possible, timing difficult recording to meal breaks and early evening or when otherwise work stopped. Frequently at later stages, the supported roadways, designed to encircle areas for infilling, approached an area recorded from a different direction, enabling the rear of pillars, for example to be completed on plans partly prepared two or more years earlier. But many areas, some fairly large, could not be approached at all.

Once the areas were accessed by the roadways, the sides of the roadways were boarded-up, a process which was not done, or completed until all visible archaeology was recorded and 'signed-off'. Concrete produced at an on-site surface plant was pumped along flexible pipes and, foamed at the nozzles, poured into the enclosed areas, raising the level in stages to allow setting and cooling. Pipes into the roof enabled the concrete to be pumped to the highest places, usually a collapse progressing upwards to the surface. Drilling of boreholes from underground or surface was used to check that these pockets were successfully filled. Finally the roadways and all shafts were filled, except, again, in the bat area where the much modified workings and two entries were left open. Effectively, therefore, the whole of the workings have been filled and destroyed, though theoretically it would be possible to excavate below the concrete filling in the spoil. This task was completed in November 2008 with some 550,000 cu m of concrete emplaced.

In terms of the archaeological monitoring and recording, the bulk of the work is best viewed as a form of rescue archaeology where the work process cannot stop except for very short periods, with the obvious limitations this imposes. It worked remarkably well in practice, thanks to both miners and management and the insistence perhaps, by B&NES that archaeology was a vital part of the operation. In the High Grade Areas the priorities were reversed, with mining purposely carried out so as to facilitate archaeology by providing specified access and a reasonable time for full recording,

Fig. 1.8 Modern roadway heading with tracked mini-excavator – East Firs

within the strenuous health and safety limits. This included use of laser scanning and video recording as well as more complete planning of the whole areas.

Subdivision of the underground workings for the archaeological survey

The archaeological plan

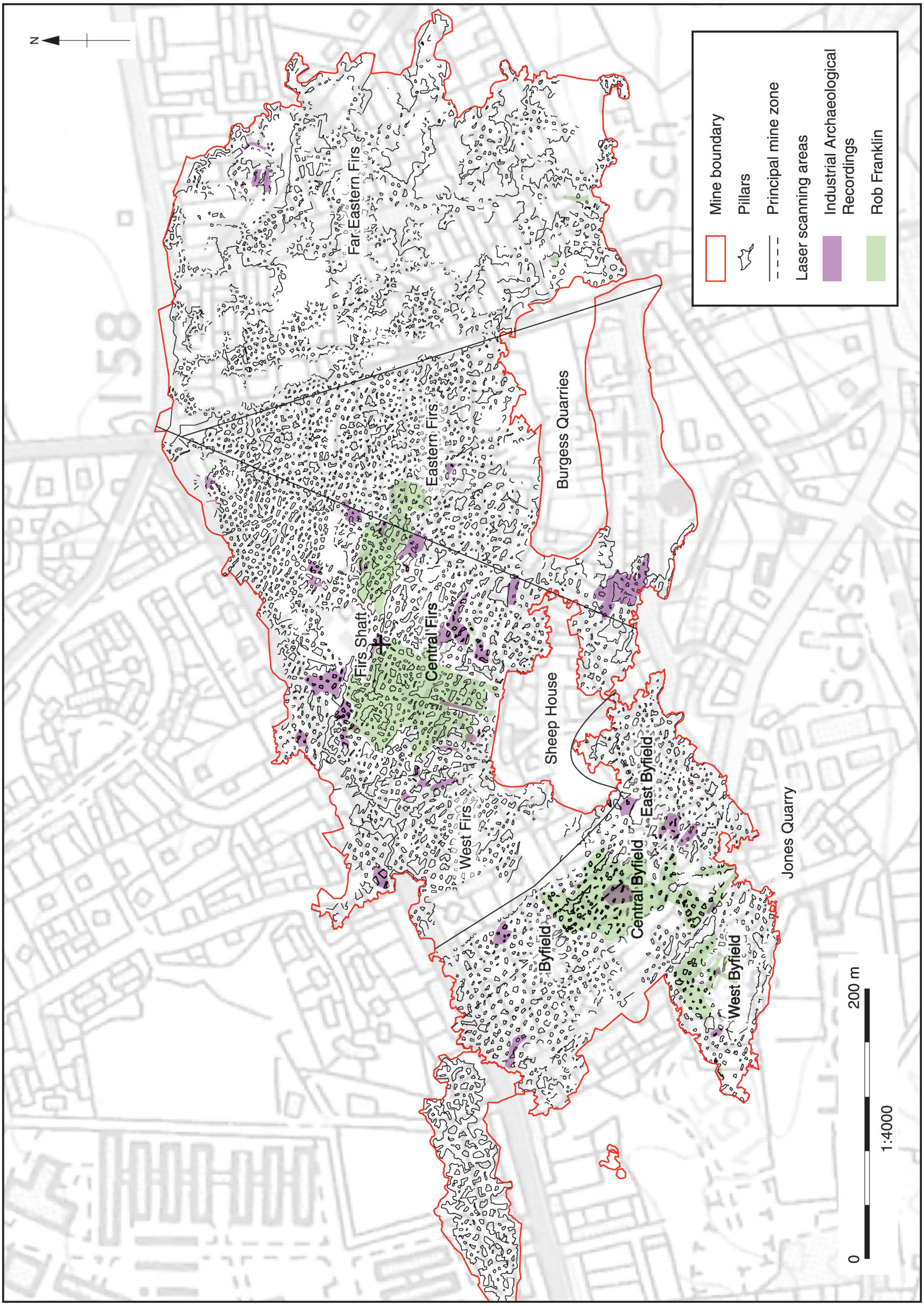
The mapping of the Combe Down Mines prior to the Stabilisation Scheme was devised and carried out by Brian Hawkins, Professor of Civil Engineering at Bristol University, who reported the results in 1994 (Fig. 1.9). His team had full access underground restricted only by time and by the limitations of the quarrying environment. Not all parts of the quarry were either accessible or recorded, especially where deposits of waste stone had been previously placed to the roof level or in areas of unstable roof. Limitations of time and money resulted in some areas, away from housing above, not being recorded. During 1994 the survey team began to map the external limits of the accessible quarries. Their recording, by electronic distance measurer (EDM) established a network of fixed points and the locations and extents of stone pillars which remained in the quarries to support the roof. It also included a number of other features including the location and extents of the roof-supporting stone packs and areas where quarrying waste had been stacked to the roof level. The whole was related to the National Grid and formed the basis for the Mine Survey during operations.

Location – in general and by Archaeological Areas and Quarry Areas

The large area involved required some form of division to aid location of features, both in general and in specific detail. The most basic division used was into the two main mines, Firs and Byfield, and the smaller dispersed underground workings (Fig. 1.2). To denote general locations, the terms West, Central and East Byfield were used, with whether it was north or south. Similarly Firs was West, Central, East (of the Avenue) or Far East (of the Long Drung). The numbers of modern roadways and 'stubs' were also used, notably on photographs where recording sometimes was irrelevant to or was ahead of planning and contexting activity. Hawkins had divided his surveyed areas into sectors designated by letters, whose relic is seen in the underground modern road numbering (eg E4 stub).

The underground quarrying landscape was subsequently subdivided into more manageable

Fig. 1.9 (facing page) Pillars and Sectors (after Hawkins 1994), with divisions used to communicate general locations within Firs and Byfield Quarries. The shading shows the High Grade Areas where laser scanning was carried out


N
Mine boundary
Pillars
Principal mine zone
Laser scanning areas
Industrial Archaeological Recordings
Rob Franklin
Far Eastern Firs
Eastern Firs
Burgess Quarries
Central Firs
Firs Shaft
Sheep House
West Firs
East Byfield
Central Byfield
Byfield
West Byfield
Jones Quarry
0
200 m
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and describable areas, termed Archaeological Areas. These are areas which appeared to have common characteristics or were conveniently-sized areas on which to report the early interpretive findings. This division was devised so that artefacts, recording and photographs could be sorted and catalogued by area. This system had substantial limitations, including the fact that few complete quarrying boundaries were accessible and the ability to define features was extremely limited before more quarry complexes were seen and experience gained. Allocation of the Archaeological Areas from 2002 onwards were assigned to anticipate the individual Quarry Areas and so were generally larger in size than previous areas and followed more closely the actual quarrying practices. The recording remained predominantly by Archaeological Area.

What emerged was that many of the Archaeological Areas that had been assigned prior to the 2002 and within the 2005 recording period were indeed arbitrary and in many cases several archaeological areas could be incorporated into a single Quarry Area, ie areas likely to have had a single operator uninterruptedly within the same chronological phase. The Archaeological Areas and Quarry Areas are shown in map form and tabulated with their characteristic features and components on the website (www.combedownstoneminesproject.com) Quarry Areas are widely used in the chapters below. In the text they are identified by their assigned number, ie Quarry 501.

Individual features were given a context number, which was recorded on the drawn plans, and/or sections and recorded on a context sheet. The context and Archaeological Area numbers are essential in retrieving data from the project archive but are not used in this report.

Monitoring methodology: standard and adaptive methods

The recording methodology

Photographic recording began in February 2001 at intervals of two weeks. Systematic archaeological recording was initially and largely carried out by the site officer (NRH) from September 2001 in conjunction with a mining archaeology consultant (LW) who attended on one or two days a week. Other site staff and specialists were brought in as the work demanded.

The initial work focused on recording individual quarrying features or components and localised aspects of the underground quarrying landscape which were being immediately impacted by the Stabilisation Scheme. An adaptive methodology was quickly developed to use the standardised OA system to appropriately record areas as they became available, including surviving parts alongside earlier modern roadways not previously archaeologically fully recorded. Most conventional archaeological planning involves the establishment of a planning grid system and requires full access to the archaeological deposits and/or structures. At Combe Down access was restricted to a network of engineered roadways and stub roads, a problem overcome by using the techniques discussed below. Throughout the decade of recording, the principles remained the same, though increased time and much better access meant that High Grade Areas were more completely covered. Laser scanning and video considerably enhanced the record in these areas.

The principle problems affecting recording were that of visibility and distance because of health and safety access restrictions within a mining environment. In two instances, access was delayed due to a different contractor or contract where the mitigation for the main scheme did not apply and it took time to negotiate entry on a voluntary basis (Grey Gables and Foxhill sites). Different methods were tried, subsequently improved, adopted or abandoned throughout the period of archaeological recording. One of the most significant was the use of 110v mains lighting rather than just headlamps or hand battery lamps: this was sometimes available on road heading machinery and from fixed power points on the roadways, but was far from universal. All High Grade Areas were so lit, which was a requirement for video filming.

Recording was carried out mostly through a programme of monitoring the stabilisation roadways in advance of any impact on the elements of the quarrying landscape. The recording involved planning in front of each of the working headings, capturing features using still photography, recording of any vertical data using conventional section drawings and/or 1:1 scale tracings of features, and in some instances laser scanning was employed with scaled hand-drawings produced from that data. In areas that had already been impacted by the enabling works a programme of reactive recording was initiated to capture quarrying areas where roadways had already been driven. This involved context numbering, planning and photographing features seen ahead and on both edges of the roadways.

Recording the quarrying components

Recording methods differed depending on the nature of the underground quarrying landscape and the type of historic activities that had taken place. For example, rooms that had been backfilled from floor to near or at the roof were impossible to record using the detailed planning methods employed where a greater vista of open underground landscape was visible.

Quarrying toolmarks survived on pillars, roof and other worked faces throughout the mines. These illustrate the various quarrying methods used. The types of tools varied by period and individual quarrying enterprises and so provide an indication of the date and of working techniques within each quarry area. Most of the toolmarks were located and described in note form on the drawn plans. Marks that were unusual or that specifically indicated the working technique were allocated individual context numbers so that they could be recorded in more detail or linked to photographs and other records. Significant toolmark profiles, for example, were drawn at a scale of 1:1 when possible and a proportionate number were routinely drawn in any given quarrying enterprise. Tool profiles were also routinely recorded at scales of 1:20 and 1:50 in other drawings to show their distribution within the quarrying area.

Graffiti

Other features, such as graffiti on pillar faces, were also recorded. Section drawings complemented the photographic and/or written record and were generally drawn where the graffito was too faint to photograph or was of such significance within the general quarrying context that it required further analysis. Some graffiti were recorded remotely by video photography and laser scanning where preserved on otherwise inaccessible pillar faces at ranges beyond the usual photographic range.

Quarrying features preserved between stone pillars included cartways, barrow-ways, and deposits produced during working. Lifting and haulage features included the former location of cranes determined by the locations of Lewis or wedge slots and square chog-hole recesses in the roof. Stone packs, used to support the roof and waste stone were a common feature of the quarries. The relative size of spoil, that is, fines and rubble-stone and blocks, including their range and distribution were recorded spatially on the plans. This information was used to ascertain the methods employed during the historic working and in the management of spoil. Some of the information gathered was difficult to transfer on to digitised plan format and is thus best examined by direct reference to the hand-drawn field plans held in the archive.

Context records

The standard pro-forma context sheets were used during the early stages of recording. These include the standard provision for recording and describing archaeological deposits, cuts and structures. It became apparent that the conventional sheets were inadequate for capturing the unique underground quarry landscape and, given the high humidity environment underground, were prone to deterioration. The recording practice was therefore adapted so that the descriptions were either recorded in surveyors' waterproof books or were detailed on the Permatrace plans and later transferred to context sheets on the surface. Several new pro-formae were designed to incorporate, in addition to the standard data check lists, feature types and descriptive terms needed to describe the quarrying landscape.

Planning and the drawn record

The Hawkins pillar plans were supplied as required by the Mine Surveyor Dr R. Narbett, of Hydrock Contracting, and 2005 onwards from the mine plan by the mine surveyor Steve Dix. The plan was based on a series of fixed points with their accuracy confirmed by use of closed traverses. The 1:100 scale plans were copied at that scale on to Permatrace of a suitable size for underground use, so that a baseline of pillars was available to map the quarrying environment in the visible area just ahead of the construction of the engineered roadways. Since most of the underground quarrying landscape and features were dictated by the position of the pillars they proved detailed baselines on to which the archaeological inferences could be mapped.

Quarry feature outlines were plotted by combining a series of offsets from the engineered roadways and reference points on to which other measured and sketched details were added. The process was designed to capture the characteristics of individual features and relate them to stone pillars and other features within the quarries. The main survey apparatus used was a Leica Disto distance measurer used to plot archaeological features that lay between the pillars. This was achieved by lining up the instrument between two known points on the Hawkins plan and measuring the distance from the points, often corners of a pillar, to the feature being surveyed.

The main limitations of this process, used on the bulk of the investigation, for the archaeological plans resulted from the method of recording pillars used by Hawkins, who naturally had other priorities than archaeological recording. Pillar survey had been done (and continued to be done on the post 2005 Mine Plan) by a series of measured off-sets using an electronic distance measurer (EDM) from a network of established survey stations. Pillars were recorded at their narrowest (ie weakest) points or at waist level, so that the individual pillar plan is an approximation of the whole, due to irregularities in their vertical form. As in many areas the archaeological survey had to use the pillars as a basis for location, the archaeological survey will have small errors as a result, which with other difficulties of access and viewpoints and working may mean errors of a few tens of centimetres in the field plans produced. Because the field plans were relocated to the mine plan at short intervals, such errors will be non- accumulative, and do not materially affect the final representation and interpretation of the quarries.

Where the Hawkins plans were inadequate to provide baseline pillar plans the current mine plans were extended by the mine surveyor using a chain survey. This involved the use of a series of survey stations set up to plot the engineered roadways. Temporary baselines and survey stations established in the roof were related to the mine survey so that the mine surveyor and/or the archaeological survey team in conjunction could produce accurate site pillar plans through measured offsets on to which the archaeological features were drawn. Data on the smaller sheets of permatrace were transferred to larger A1 size sheets when the survey station data became available. This process was laterally accurate for capturing the pillars on either side of a roadway but had more limited accuracy forward of any of the roadways due to the increased distance; 'best-fit' judgements had to be applied during transfer. Where rooms (between pillars) were not filled with floor-to-roof rubble, an advanced primary measured sketch was made forward of the roadway advancement that could later be correlated to the baseline survey.

As archaeological recording progressed, a dedicated full time mine surveyor and survey team were employed by Hydrock to survey the existing roadways. This included weekly surveys of the advancing headings, including the pillars ahead. This was especially important in the far eastern edge of the Firs Mine where access to the Hawkins team had been restricted by floor-to-roof infilling and restricted head room within the quarries generally. This meant that the steel supports within each of the roadways were individually surveyed by the Mine Survey team, and these provided good locations to laterally survey from the roadways, if necessary in advance of their survey. Where the pillars were not picked up by the mine surveyor (due to filling of the sides with spoil before he could attend), the archaeological results from off-sets from the roadway steel supports were provided to update his comprehensive pillar plan.

Sections, elevations and the drawn record

Section drawings were produced to capture vertical features of the quarries such as floor-to-roof waste rubble deposits, barrow-ways and stone packs. Conventional recording methods through measured off-sets were used when structures and deposits were accessible from the roadways, drawn at a scale of 1:20 or 1:50. Features such as toolmarks, which required more detailed recording, were drawn at 1:10. Graffiti on faces were drawn at 1:1 to supplement the photographic record, especially in the case of faintly preserved graffiti.

An adaptive use of the Leica Disto measuring instrument attached to an inclinometer facilitated recording of structures, deposits and floor to roof profiles located beyond the supported roadways. The quarry feature outlines were plotted using the distance and inclinometer angles to capture the limits of contexts, on to which additional sketched details and interpretation were added. An electronic distance measurer (EDM) was sometimes employed to record profiles beyond the roadways and produced similar results.

Artefact recording and recovery (including recovery of graffiti)

A wide variety of artefacts were located underground. Some related to the actual quarrying activity, including tools and personal equipment, others to items brought in by later explorers, In addition, a very substantial number of items had been dumped into shafts or other entries or, in lesser quantity, stored within the workings.

Artefacts were recorded on the standard OA small finds pro-forma, although graffiti was considered a feature and recorded on the context sheets.

In the case of obvious dumped, lost or stored material of a post-working type, samples were taken and recorded, for instance of bottles and pottery, whilst others, car body parts for example, were noted and left in situ. Where there was possibly a relationship with working, eg the material brought up from the well and discarded in the E4 stub, which yielded a range of early and mid 18th-century pottery, then it was fully recorded and recovered.

Quarrying-related material was all recorded and photographed *in situ* if possible. By the nature of their activities, many artefacts were first discovered by the mining teams. They soon appreciated the need for leaving *in situ* where possible, for instance, pipes left on ledges, and were careful to note the situation of any material they were forced to move. Such artefacts were placed at an agreed point or into a finds tray, and recorded on the next visit. Smaller finds could usually be conveyed out, suitably protected, on the archaeologists' equipment-wheelbarrow, while larger items, such as banker mason work was brought out by the tracked dumpers on pallets when convenient. A temporary store was set up at the buildings at Ralph Allen Yard (a former malthouse) and used until items could be conveyed back to the Oxford store. Some items were drawn on-site, others while in store.

Graffiti was a common feature, especially near entries, and some had useful content either for its direct relationship with quarrying, or for its contemporary social information which had potential for museum or interpretative centre display, so was physically recovered. This was done in one of two ways.

Most graffiti was drawn using a coal-like material, together with coloured earths, on the flat sawn faces of pillars. Some it was possible to recover by processes developed by a specialist consultant, Dr Dana Challiner. The surface was sprayed with a liquid silicone, then silicone rubber (similar to latex) was applied in a thick layer using a spatula. The following morning the silicone rubber could be peeled off, bringing the surface layer, including the graffiti, with it as a negative.

Subsequently this was applied to a sheet of long-life resin sheet, coloured appropriately in advance by ground rock. The result was the original image on a surface suitable for exhibition. The process worked well on a number of examples.

In other cases the graffiti was either inscribed, or was covered with a thin layer of calcite deposited as flowstone from seepages. Initially assistance was elicited from a local mason, Gerry Melksham and such examples were cut around until it was possible to saw the slab, 100-150 mm thick, off of the stone face. The largest of these pieces was some 1.8 m x 1.0 m.

The feature was first protected. White spirit was sprayed on and a wax composition (cyclododocane) was sprayed and then painted on in a thick layer. The wax would eventually sublimate over months when exposed to air, leaving no trace. This surface was then covered with a thick layer of the silicone rubber noted above. A large angle grinder with a 12-inch diamond cutting blade (110v or compressed air as available) was then used to cut a neat perimeter around the feature. At the base two horizontal cuts were inserted about 100 mm apart and the stone between was removed with a chisel. The feature was then covered by a thick plywood board, fitted with a wooden section which fitted into the slot created at the bottom which was wedged tightly into position. The feature was thus doubly protected. The three other sides were then chiselled back (using hand or powered tools, the latter if possible) until a frig bob saw could be inserted. This was the traditional one-man, cross-cut-type saw used for this work, and it worked well with a drip of water from a can to clear the teeth (and even better with the hose pipe we were able to use on some occasions). It is hard work to operate and the sawing was done in relays. It was a useful form of experimental archaeology. Once the saw was deep enough, ratchet straps were inserted into the top of the cut to bind the board tight to the slab being cut. Once cut through, the slab was tilted on to a prepared pallet and slid over wooden beams on to the bed of a tracked dumper and conveyed to surface, then with a fork lift truck to the store. We were grateful for abundant advice from passing miners.

After the graffito is re-exposed by removing the protective board and silicone rubber, the wax disappears (by sublimation) over a period of some months, leaving the stone slab with the graffito intact.

Artefacts and graffiti are considered in a series of detailed reports on the website, which are also summarised in Chapter 11 of this monograph.

Adapted methodologies

At the outset of the Stabilisation Scheme it was assumed that some archaeologically important areas of the mine would be preserved. These were to be supported and made accessible from the network of inspection and survey tunnels after the stabilisation works were completed. The OA archaeological team identified areas for preservation on the basis of their importance and visual interest in consultation with the project engineers. The Archaeological Preservation Areas were located beneath the Firs Field Recreation Ground, where it would have been possible to carry out the large scale engineering works required for insertion of a sub-surface and surface support framework to ensure long term stability. These areas were largely but not entirely coterminous with the High Grade Areas, which are shown on Figure 1.5.

The areas selected as Archaeological Preservation Areas were:

- Stub E4: an area of early 18th century, probably pre-Allen, quarrying.
- Two lengths of Allen-period (18th-century) cartway.
- An area of 19th-century deep quarrying
- The Grand Canyon: an area of late 19th-century deep quarrying, monumental in size (hence the name) and (unusually for the quarry complex) not backfilled with later quarry waste

It eventually transpired that the inherent engineering difficulties associated with stabilising these areas were insurmountable and it was reluctantly decided by English Heritage in consultation with B&NES to carry out a programme of enhanced recording of these areas and allow them to be backfilled along with the rest of the underground quarries. Enhanced recording was carried out using a mix of traditional archaeological techniques and other recording media such as laser scanning and video recording. Whereas, during the main scheme, roadways were driven for engineering purposes and archaeology recorded as it was encountered, for the Archaeological Preservation Areas archaeologically led roadways were driven to allow access to the core elements of the Areas and to facilitate the laser scanning and video recording.

Foxhill and Church Road: an alternative methodology

The Foxhill quarry complex, consisting of four small adjacent underground quarries, was archaeologically recorded using a variant of the standard archaeological method devised for Combe Down. Interpretation at the reporting stage utilised photographic images, provided by others (mainly engineering staff) of features impacted prior to the start of archaeological survey. Numerous artefacts were recovered from the site agent, which were related where possible to archaeological contexts or to a general location. Approximately a hundred artefacts were photographed *in situ*. The impacted quarrying features were assigned additional contextual information derived from photographs and their locations established in conference with the site agent. The photographic data was correlated with the archaeological survey data and with historic references derived from mines inspectors' records and those of others, to assist in dating the four quarrying areas.

Church Road voids

The Church Road voids located to the south and north of the road were not all accessible. Quarry Areas to the north of the road were partially surveyed where access permitted and were included in the Quarry Area descriptions. In order to record the voids located south of the Church Road a laser scanning machine was lowered down boreholes to record the limits of the quarrying, enhanced by video survey. No standard archaeological surveys were undertaken in these locations but the scans were interpreted to establish the character, dimensions and the direction of later surface-derived quarrying waste and so identify the former quarry entries.

Enhanced recording

Photography – still images

A combination of colour transparency, colour print and black and white negative photographs was used in recording, enhanced by digital photography from 2007 onwards. The latter was particularly effective in the recording of graffiti images and tools. Over 7000 colour images, 1000 digital images, and over 3000 black and white photographs were taken to depict the extensive and complex nature of the underground and related surface features. These totals included production of duplicated or multiple images to ensure satisfactory results were obtained by varying the lighting, viewpoints etc. Transparency and print films were digitised for archive deposition, in accordance with all other report data.

Video photography and the remote recording

In non-professional mining archaeology, video-imaging is in widespread use underground, though there is still a compatibility problem, largely because of different recording standards and the change from analogue to digital. Nevertheless, it has many advantages, especially for exhibition use. Video recording provides different and sometimes more information than equivalent still images, which it complements rather than replaces. It can, for instance, place a small feature in its larger context in a clear and obvious way, and can produce panoramic views, allowing full examination of an underground landscape with ease. Its ability to use very low light levels means simple hand lamps or 110v industrial electrical supplies can be used for lighting, though the latter is far preferable and was used in all High Grade Areas. Its zoom capacities combined with low light capability make features visible at ranges impossible to the naked eye or still camera, rivalling the data only otherwise obtained by laser scanning. Distant items of graffiti are particularly easily recorded and, if necessary can be converted to a still image.

At Combe Down video recording was initially used in 2003 and 2006, employing IA Recordings, a small, semi-professional unit, particularly skilled in underground video-imaging. They used a broadcast standard camera and the output is available on videotape and DVD. A second phase of video photographic survey, which concentrated on the High Grade Areas, commenced in March 2007. This was carried out by independent video film-maker, Rob Franklin. Filming was carried out in advance of the archaeologically-led engineered roadways and from the sides as access became available, usually as the next row of pillars was passed.

As well as using traditional tripod mounts, restricted access in an area known as the Grand Canyon necessitated the use of a large camera boom for surveying the floor and other areas inaccessible using the conventional tripod. An aerial cable was erected close to the roof along the eastern end of the Canyon to record aspects not visible from any other location.

Laser scanning and remote recording

Another key recording strategy was the use of laser scanning. This technique had a dual function, being used for both high quality recording of High Grade Areas and also acted as a the key element in the production of a 3-D digital model of the workings. The subsequent creation of this digital model represents a major output of the recording strategy, forming an accessible record of the results of the recording action (as a GIS) and is the basis of the 'fly-through model' intended for the proposed interpretation centre.

APR Services carried out a pilot laser scan survey in May 2003. The preliminary scans, coloured from still photographs produced almost film-like representations which could be viewed and interrogated. With a range of up to 100 m and a variable spacing of the point cloud down to about 1 cm, the equipment has the capacity to produce a high definition, three dimensional survey of areas either too far distant for other methods, or which would normally require a remote access device for entry. The survey instrument was set up on a tripod stand at intervals along the length of the roadway so that each scan could be referenced to the previous scan location and to a network of survey stations located using EDM by the mine surveyor. Scanning locations were also set up outside the roadway supports within a discretionary distance of 1m, so that the roadway structure did not impede the scanner's line of survey.

The introduction of a more extensive laser scanning programme in the High Grade Archaeological Areas in Byfield and the Firs Mines (Fig. 1.9) from February 2007 proved essential for the permanent 3-D underground landscape survey and allowed a more comprehensive and accurate survey of the pillar plan in areas surveyed from Roads 1, 2, 3 and 4, near the Firs Shaft, originally using conventional drawn plans in 2001 and 2002. Laser scanning, because each point of the 'cloud' was fixed in space and because of the long range feasibility, enabled pillars previously visually inaccessible from the roadways to be plotted from the survey data, and then provided 1:100 scale drawings that could be combined with the drawn record. This recording was carried out with the conventional tripod based laser scanner machine, used elsewhere during the project, and with the aid of the borehole laser scanner from several horizontal pipe locations projected over the Grand Canyon floor, that were inaccessible to the conventional laser scanner. This was particularly important in the Grand Canyon where the 6-8 m high quarry could be captured and depicted at the lower quarry floor level from a viewing platform positioned over 6 m above. Detailed plans were drawn from this pillar plan data on to which features between the pillars could be sketched without having to cope with the challenges of altered perspective from planning from a great height. The survey was also an important tool for capturing vertical elements of the landscape such as stone packs, inaccessible by traditional recording techniques.

Post-excavation methodology

Ongoing analysis and coloured plans

Post-excavation analysis began during the later stages of recording. During the recording survey the plans of the underground quarrying landscape were drawn at a scale of 1:100, then reduced to a scale of 1:200 to be used as synthesised interpretative drawings during on-site analysis. As more of the quarrying landscape was accessed the plans were extended and up-dated. In some quarrying areas the final plans were finalised several years after the original work due to piecemeal access. The synthesised plans were updated during final analysis to indicate Quarry Areas which are used to locate items mentioned in the text herein.

The features recorded on these plans included the transport routes (cartways, railways and the barrow-ways), and where possible the direction of quarry workings and spoil tipping. The locations of tipping episodes associated with barrow-ways, tipping platforms and tipping fronts, where they were tipped over earlier quarrying features enabled the stratigraphic sequencing of quarrying areas and phasing of some quarrying. The plans also indicated the location of boundary pillars and larger groups of linear spaced pillars. These were often located on the limits between quarry areas and better defined their boundaries. The plans allowed analysis of the extents and the locations of quarrying areas that could be linked, in some cases, to documentary sources.

Digitisation of records (CAD, GIS)

The site plans were scanned by the OA Graphics Department and saved in .tif (no-loss) format. Scans of the plans were inserted into an AutoDesk Map CAD drawing and transformed to the correct location, using points on the pillars and roadways. Each archaeological layer was traced in CAD to produce a closed polygon. Archaeological layers, such as spoil tips, cartways and surfaces had closed polygons, whereas features such as sawn faces, jad slots and roof joints were unclosed polygons, and small find locations, Lewis slots and chog-holes were represented by a point. Context, small find, section numbers and other data were attached to the polygons and points. Once the plans were drawn, scanned and digitised the boundary pillars were used to ascertain historical quarry areas. These areas were altered to closed polygons with the quarry number attached. On completion of the CAD work the polygons and points were exported as shape files with their data attached. The shape files were imported into ESRI ArcGIS to allow analysis of the data.

Analysis of GIS and records

The GIS data was used in a number of ways. Cartway and barrow-way routes were correlated with the primary underground survey data and their limits plotted. Plots included, for example, cartway ruts, their orientation and extent. Where ruts were obscured their extent was extrapolated using synthesised drawings, pillar patterns and locations of vertical winding shafts and/or boundary pillars. Barrow-way routes were better defined and the data has allowed an understanding of the total lengths of the routes and their orientations.

GIS data was also used to establish the spatial distribution of quarrying features including sawn faces, wedge pits on worked faces and the roof, crane anchorage wedges and Lewis slots. The plots were used to examine similarities and abnormalities of distribution of quarrying features. The limits of each Quarry Area was calculated and the location of roof supporting pillars established through GIS data. The plots excluded pillars inaccessible to primary survey that could not be closed into polygons. The area of the pillars was deducted from the total area of the established quarry limits to suggest the total area of stone quarried. This total did not record the actual cubic volumes of extracted stone, as the depths of the quarries could not be established due to spoil deposition within them, but it did allow rough estimates to be made.

Analysis of other recording media: laser scans and video, planar viewing and measurement

Non-standard archaeological recording methods used during the underground survey facilitated analysis of features beyond the engineered roadways and which were otherwise inaccessible to the survey team.

Laser scanning

By means of fly-through laser scanning the overall areas of quarrying could be examined to determine three-dimensional aspects of the landscape not achievable through standard archaeological data capture, and to inform general trends in understanding specific quarrying areas.

Planar viewing and measurement

Laser scan data was used to measure the heights of the roof in inaccessible areas, and along cartway and barrow-way routes, and also to inform analysis of the quarrying operations that had been undertaken. Features analysed included working heights below the roof negotiated by quarrymen during working at the quarry face, and spoil deposition. Laser scanning was also employed to record the inaccessible northern side of the Grand Canyon Quarry Area to show the height and position of the full height pillars, and to record the stone packs, barrow-ways and spoil deposits. The scans also provided the inclination, the height from the floor to the roof and the extent of an important inclined barrow-way. The data also provided the extents of the vertical winding shafts, including the scaled images of shaft capping, and the construction details in some of the wells.

Recorded evidence of the inaccessible historical graffiti and some of the worked faces was also analysed. This enabled scaled recording of sawn faces with graffiti, in some cases establishing the names of the individual quarrymen that were faint and illegible when viewed from the stabilisation roadways. Scale-drawings of the worked pillar faces were also prepared so that synthesised drawn sections could be completed and reproduced in the report.

Video

The video was used in correlation with the Planar viewing and measurement (see above) to record the sawn faces with quarrymen graffiti and obtain images of features which lay further from the stabilisation roadways and were therefore not achievable by conventional still photography, or that would have been impacted before good access could be achieved.

Video photography was used to record the areas of the underground quarrying landscape which were inaccessible to the standard recording methods in the former High Grade Archaeological Areas prior to the impact by the stabilisation scheme roadways. This data was analysed during the interpretation and reporting periods to better understand the quarrying environment.

Structural, stratigraphic and artefact analysis

The analysis of the artefacts (and their stratigraphic context) continued work begun during the on-site recording. This included the lost or abandoned quarrying tools, the quarrymen's personal effects and the discarded or buried stone artefacts.

Analysis of both archaeological and documentary sources attempted to establish the actual individual quarrying areas and their phase of activity. Each of the artefacts was assessed on whether they had been originally recovered from a closed context, for example, from a barrow-way surface, a platform or tipping front make-up; or whether they had been recovered from a pillar ledge or from within a niche on a pack wall. Those artefacts that were not attributable to a closed context may have been abandoned or lost during any of the quarrying periods, and also may have been moved from their primary to secondary contexts during either a later phase of working, possibly for re-use, or in the post-quarrying periods. Some of these artefact types were attributable to surface-derived material deposited through either vertical winding shafts or other entries including from the spoil from surface infilled quarries.

The possible redeposition of artefacts had to be considered. Even those artefacts that were recovered from secure contexts, for example the tipping fronts, had to be assessed to establish from which quarry area the tipping front had originated, regardless of which adjacent quarrying area happened to be nearest.

The small finds were added to the GIS which facilitated analysis of their distribution, their material and their type. This element of the GIS was extensively used by the finds specialists in order to inform their discussion of the distribution of the artefacts and to further refine analysis of the quarry dating. These reports are discussed in a later chapter, with the full report available on the website.

Combe Down and underground archaeology

The study of underground mining and quarrying is a relatively unusual branch of professional archaeology in Britain, though it has been established for several decades in Germany, based on the Deutches Berbau Museum at Bochum, usually published in the journal *der Anschnitt*. Probably the first substantial underground excavation in England was at Grimes Graves, in Norfolk (Sieveking 1979). Since the lack of recent work undertaken in the United Kingdom is due to increasing health and safety restrictions, a situation which has favoured work by amateur groups (who nevertheless often include professional archaeologists and others with the requisite skills). These groups have fairly frequently gained financial help via grants.

Carrying out such archaeological work during active mining operations, professionally or as amateurs, is also unusual, though less so at surface than underground (see for instance, Hartley's investigations of Tudor mining in a Leicestershire opencast mine (1994)). Combe Down is probably the first substantial such underground investigation in the UK. However one of the present writers (LW) has carried out (with colleagues) similar work during mining operations fairly extensively in India and at Rio Tinto in Spain (see articles under Willies on www.pdmhs.com). Underground archaeology, or projects with a substantial archaeological content, in the UK has been fairly extensively carried out by Timberlake and Barnatt, separately and independently, and Willies, under the auspices of the Early Mines Research Group or Peak District Mines Historical Society. Arthur J. Price of the Cotteswold Naturalists Field Club has recently published an account of Cheltenham's Whittington Quarries which has the results of a fairly substantial underground archaeological work (Price 2007).

Continental interest in underground archaeology has also been increasing in recent years and there have been or are ongoing several projects of comparable significance to Combe Down. The Bergbau Museum under its archaeologist the late Professor Gerd Weisgerber and now under Dr Thomas Stollen have many reports to their credit (see for instance Wagner and Weisgerber 1986 and Weisgerber and Goldenberg 2004) and Weisgerber in particular deserves the credit for establishing the discipline. In Romania the Department of Archaeology of Toulouse University is investigating the Roman gold mines at Monte Rosa.

At least two teams, made up of professional archaeologists combining with skilled amateurs in France have engaged with underground archaeology, including current investigations at the Laurium Silver Mines, Greece. The recently formed *Institute Europa Subterranea* has held three symposia on archaeological mining history, the most recent reported in Silvertant and Mhairtin (2008). This publication has a range of material from detailed archaeological investigation of mines in south-west Germany (Strassburger 2008) to more general articles with a strong emphasis on survey and photographic recording rather than full archaeology. Much the same is happening in Britain which has a strong tradition of such work, much of it unpublished: including, for instance photographic collections by Paul Deakin (of PDMHS) of underground mining and quarrying nationally, and, in underground stone quarries with strong links to Combe Down, Derrick Hawkins for photographs (NAMHO 2010 Conference at Coalpit Heath near Bristol) and for surveys, the Box Freestone Mine Survey by members of the Shepton Mallet Caving Club (*c* 1998). Video filming with strong archaeological content has been carried out by IA Recording (who also contributed at Combe Down) and by David Webb of PDMHS.

The Combe Down Stone Mines Project has, for the very first time in England and the UK, placed the full resources of a professional archaeological body, Oxford Archaeology, into a large scale archaeological examination of underground quarries, with all the back-up for specialist expertise and finds examination that that implies. It has shown that such work is compatible with ongoing mining operations within old workings (which has implications for mitigation strategies where old workings are to be disturbed by development), and that an integrated strategy of archaeological investigation combined with an extensive examination of documentary and published resources can yield a coherent result, which would not have been available by any other means for describing this fundamental part of the Building of Bath.