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Quarrying on the Eastern Moors

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Quarrying on the Eastern Moors



Abandoned millstone roughouts, Curbar Edge, February 2012: Photo - author

Abstract

This dissertation builds on the raw data on 1,177 quarrying-related features of the Eastern Moors, Peak District National Park, published in the Eastern Moors Survey Report (May & Badcock, 2011), by extending its dimensional content through a programme of fieldwork to 321 of the features, and correlating the data with geological, topographical and routeways information. A new quarry typology is developed and used to interpret the data. Quarried volumes by quarry type and geological stratum are estimated, confirming that most quarrying exploited the better sandstones and millstone grits exposed along the scarps and Edges. The distribution of quarries is also closely associated with the dense network of routeways across the moors. Census data are used to estimate that about 35-40 people were working in the quarrying industry on the moors in the 19th century. The visible quarries represent a total quarried volume of over 154,000 m³, 85% of which came from the 296 larger quarry pits over 1m deep. Historical records provide information on wages, costs, prices and profits in the quarrying industry in the past, and confirm that millstone making was concentrated in the south-west of the study area, and profitable until the 18th century. Combining this data shows that quarrying was similar in economic importance to agriculture on the moors, albeit that neither was of great economic importance in the 19th century.

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This research would not have been possible without the work of the dedicated team of ArcHeritage surveyors, who went out in often terrible conditions during the winter of 2010-11 to gather and compile the raw data on the 5,937 features in the East Moors Survey Report.

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Contents

Chapter 1	Introduction	7
Chapter 2	Historical and archaeological context	10
2.1	Eastern Moors Survey Report	10
2.2	Other material	11
2.2.1	<i>Prehistoric period (before AD 43)</i>	12
2.2.2	<i>Romano-British period (AD 43-410)</i>	12
2.2.3	<i>Medieval period (AD 410-1485)</i>	12
2.2.4	<i>Post Medieval – Early Modern period (AD 1485-1901)</i>	13
2.2.5	<i>Millstone & grindstone making</i>	13
2.2.6	<i>Geology, quarrying methods and technology</i>	14
Chapter 3	Social and economic context	16
3.1	Census data – who were the quarrymen?	16
3.2	The economics of quarrying	20
3.3	Chapter summary	22
Chapter 4	Research methodology	23
4.1	Desk-based initial assessment	23
4.2	The new database	24
4.3	Fieldwork	25
4.4	Incorporating other data	27
4.4.1	<i>Bedrock type</i>	27
4.4.2	<i>Routeways data</i>	27
4.5	Chapter summary	29

Chapter 5	Combining and analysing the data	30
5.1	A proposed quarry typology	30
5.2	Estimation of quarried volumes	34
5.2.1	<i>Quarry pits</i>	35
5.2.2	<i>Quarry scoops</i>	36
5.2.3	<i>Quarried scarps</i>	37
5.2.4	<i>Quarry – type not clear</i>	38
5.2.5	<i>Surface workings</i>	39
5.2.6	<i>Limitations – backfilling</i>	40
5.2.7	<i>Quarrying volumes summary</i>	41
5.3	Distance to routeway	41
5.4	Spoil heaps	46
5.5	Bell pits	49
5.6	Structures and other features	49
5.7	Quarrying and topography	49
5.8	Quarry types and bedrock geology	50
5.9	Quarry product type	53
5.10	Chapter summary	53
Chapter 6	Discussion and conclusions	55
Chapter 7	Recommendations	58
Appendix 1	Calculating areas and volumes - a note on length, width, depth/height and form factor	59
Appendix 2	Quarried volume calculations (table)	61
Bibliography		62
Maps		67-85

List of Tables	<i>These appear within the text</i>	
3.1	Derbyshire male occupations by census year	16
3.2	Local occupational data by census district and year	18
4.1	New database – setup	25
4.2	Determining the geographic distribution of routeway distances	28
5.1	Proposed new quarry typology	33
5.2	Analysis of quarrying features using the new typology	34
5.3	Summary of the quarry features dimensional analysis	41
5.4	Distribution of routeway distances by quarry feature type, using the new typology	42
List of Figures	<i>These appear within the text</i>	
4.1	Screenshot from new Bento database	24
4.2	Methodology flow chart	29
5.1	Distance to a routeway for selected quarry types	43
5.2	Distance to a routeway for the ‘Not clear’ feature type	44
5.3	Distance to a routeway for selected non-quarrying features	46
5.4	Sketch plan of a small quarry pit	48
5.5	Bedrock properties by quarry type (by numbers of features)	51
5.6	Bedrock properties by quarry type (by quarried volume/area)	51
List of Photos	<i>These appear within the text</i>	
1	The Eastern Moors, looking north – annotated aerial view	7
2	Feature 217, a Quarry pit	35
3	Feature 5354, a pair of Quarry scoops	36
4	Feature 5032, a Quarried scarp	37
5	Feature 6154, Curbar Edge millstone working area.	39
6	Feature 6762, a small Quarry pit with surrounding spoil heap	47

List of Maps

These are grouped together at the end of the text, from page 67

1. Location map
2. East Moors Survey Area – local topography
3. Routeways in and villages near the survey area
4. Routeways and the multiple ring buffer
5. Intensively worked areas in the study area
6. Sampling grid
7. Example of a fieldwork location map
8. Quarry features before and after fieldwork
9. Quarried scarps and contours
10. Quarry pits and contours
11. Quarry scoops and contours
12. Surface workings and contours
13. Quarried scarps and geology
14. Quarry pits and geology
15. Quarry scoops and geology
16. Surface workings and geology
17. Locations of known quarry products
18. Civil parishes and villages

1. Introduction

The Eastern Moors are an area of mainly open moorland, between 250m and 400m AMSL, lying about 10km to the SW of Sheffield (Map 1). The ground cover is mostly heather and bracken, and the land is used for rough grazing. The moors have very few habitations – a couple of farms and former gamekeepers lodges around the periphery (Map 2), and little or no arable farming, which has aided the preservation of remains from the Neolithic onwards. There are, however, a number of significant villages along the western side of the moors, and a few more rather further away, to the east, between the moors and Chesterfield. The moors are criss-crossed by a dense network of paths, hollow ways and old tracks (Maps 3 and 18).

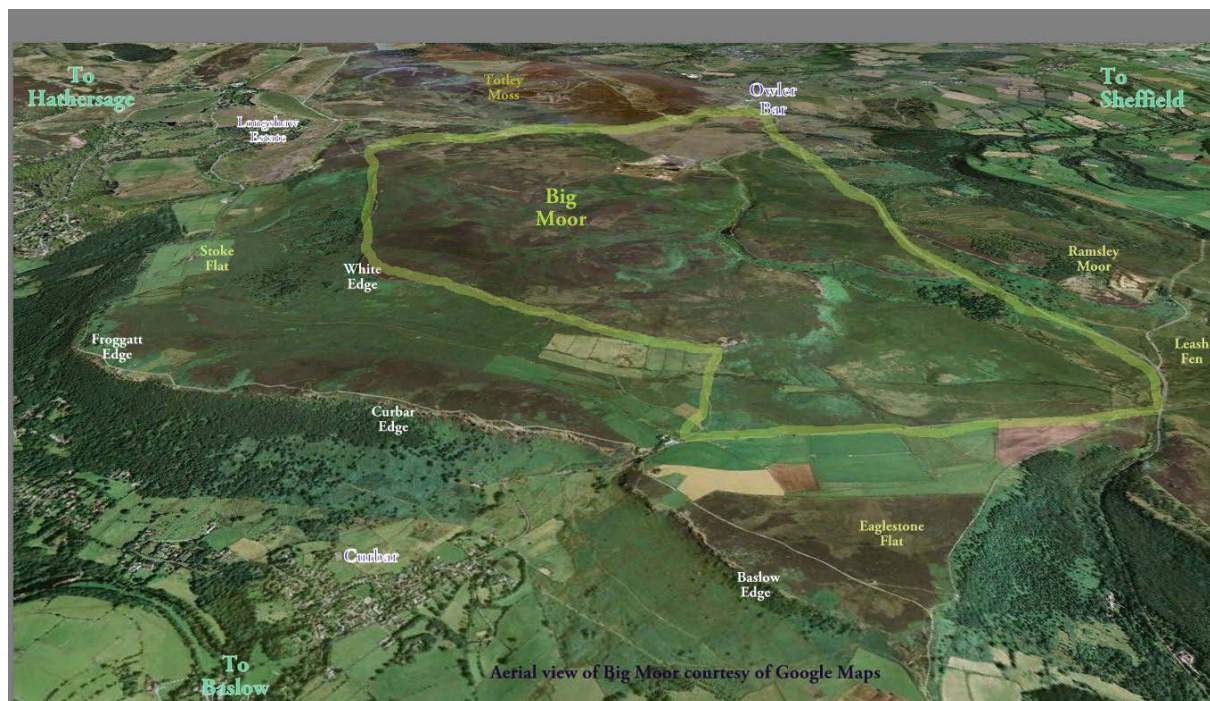


Photo 1: The Eastern Moors, looking north - an annotated aerial view. Sources: Original - Google Maps; this version Temple (2014)

The moors lie within the Peak District National Park (PDNP), and are very popular with walkers and climbers. PDNP managed the area as open access land until the end of 2010, when it concluded a new management agreement with a consortium made up by the National Trust (NT) and Royal Society for the Protection of Birds (RSPB) - see

Chapter 1 - Introduction

www.easternmoors.org.uk for more details. As part of the handover, a historic landscape survey of the Eastern Moors was carried out by ArcHeritage between October 2010 and March 2011, and their report was published in March 2011 (May & Badcock, 2011). The report listed 5,937 features across the 26sq. km. survey area, each of which was located using survey-grade GPS, and described, with particular attention to the current state of preservation, ground cover and any evident threats. Amongst other things, the authors recommended (ibid., 55) that:

“The huge diversity and widespread nature of stone extraction is of great interest and should be explored in greater detail. [A Sheffield University undergraduate is already considering this as a dissertation topic]”.

Under the academic regulations then applying, the author was allocated this dissertation topic in 2011, and completed a feasibility study and research plan as part of assessed work for AAP201 (Mailer, 2011). The research would concentrate on the quarrying features, with the aims of:

- identifying and quantifying different types of quarrying
- dating the features where possible, and relating them to any historical records
- deducing the contribution of quarrying to the local lifestyle and economy.

Work began in the summer of 2011, and continued intermittently (given the other academic and non-academic demands on the time of a part-time student) until late 2013, when writing-up commenced. In practice, fieldwork could only be conducted during winter and spring (weather permitting), as groundcover obscured many of the smaller features at other times.

After an initial analysis of the raw data, it became clear that there was insufficient quantitative information to address the research question, and a significant effort would be required in the

Chapter 1 - Introduction

field to measure a broad sample of quarrying features. Effort would also have to be applied to gathering employment statistics from the 19th century census records, and economic data from both academic articles and original publications.

This dissertation begins with a review of the historical and archaeological context of quarrying and the stone industry in general. There is not a great body of material, and not much of that is concerned with the Eastern Moors. Most of the material that could be found has tended to concentrate on millstone manufacturing in the Peak District and neighbouring areas. This is followed by a short review of the economic and social context of quarrying in Derbyshire in the recent past, based on an analysis of information on quarry workers around the study area, from the 19th century national census returns, and research on the economics of pre-industrial quarrying. The methodology developed to analyse the raw data, including the creation of a new, more structured database, and the fieldwork needed to fill in the gaps identified in the original data, are described in Chapter 4.

The main analysis of the full dataset, using both statistics and GIS mapping is given in Chapter 5. In Chapter 6, the links between the different types of data are discussed, and conclusions are drawn about the size and economic importance of quarrying on the Eastern Moors. Finally, a number of recommendations are made for further work.

Throughout this dissertation the acronym 'EMSR' will be used to refer to the Eastern Moors Survey Report, associated database and GIS shapefiles (May & Badcock, 2011), which were obtained in electronic format at the start of the project.

2. Historical and archaeological context

In his review of the archaeology of quarrying, Stanier (2000, 9) remarks that “Quarrying has been barely covered in the archaeological literature”. Not much has been added in the intervening years, and it is possible to briefly summarise what we know about quarrying, particularly on the Eastern Moors, in a few pages.

2.1 Eastern Moors Survey Report (EMSR)

The survey report (May & Badcock, 2011) is the source of most of the raw data used in this dissertation, including the original field survey database, and some of the ArcGIS shapefiles. It proved to be generally accurate, with only a few duplicate or incorrect entries, and without it, this work would have been impossible.

It is now the major source of collated information about the survey area and its environs. The authors (*ibid.*, 10-11) confirm that most of the survey area consisted of unenclosed wastes and commons, from the medieval period until the 18th century, when, although it remained mostly unenclosed, much became private moorland, developed by the Duke of Rutland for grouse shooting. Quoting Harris (1971, 82-83), they mention the millstone industry of the west, the quarrying of stone for the construction of buildings and roads across the survey area, and the extraction of clay in the north (May & Badcock, 2011, 12). They give a collated description of the stone extraction features in section 6.4.3 stating that:

“Most outcrops, ridges and boulder strewn head deposits on the lower scarps appear to have been subject to quarrying in various scales, ranging from quarrying of individual boulders to larger-scale extraction pits and face quarries” (*ibid.*, 26).

They describe the remains of abandoned millstones along the Edges of the south and west, and evidence of small, crude buildings identified as quarrymen’s shelters. Smaller pits and

Chapter 2 – Historical and archaeological context

quarries are widespread, whereas larger quarries tend to be associated with the ridges and Edges. They associate the smallest features, such as those on White Edge Moor, with “ ‘day-working’ - where permission was granted by the landowner for an individual to quarry as much stone as they could remove in one day”, perhaps for the construction or repair of walls or tracks (ibid., 27).

In the following section (ibid., 28-30), they deal with coal and ganister extraction, which is generally a mining operation, and is therefore mostly beyond the scope of this dissertation. Some such features, such as open-cast works, are difficult to distinguish from quarrying, and some have therefore been included, as have Bell pits, in the initial scope of this study.

2.2 Other material

Reviewing the Transactions of the Hunter Archaeological Society and the Derbyshire Archaeological Journal (and its predecessor, the Journal of the Derbyshire Archaeological and Natural History Society) from 1950 to 2012 revealed only 14 articles of any relevance to quarrying in the study area, most of which are cited below. General searches on ‘quarrying’ mainly produced reports on the impact of quarrying on the archaeological record, such as Brightman & Waddington (2010).

Stanier (2000, 12-17) outlines the long history of British quarrying, beginning with the obtaining of flint for tools and stones for structures such as Stonehenge. The Romans did a lot of quarrying in Britain, the Anglo-Saxons very little, and the industry only expanded again under the Normans.

I will first outline general material in broadly chronological order, using similar terminology to that in the EMSR (May & Badcock, 2011, 5) and then review material dealing with the millstone and grindstone industries, geology and quarrying technology.

Chapter 2 – Historical and archaeological context

2.2.1 Prehistoric period (before AD43)

The study area has one large prehistoric structure, the Gardom's Edge Enclosure (Ainsworth & Barnatt, 1998) and many other smaller structures such as stone circles, field boundaries and cairns (Henderson, 1979; Barnatt, 2001; Ainsworth, 2001; Barnatt & Smith, 2004, p9, Fig. 4), which are built from gritstone boulders, gathered from the surrounding land. Shale was extracted and worked into jewellery and ornaments (Radley, 1969; Beswick, 1975). Barnatt (2000) also catalogues all the settlements and farms found to date.

2.2.2 Romano-British period (AD 43-410)

Although the Romans did a lot of quarrying in England (Stanier, 2000, 13), as evidenced by the remains of their stone buildings, and the re-use of Roman stonework in later buildings, few Roman quarries have been identified, none of which lie in the study area. Blagg (1990), for example, outlines the Roman stone industry, but identifies only two quarries in northern England, one in Lincolnshire and the other near Hadrian's Wall.

2.2.3 Medieval period (AD 410-1485)

Local gritstone was quarried to produce house foundations, field boundaries (Makepiece, 1973) and grave slabs, some of which were reused as lintels during a 15th century renovation of Baslow parish church, and were tentatively dated to the 12th-14th centuries (Ryder, 1985). Jope (1964) published a review of the Saxon stone industry, but only covered south/central England. Even in limestone areas, gritstone was used for crosses and waymarkers (Sharpe, 2002, 7) from Saxon times onwards. Knoop & Jones (1938) provide some useful data on the economics of medieval quarrying, mainly during the 15th century, but with nothing specific to Derbyshire. Stanley (1990, 169) confirms that local stone was used in the construction of churches, castles and houses in Derbyshire from Anglo-Saxon times onward, but only provides specific examples from mid-Derbyshire. Overall, the evidence is sparse, but it is at

Chapter 2 – Historical and archaeological context

least clear that most stone was used or re-used locally, given the high cost of transport, amounting to 40% or more of the delivered price (Parsons, 1990, 1; 10-12).

2.2.4 Post medieval – early modern period (AD 1485 – 1901)

Machin (1971, 11) observed that “Quarrying and stone dressing took place along the Swine Sty escarpment prior to the Parliamentary Enclosure Awards of 1820-30”. Radley & Penny (1972) described the development of turnpike roads (with their need for hardcore) across the study area in the 18th and early 19th centuries, and two quarry features (May & Badcock, 2011: feature IDs 2238, 2247) in the study area are explicitly associated with nearby turnpike construction.

Farey’s (1811) report gives a detailed account of the geology, agriculture, mining and quarrying industries of Derbyshire in or around 1810, and is often cited by the other authors quoted in this review. He provides considerable detail on the locations, economics and health of these industries at that time, which complements the economic data given in papers dealing with earlier periods, such as Meredith (1981) and Polak (1987).

2.2.5 Millstone and grindstone making

Stanier (2000, 31) and Palfreyman & Hibbs (2007) refer to pre-medieval quern manufacturing from gritstone in Derbyshire and South Yorkshire, but the earliest evidence for millstone/grindstone making in the Peak District is from the later Medieval period. Meredith (1981) details some documentary evidence for millstone-making near Yarncliffe in the 15th century while Polak (1987) outlines more detailed evidence covering 15th-18th centuries, including manufacturing and transport costs for Baslow and other Peak millstones shipped to London, Hull and Kings Lynn, for export. During this period (ibid., 68), the trade rose during times of war and declined when better-quality continental stones were more readily available, and then declined more sharply after 1750, when demand for white flour increased.

Chapter 2 – Historical and archaeological context

Derbyshire millstones produced grey flour, and were thus only suitable for producing animal feed. Tucker (1985, 43; 45, Fig 2; 55, Table 1; 56, Table 2) agrees with this overview, and gives a more detailed account of the locations of the main millstone manufacturing quarries (see Map 5), and the processes used. (Map 5 also shows the locations of intensive areas of coal mining and clay processing). Three major millstone manufacturing areas lie within or adjacent to the study area (Gardom's Edge, Curbar Edge and Froggatt Edge) plus one minor one (Blackstone Edge). The quarrying features on Gardom's Edge are extensive and particularly well preserved (Barnatt & Bannister, 2009, 141-142). Baslow Edge, another major area, lies less than 1km west of the study area. Radley (1964b) cites Farey (1811) as evidence that millstone manufacturing had ceased at Baslow and Curbar by 1811. Froggatt's quarries continued a little longer, and also produced building stone (Farey, 1811, 418). Bole Hill quarry (2km NW of the study area) continued through the 19th century, supplying animal feed mills, and diversified into making the 'new shape' millstones for pulping paper and other industrial uses. After a very busy period producing stone for the construction of the Derwent dams, all quarrying finally ended in the early 20th century (Tucker, 1985, 52-54).

Radley (1964a) also described the excavation of a small building on Gardom's Edge, which he interpreted as a smithy associated with nearby millstone workings.

2.2.6 Geology, quarrying methods and technology

Harris (1971, 81-94) describes how Chatsworth and Rivelin Grits (subtypes of the Millstone Grit series) were the best for millstone making, but were also used in construction, while thick, uniform strata like Kinderscout Grit were best for heavy construction, both of whole buildings such as churches, and for components such as mullions and lintels. Thinner-layered strata such as Redmires Flags were readily split into pavers and roofing tiles. Eden,

Chapter 2 – Historical and archaeological context

Stevenson, & Edwards (1957, 14-24; 166-179) give a more detailed account of the geology of the Millstone Grits, and their uses.

In addition to Tucker's (1985) account of how millstones were manufactured, Stanier (2000, 18-30) provides a more general account of quarrying methods through time, how to investigate the archaeology of quarries (ibid., 31-38), and another summary of millstone manufacturing (ibid., 47-54), largely based on Tucker (1985). Together, Tucker and Stanier provide a useful field guide to investigating abandoned quarries.

3. Social and economic context

Original census records from 1841 to 1910 are now available online (Ancestry, 2014), and can be accessed free of charge in public libraries. Summaries of some historical census data can also be accessed from the Histpop (2014) database via the University library. A few quarry account books have survived from the late Medieval period, along with customs and taxation accounts from the 16th century onwards, and a comprehensive survey by Farey (1811) gives us a snapshot of the Derbyshire extractive industries around 1810. This is explored further in the sections below.

3.1 Census Data - Who were the quarrymen?

The Derbyshire County summary tables for 1851 and 1881, obtained from UK Data Service, (Histpop, 2014) are summarized in Table 3.1.

<i>Census year</i>	<i>1851</i>	<i>1881</i>
Derbyshire total	129,501	195,110
Brick, stone & clay	1,941 1.5%	2,668 1.4%
Agriculture	19,369 15.0%	14,515 7.4%
<i>Table 3.1: Derbyshire, male occupation totals by census year. Source: Histpop(2014)</i>		

In both years, about 1.5% of the male working population were engaged in the ‘mineral’ trades. In the same period, the proportion engaged in agriculture dropped by half, from 15% to 7.4%. A study of the local census records from 1841 to 1901 (Ancestry, 2014), supplemented with information from Dalrymple-Smith (2014) and Lockie (2014) produced the occupational data in Table 3.2, for the nine civil parishes surrounding the study area,

Chapter 3 – Social and economic context

shown on Map 18. Direct comparisons with the county level figures in Table 3.1 are difficult, as they use slightly different classifications from those used in the censuses, which also differ from year to year. However, in 1881, for example, it is clear that both Agriculture (31.7%) and stoneworking (10.2%) are relatively much more important in these parishes than they are in Derbyshire as a whole, and that stoneworking is relatively more important in these parishes, compared to agriculture, than it is in the county as a whole. Hall's (1978, 76, Table 1) figure of 9% engaged in agriculture across the combined parishes of Baslow, Curbar, Calver and Froggatt seems at variance with the figures in Table 3.2, until the different calculation bases are noted. Table 3.2 lists male occupations as a proportion of the male population, while Hall reports occupations as a proportion of the total population, and notes (ibid., 75) that most females were counted as having no occupation. Hall also says that Derbyshire's population was stable or in overall decline during the second half of the 19th century, but he does not mention quarrying.

People described their occupations in a number of different ways, some quite specific, such as 'Quarryman' or 'Quarry owner', while others used more generic and overlapping terms such as 'Stoneworker' or 'Mason'. These are listed separately in Table 3.2. 'Mason' does however include builders and probably also (funerary) monumental masons, who are not quarry workers. Several individuals had dual occupations, including 'Farmer/quarryman' and 'Innkeeper/mason', and these have been included in the quarryman and mason categories. It is also likely that many more people, particularly, but not only, farmworkers, engaged in occasional stone-getting, either to complete landscape management tasks such as wall or barn building, or as a secondary occupation, when there was insufficient farm work to sustain them. Polak (1987, 57) argues that millstone making, because of its complexity, was necessarily a full-time activity, unlike other forms of quarrying.

Chapter 3 – Social and economic context

Occupation data by district and census year											
		1841	1861	1881	1901			1841	1861	1881	1901
Baslow	Adult males	361	287	302	267	Agriculture		31.6%	25.4%	19.9%	15.0%
	Farming	114	73	60	40	Stoneworking		5.0% ↗	4.2% ↗	3.3% ↗	2.6%
	Stoneworker	4	11	9	5	Other occupations		63.4%	70.4%	76.8%	82.4%
	Quarryman	1	1	1							
	Mason	13			2						
	All other	229 ↗	202 ↗	232 ↗	220						
Calver	Adult males	173	186	125	137	Agriculture		15.0%	26.9%	15.2%	18.2%
	Farming	26	50	19	25	Stoneworking	↗	0.0% ↗	1.1%	7.2% ↗	8.8%
	Stoneworker			5	7	Other occupations		85.0%	72.0%	77.6%	73.0%
	Quarryman		2	3	5						
	Mason			1							
	All other	↗ 147 ↗	134	97 ↗	100						
Curbar	Adult males	105	103	100	87	Agriculture		43.8%	31.1%	22.0%	20.7%
	Farming	46	32	22	18	Stoneworking	↗	3.8% ↗	6.8%	21.0% ↗	19.5%
	Stoneworker			14	2	Other occupations		52.4%	62.1%	57.0%	59.8%
	Quarryman	2	1	1	15						
	Mason	2	6	6							
	All other	↗ 55 ↗	64	57 ↗	52						
Froggatt	Adult males	37	40	39	26	Agriculture		43.2%	17.5%	28.2%	19.2%
	Farming	16	7	11	5	Stoneworking	↗	32.4% ↗	37.5%	35.9% ↗	50.0%
	Stoneworker		13	11	2	Other occupations		24.3%	45.0%	35.9%	30.8%
	Quarryman		2	1	11						
	Mason	12		2							
	All other	↗ 9 ↗	18	14 ↗	8						
Grindleford	Adult males	60	88	71	76	Agriculture		50.0%	19.3%	32.4%	25.0%
	Farming	30	17	23	19	Stoneworking	↗	11.7% ↗	5.7%	14.1% ↗	22.4%
	Stoneworker	3	1	1	4	Other occupations		38.3%	75.0%	53.5%	52.6%
	Quarryman	4	4	7	13						
	Mason			2							
	All other	↗ 23 ↗	66	38 ↗	40						
Padley & Stoke	Adult males	27	35	23	31	Agriculture		55.6%	51.4%	60.9%	25.8%
	Farming	15	18	14	8	Stoneworking	↗	3.7% ↗	8.6%	13.0% ↗	25.8%
	Stoneworker	1	3	1	7	Other occupations		40.7%	40.0%	26.1%	48.4%
	Quarryman			2	1						
	Mason										
	All other	↗ 11 ↗	14 ↗	6 ↗	15						
Totley	Adult males	80	117	177	264	Agriculture		33.8%	35.9%	32.8%	9.5%
	Farming	27	42	58	25	Stoneworking	↗	6.3% ↗	1.7% ↗	11.3% ↗	6.1%
	Stoneworker	5				Other occupations		60.0%	62.4%	55.9%	84.5%
	Quarryman			8	1						
	Mason		2	12	15						
	All other	↗ 48 ↗	73 ↗	99 ↗	223						
Holmesfield & Millthorpe	Adult males	136	185	168	150	Agriculture		33.1%	47.0%	53.6%	50.0%
	Farming	45	87	90	75	Stoneworking	↗	2.9% ↗	1.1% ↗	5.4% ↗	0.0%
	Stoneworker					Other occupations		64.0%	51.9%	41.1%	50.0%
	Quarryman	1	1	6							
	Mason	3	1	3							
	All other	↗ 87 ↗	96 ↗	69 ↗	75						
Brampton (West)	Adult males	120	102	108	98	Agriculture		75.0%	49.0%	51.9%	42.9%
	Farming	90	50	56	42	Stoneworking	↗	6.7% ↗	10.8% ↗	16.7% ↗	14.3%
	Stoneworker					Other occupations		18.3%	40.2%	31.5%	42.9%
	Quarryman	8	11	10	6						
	Mason			8	8						
	All other	↗ 22 ↗	41 ↗	34 ↗	42						
Totals	Adult males	1099	1143	1113	1136	Agriculture		37.2%	32.9%	31.7%	22.6%
	Farming	409	376	353	257	Stoneworking		5.4%	5.2%	10.2%	9.2%
	Stoneworker	↗ 13 ↗	28 ↗	41 ↗	27	Other occupations		57.4%	61.9%	58.0%	68.2%
	Quarryman	↗ 16 ↗	22	39 ↗	52						
	Mason	↗ 30 ↗	9 ↗	34 ↗	25						
	All other	631	708	646	775						
	All stoneworking	59	59	114	104						

Table 3.2: Local occupation data by census district and year. For sources, see text.

Chapter 3 – Social and economic context

The 19th century saw an overall decline in agricultural employment nationally, and in most of the parishes studied. It must also be noted that some parish and enumeration district boundaries changed between the censuses, particularly in the parishes to the east of the study area, which were affected more by urban growth in Sheffield and Chesterfield.

Very few people lived within the study area itself – there were (and still are) only a couple of farmsteads and isolated houses (for example the gamekeeper's lodges built by the Duke of Rutland). Many of those included in Table 3.2 will have worked wholly or partly outside the study area, for example in the nearby large commercial quarries, such as Stoke Hall.

All the above uncertainties make estimating the numbers engaged in quarrying within the study area very difficult, and therefore the discussion below is highly speculative.

The total number of stoneworkers, quarrymen and masons enumerated by the censuses in the surrounding parishes stood at about 60 in 1841 and 1861, rising to over 100 between 1881 and 1901, while the numbers employed in agriculture over the same period fell from just over 400 to about 250. This is in line with expectations, with an increasing demand for roadstone and masonry, and declining numbers employed in agriculture. Relatively little of the study area is suitable for arable farming, and is mostly used (if at all) today for rough pasture.

There are a few stands of timber, and in the 19th century, the larger moors were used for grouse shooting. None of these activities required large numbers of workers.

On a simple model assuming an even distribution of employment around a village, we can postulate that half of the stoneworkers/quarrymen in the enumeration districts where the main villages adjoin the study area on the west (Baslow, Curbar, Froggat and Padley & Stoke) worked (at least some of the time) within the study area, while less than a quarter of those in the eastern parishes did so, given their greater distance from the study area, and much greater opportunities for other work in Sheffield and Chesterfield. The men from Grindleford and

Chapter 3 – Social and economic context

Calver can be excluded completely, as these villages do not directly adjoin the study area, and there were large commercial quarries there capable of employing most of them. Several of the census records did indeed make this link explicit. Applying these assumptions to the figures in Table 3.2 suggests that the numbers of quarrymen/stoneworkers active within the study area was between about 20 and 25 between 1841 and 1901.

Given the nature of the land, perhaps only 10% of those employed in farming will have worked within the study area, and only some of them will have spent some time engaged in quarrying work. Combining these two factors, we may guess that less than 5% of the farmworkers could be considered to be engaged in occasional quarrying within the study area – say between 20 in 1841 and 10 in 1901. An unknown number will also have had occasional or regular employment in the ‘grouse shooting’ industry, popular in the 19th century with the landowner, the Duke of Rutland.

Adding together the ‘full-time’ and ‘occasional’ figures above indicates that 35-40 men worked in quarrying within the study area during most of the 19th century. This is not a large number of individuals, but is of a similar order to that engaged in agriculture and gamekeeping.

3.2. The economics of quarrying

Millstones were expensive things. Meredith’s (1981) analysis of fragmentary cash books from a manufacturer in Yarncliffe (see Map 5) indicates that a pair of 15 “hand” (1.35m) diameter millstones sold for 7 shillings (35p) at the quarry, and nearly twice that, delivered to a (local) customer, in 1466. The craftsman received about 6 shillings (30p) of this, indicating a rather small margin for profit and other expenses of about 14%. According to Polak (1987, 56), a craftsman could make a pair of millstones in a month, and was paid about the same as a building worker. The current UK minimum wage is about £1,000 per month, and building

Chapter 3 – Social and economic context

workers can earn up to twice that, judging from recent job advertisements. This indicates a currency conversion ratio from 1466 to 2014 of about 3,000 – 6,000, and an equivalent sale price (delivered) of between £2,000 and £4,000 for a pair of millstones, in modern cash terms.

Polak (1987) summarises legal documents from a 1590 dispute between millstone makers in Hathersage (see Map 1) and their vicar, about tithes. From these, we have the above estimate that one man could make 12 pairs of millstones per year, and a sale price at the quarry of 12 shillings (60p) each, but with considerable variations in both the selling price and quarry rents during the 15th to 17th centuries. Inflation also saw wages increase considerably between 1466 and 1590, to 4 shillings per week for a labourer, and 6 shillings for a craftsman.

Labourers' wages doubled during the 17th century (Boulton, 1996, 276, Fig 1), and doubled again in the 18th century (Gilboy, 1936, 140, Table 2) – a measure of inflation, rather than of any increase in prosperity. By 1634, according to a probate valuation, a pair of new millstones in Baslow was valued at just over 22 shillings (£1.10). Polak (*ibid.*, 57) confirms that millstone making changed little until the 19th century, so direct comparisons with earlier times are justifiable, with prices and costs related to market conditions and general inflation, but not technology. Millstone makers also produced other things, such as roadstone, troughs and quernstones (*ibid.*). The industry declined through the 18th century (*ibid.*, 58), as only foreign stones could meet the growing demand for white flour, with occasional respites when war in Europe interrupted supplies. The imported stones were often twice the price of Peak millstones (Tucker, 1987, 169), but the demand for white flour ensured their success. Quarry rents fell by 75% between 1744 and 1784 (*ibid.*), while money wages increased by over 40%, in the north, in the same period (Gilboy, 1936, 140, Table 2). Inflation saw the price of a pair of smaller (1.5m diameter) millstones rise to over £10 by 1810, but production had by then ceased everywhere except near Hathersage, according to Farey (1811, 221). Most Peak millstones were sold locally, due to high transportation costs, but a significant export market

Chapter 3 – Social and economic context

existed in the 17th century, with a peak of over 50 pairs per year exported via Hull, mostly to London and Kings Lynn, between 1674 and 1684 (Polak, 1987, 63, Table 1). Unfortunately, we do not have any estimates for total production.

Only Farey (1811, 423) provides any costings for sandstone quarry products other than millstones. He quotes prices for Derbyshire building stone between 7 and 10 (old) pence per cubic foot (approximately £1 per cubic metre). For comparison, a £10 domed 1.8m diameter millstone is about 0.38 cubic metres, or £26 per cubic metre, representing much higher value added in the labour needed to make it. Paving stone, requiring more work than building stone, cost from £1.50 to £4 per cubic metre (based on Farey, 1811, 426). The best gritstone could be made into troughs, and a 100 gallon (450 litre) trough cost about £2 (ibid., 434), equivalent to about £4.50 - £5 per cubic metre of quarried stone. Today, an internet search (e.g. <http://www.beestonreclamation.co.uk/Current-Stock/troughs/grit-stone-trough>, accessed 11/3/2014) indicates that old 150 litre gritstone troughs retail at about £400-£500, as garden ornaments.

3.3 Chapter summary

Millstone making provided a good living for a significant number of families in the Peak District during most of the 17th century, and although in decline, continued to be important during the 18th century. The manufacture of grindstones for industrial use continued during the 19th century, but not in the study area, where 35-40 men worked regularly quarrying stone for buildings, roads and walls, and clay for bricks in the north-east. The quarrying of building stone was always a steady earner, and the manufacture of other stone products continued to provide a viable living until the end of the 19th century, when mechanization and the economies of scale reduced the industry to the small number of commercial quarries still operating today, none of which lie in the study area (Willies & Parker, 1999, 87-90).

4. Research methodology

The research question for this study, as set out in the feasibility study (Mailer, 2011), was :

Is it possible to identify and quantify specific types of quarrying (i.e. mineral resources and quarrying methods) at quarry sites identified by this survey, to date the activity, relate it to any historical records and, from this, deduce how much quarrying on the Eastern Moors contributed to the local lifestyle and economy during the post-medieval and early modern period (1500-1900 AD)?

The primary resource was the EMSR report (May & Badcock, 2011), database, and set of GIS shapefiles, all provided on a single CD. The historical resources included literature, historic maps (Edina, 2014) and census data (Ancestry, 2014; Histpop, 2014). Modern topographical and geological mapping, in GIS format, also came from Edina (2014).

4.1 Desk-based initial assessment

A desk based study of the report and database enabled 1,180 features out of the 5,937 to be identified as probably quarrying-related. Some 327 mining-related features were also noted, but not considered further, as the study was restricted to quarrying. A further 619 features were identified as tracks, paths and hollow ways, collectively referred to as routeways. Three quarrying features were identified as duplicates, reducing the total to 1,177, including 28 Bell pits. Identification was hampered by the text-only nature of the original 'Monument type' field, which included both typographical errors and duplications such as 'Millstone' and 'Grindstone', plus their plural forms. An initial rationalisation and de-duplication exercise was thus performed to eliminate this.

It was also evident that the research question required quantitative data, principally the size of features, and the relationship, if any, to the routeways and local geology. The original

Chapter 4 – Research methodology

‘Description’ field was broken down into numeric fields to hold dimensional data, and a separate field to hold any data on the product(s) of the quarry. Full dimensional data existed for 497 quarry feature records. Plotting these on the OS 1:25000 map (Edina 2014) using ArcGIS 10 (ESRI, 2014) revealed (Map 8a) that dimensioned features were not evenly or randomly distributed, but appeared to reflect the varying practice of individual surveyors.

4.2 The new database

The screenshot displays the 'Bento Quarries 0210' database interface. The form includes the following fields and sections:

- ID:** 5032
- Site name:** Big Moor
- Period:** Post-medieval (AD1540-1900)
- NGR Easting:** 426492
- NGR Northing:** 375499
- Monument type:** Quarry
- Alternative/additional type:** (empty)
- Definite (blank), probable or possible:** (empty)
- Typology:** Quarried scarp
- Product:** Building stone
- Description:** Walling stone quarry. **Duplicate of 5969. Dimensions input here only. Extensive quarry along scarp edge, with abandoned pile of walling stone.
- Dimensions (m):**
 - Length: 41.0
 - Width: 5.0
 - Depth: 2.0
 - Form factor: 1
- Calculated dimensions (m2 or m3):**
 - Area: 205.0
 - Volume: 410.0
 - Face area: 82.0
 - TrackDist (m): 900
- Bedrock type:** PENNINE LOWER COAL MEASURES FORMATION
- Condition:** (empty)
- Threats:** (empty)
- Ground cover:**
 - ☐ Bracken
 - ☐ Grass
 - ☐ Heather
 - ☐ Moss
 - ☐ Reeds, Rushes or Sedge
 - ☐ Trees
 - ☐ Other GC

The interface also features a search bar at the top right, a 'Photo1' and 'Photo2' section on the right with landscape images, and a bottom toolbar with various editing tools. The status bar at the bottom indicates 'Record 451 of 1131'.

Figure 4.1: Screenshot from the new Bento database

The original EMSR database was provided as an MS Access table, with all fields of type ‘Text’. These data were imported into Bento, an Apple Mac database, and converted as outlined above. Links to the original dataset were preserved using the feature ‘ID’ field. To simplify presentation, and eliminate unintended duplication via typographical error, some text fields were also converted to restricted picklists, or yes/no checkboxes. Figure 4.1 illustrates this, in a screenshot from the new database. (Although no longer available – see

Chapter 4 – Research methodology

info.filemaker.com/Bento_Statement.html – the complete new dataset can be re-exported in MS Excel or .csv format)

Table 4.1 below summarises the main changes made during conversion

Original MS Access field (all of type 'Text')	Equivalent New Bento field	Bento field type
ID	(Feature) ID	Integer
Period	Period	Picklist
Monument type	Quarry feature type (additional - new typology)	Picklist
Description	<i>Broken down into subfields</i>	
	Length	Real
	Width	
	Depth/Height	
	Form factor	
	Quarry product	Picklist
	Residual description	Text
Condition	Condition	Picklist
Ground cover	Separate fields for grass, heather, bracken etc.	Boolean/Checkbox
New fields from this research	Bedrock type	Picklist
	Distance to track	Integer
	Marked on 1 st edition OS map	Boolean/Checkbox
	Updated	Boolean/Checkbox
	Volume, Surface area, Face area	Real, calculated
	Photo1, Photo2	Media
Table 4.1 – New database setup		

4.3 Fieldwork

A programme of site visits was prepared, targeted at the largest concentrations of features lacking at least one dimension. This was accomplished by generating (in ArcGIS 10) a grid of 1Ha squares covering the whole study area, shading each square in proportion to the

Chapter 4 – Research methodology

known volume of fully dimensioned features, and labelling each square with the total number of features, where that exceeded 1 (see Map 6). A lightly shaded square with a high feature count indicated a 'hot spot' where undimensioned features were probably concentrated. A field recording book was then assembled, consisting of a printed version of the full quarrying database table, and, for each 'hot spot', a small-scale (~1:5000) map (see Map 7 for an example) showing all the features, and identifying the undimensioned ones. Each 'hot spot' was then visited, and all features lacking full dimensions were located using a hand-held Garmin E-trex 30 GPS unit. Nearby features, not within the hotspot, were also visited if this did not require too much additional effort. Measurements were made using either a Bosch PLR25 digital measure, or a conventional tape measure. Linear measurements are all approximate, no better than $\pm 0.5\text{m}$ for larger features down to generally $\pm 0.1\text{m}$ for smaller ones. The main limitation is in estimating where the edges of features are, not in making the measurement itself. The precision and methods of the EMSR surveyors are not known, but are presumed to be no better. In addition to dimensional data, any evidence of quarry product was noted, and exposed bedrock examined where possible. The results were added to the field recording book table. Of 360 features identified in this way, 321 were updated, and the remaining 39 could not be found. The results were input to the new database. Map 8b shows how the fieldwork programme improved the original patchy distribution of dimensioned features.

This fieldwork took about 25-30 days to accomplish, and left over 200 features without full dimensions, scattered fairly evenly across the survey area. Fully dimensioned features now represented over 75% of the total, and more accurately represented the geology and topography of the survey area. This was considered sufficient for the intended analysis.

Chapter 4 – Research methodology

4.4 Incorporating other data

Data tables could be exchanged between ArcGIS 10 and the database. Processing them in ArcGIS enabled additional geographical data to be identified and associated with each feature, specifically **bedrock type**, from the geological maps (Edina, 2014), and **distance to the nearest road or track**, from a combination of trackways noted by the surveyors, and established tracks, paths and roadways, collectively referred to as the ‘Routeways data’. Both fields were then added to the database.

4.4.1 *Bedrock type*

The survey area corresponds to parts of four separate sheets from the British Geological Survey, obtained as GIS shapefiles, via Edina (2014). Unfortunately, different colour schemes were used on the four maps, but this was corrected in ArcGIS, with advice from R Johnston (pers. com.). Eight different bedrock types were identified in the study area, six of which were pure sandstones, while the remaining two were classed as mixed mudstone/siltstone/sandstone on the geological map (Edina, 2014).

4.4.2 *Routeways data*

Data on roads, tracks and paths across the study area came from three sources:

- Current Ordnance Survey Digital mapping, scale 1:25000 (GIS shape file, Edina, 2014)
- Historical trackway data from Dodd & Dodd (1974) and Radley (1963, 40, Fig. 9)
- Tracks and hollow ways recorded in EMSR (GIS shape file, EMSR, 2011).

In order to combine these, the ‘Packways’ map from Radley (1963, 40, Figure 9), which formed a useful summary of pre-turnpike through-routes, was scanned and digitized in

Chapter 4 – Research methodology

ArcGIS 10.0. Some of these routes were duplicated in either the OS or the Survey data, and were therefore deleted. The three sets of routeways data were then combined into a single GIS shape file (Map 3). Map 4 shows the multiple ring buffers created from this data to identify the parts of the survey area within 25m, 25.01-50m, 50.01-100m, 100.01-250m, and 250.01-500m from a road, track or path. The small area beyond 500m, which contained no quarry features, was measured manually. The multiple ring buffers included significant land areas outside the survey area, indicated by cross-hatching on Map 4, which were also measured and removed manually.

Table 4.2 summarises how the ring buffer data were processed to determine the distribution of routeway distances within the survey area. The survey area comprised 24.4 sq. km, whereas, after manual adjustments to remove ring buffer areas outside the survey area, the estimated total ring buffer area within the survey area was 26.07 sq. km. This represents an error of only 7% compared to the true area, and is considered small enough to ignore for the purposes of column E of Table 4.2, the proportions of the survey area at each routeway distance.

A	B	C	D (=B-C)	E	F
Distance to routeway (m)	Area on ring buffer map (sq. km)	Est. ring area to exclude* (sq. km)	Est. ring area within survey area (sq. km)	Proportion of survey area at each distance	<i>Proportion of quarry features at each distance</i>
<25	6.59	0.54	6.05	23.2%	44.8%
25-50	4.80	0.58	4.22	16.2%	20.3%
50-100	7.09	1.05	6.04	23.2%	23.8%
100-250	11.76	4.79	6.97	26.7%	10.6%
250-500	9.71	7.18	2.53	9.7%	0.5%
>500*	0.26	0	0.26	1%	0%
Total	40.21	14.14	26.07	(100%)	(100%)
* Measured manually using the ArcGIS length/area tool					
Table 4.2 – Determining the geographic distribution of routeway distances					

Chapter 4 – Research methodology

When the proportions of quarry features falling within each distance range (column F) are compared with the topographical distribution of distances (column E), a clear bias towards being closer to a routeway is obvious. Given the weight of quarry products, it is hardly surprising that tracks developed, or were constructed, to link the quarries to main transportation routes across the moors.

4.5 Chapter summary

The main aspects of the methodology are summarized in Figure 4.2 below.

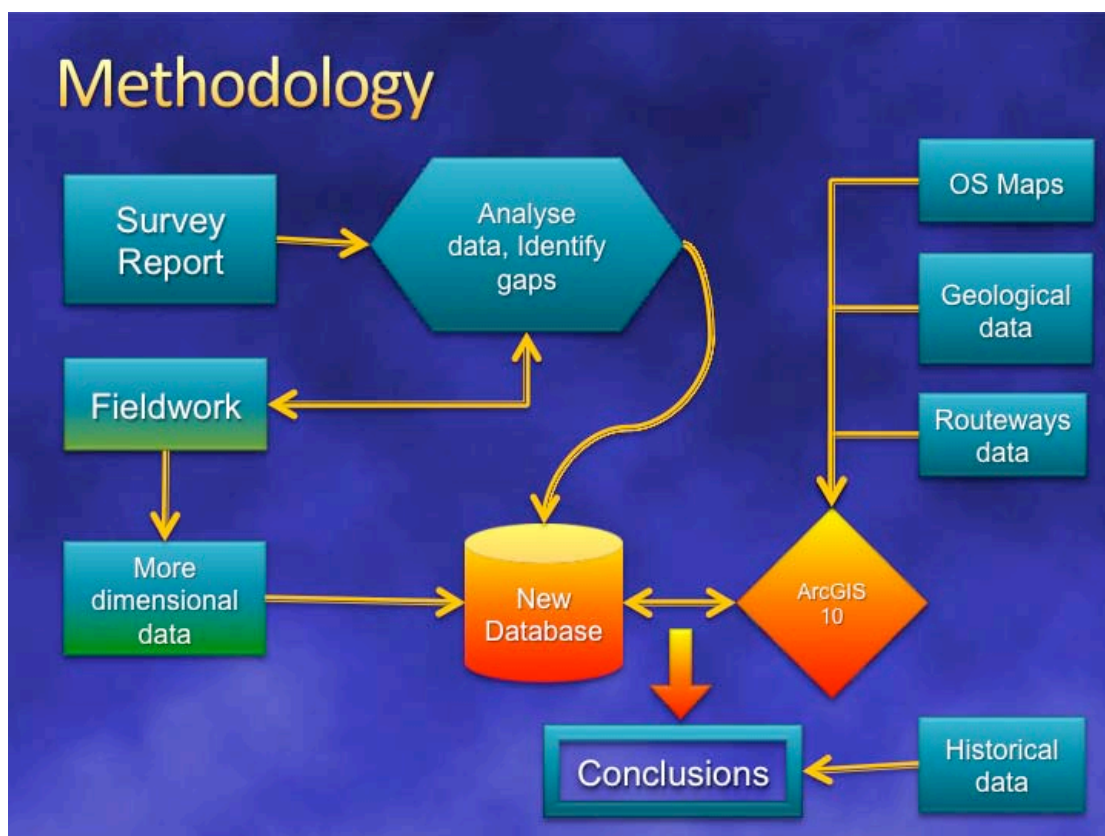


Figure 4.2: Methodology flow chart

5. Combining and analysing the data

In this chapter, I will examine the quarry dimensional and location data, and relate these to both bedrock geology and transportation networks, in an attempt to better understand the different types of quarrying that took place, and the relative importance of each type.

Within ArcGIS, the bedrock and routeway distance data were combined with the basic database of features into a single combined attribute table, which was then re-exported, and used as the basis for the final expanded database. The end product of the desk based study and fieldwork was thus a new database and a set of ArcGIS shapefiles, which could be analysed both statistically and topographically. This was an iterative process, in that carrying out fieldwork created a better appreciation of the types of features present, and how to classify them, while analysis of interim data suggested new ways of collecting data, such as the grid system mentioned above. The subsections below present some of the main findings of this analysis.

5.1 A proposed quarry typology

The first task was to devise and apply a consistent typology to the quarry feature database. EMSR has a field called 'Monument type'. After removing typographical errors, merging the plural with the singular, and combining 'Millstone' and 'Grindstone'¹, the following main categories remained:

¹ There is no evidence to suggest that, in EMSR, 'Grindstone' implied metalworking uses, and 'Millstone' implied corn grinding, as distinguished by Stanier (2000, 47), who states that true grindstones were made around Sheffield, north of the survey area, from sandstones in the coal measures.

Chapter 5 – Combining and analysing the data

Bell pit, Clay extraction, Millstone(s), Millstone working site, Peat cutting, Quarried block, Quarry, Quarry scoop, Quarrying waste, Robber pit, Stone extraction site, Stone working site,

These ‘Monument Types’ do not appear to have been closely defined. While ‘Bell pit’ and ‘Quarrying waste’ were used consistently, if sparingly, most of the other terms were used variably and interchangeably by the different surveyors. Both ‘Millstone’ and ‘Millstone working site’ were used to indicate a collection of millstones, for example.

The proposed new typology uses the grouped quarrying feature types below:

Group 1: Quarrying sites:

Bell pit, Quarry pit, Quarry scoop, Quarried scarp, Surface workings, Quarry
(but) type unclear

Group 2: Quarrying artefacts and other features:

Millstones/grindstones, Other worked stone, Structures, Spoil heaps and All
other.

This typology is proposed, based on observations during visits to 360 of the 1177 quarrying-related features identified in EMSR, targeted mostly at features lacking dimensional information. Although this is similar to Stanier’s (2000, 49) four types of millstone-making site, it was derived independently, and is of more general application.

‘Quarry product’ (Table 4.1) is a new field, distinct from the quarry feature type, which takes data from both the description and the original ‘Monument type’. For example, in the proposed typology, a ‘Millstone working site’ becomes *either* one of the classes of quarry in Group 1, with ‘Millstones’ in the quarry product field, *or* it is included under

Chapter 5 – Combining and analysing the data

‘Millstones/grindstones’, if no indication of actual quarrying appears in the site description, again with ‘Millstones’ in the quarry product field, for consistency.

Similarly, EMSR uses the Monument types ‘Peat cutting’ and ‘Clay extraction’, whereas the proposed typology subsumes both of these into one of the quarry classes in Group 1, with ‘Peat’ or ‘Clay’ in the quarry product field.

In EMSR, the terms ‘Quarry’, ‘Quarry scoop’, ‘Stone working site’ and ‘Stone extraction site’ are all used to mean much the same thing, based on my own field observations. I have replaced these terms with the five defined classes of quarry feature in Group 1. The proposed division between a ‘Quarry pit’ and a ‘Quarry scoop’ is based on a depth of 1m, which is to some extent arbitrary, but generally indicates the observed difference between small-scale examples of daywork, and larger enterprises requiring several men over several days to dig. One could further divide ‘Quarry pit’ into ‘medium’ and ‘large’, the latter applying to pits over (say) 5m deep or 500 m² in surface area, but no great benefit derives from this, as there are only 7 Quarry pits over 5m deep, and 10 over 500m² in area.

EMSR uses the term ‘Robber pit’ eleven times to refer to quarrying which cuts into the Gardom’s Edge enclosure wall. I do not distinguish these as separate types of quarry – the site description text covers this special aspect.

The full set of descriptions and definitions are given in Table 5.1, and Table 5.2 shows the distribution of the survey data using the proposed typology.

Chapter 5 – Combining and analysing the data

Quarry feature type	Description	Characteristic dimensions ✓ essential ⌘ desirable ✗ not needed				
		Length	Width	Depth/Height	Shape	Definitive
Bell pit	Generally near circular, with large spoil heap around small central depression	✓	✓	✗	✗	Surface Area
Quarry pit	Excavation of any shape, deeper than ~1m	✓	✓	✓	✓	Volume
Quarry scoop	As quarry pit, but shallower than 1m	✓	✓	⌘	⌘	Volume or Surface Area
Quarried scarp	Generally any linear outcrop feature with no easily definable width	✓	✗	✓	⌘	Face Area
Surface workings	Any extensive area of shallow pits and/or low outcrops or boulders not better described otherwise, including stone processing areas	✓	✓	✗	✓	Surface area
Millstone/grindstone	Any recognizable stones, whole or broken, finished or not. State if domed or square-edged	⌘	⌘	⌘	✓	Diameter
Other worked stone	Any evidence such as cut marks, fire setting marks, shaped stonework	✗	✗	✗	⌘	None
Spoil heap	Any form of quarrying waste, separate from any of the above	⌘	⌘	⌘	⌘	Volume
Quarry, type unclear	A quarry pit, scoop or scarp, but insufficient data to determine which					
Other	Anything not included above, such as building platforms					

Table 5.1: Proposed new typology

Chapter 5 – Combining and analysing the data

Group	Quarry feature type	Dimensions known	Dimensions not fully known	Total
Quarrying	Quarry pits	267	29	296
	Quarry scoops	451	63	514
	Quarried scarps	34	24	58
	Quarry - type unclear	0	110	110
	Surface workings	44	35	79
	<i>Bell pits</i>	<i>18</i>	<i>10</i>	28
<i>All quarrying</i>		814	271	1085
Artefacts	Millstones/grindstones	15	4	19
	Other worked stone	21	19	40
Other	Structures	2	2	4
	Spoil heaps	10	15	25
	All other	3	1	4
<i>All sites</i>		865	312	1177
Table 5.2: Analysis of quarrying features – using the proposed typology. Bell pits are more closely related to mining than quarrying – see section 5.5				

5.2 Estimation of quarried volumes

A quarry is a hole in the ground, a space where something – stone, earth and other spoil – used to be. To understand the economic importance of a quarry, we need some measure of its useful lifetime output, and the excavated volume, the size of the hole, is our best proxy for that, along with the intrinsic value of the quarried product itself. EMSR made no use of the limited dimensional data the surveyors collected, nor did it consider the factors outlined in Chapter 3. In the following subsections, the quarried volumes within the study area are estimated by the author for each quarry type, using the new typology. The calculations used to estimate extracted volumes are outlined in Appendix 1.

Chapter 5 – Combining and analysing the data

5.2.1 Quarry pits

(Excavations deeper than 1m)



Photo 2: Feature 217, a Quarry pit 15m long, 10m wide and 2m deep, with an incomplete window mullion (centre/right and inset). *Photos author*

For the 267 Quarry pits of known dimensions, the mean length, width and depth are 10.9m, 6.6m and 2m, respectively, excluding feature 684, an exceptionally large and unusually shaped probable clay pit, which measured approximately 200m x 100m x 2m deep. The total excavated volume of these known Quarry pits is $86,312\text{m}^3$, plus another $40,000\text{m}^3$ for the excepted clay pit.

The remaining 29 Quarry pits (lacking length and/or width dimensions) had a mean depth of 1.6m, (minimum 1m and maximum 2m). If we use the mean area of the known Quarry pits (102.9m^2), we can estimate the excavated volume of these 29 pits as $4,774\text{m}^3$.

The estimated excavated volume for all 296 Quarry pits is thus $131,086\text{m}^3$.

Chapter 5 – Combining and analysing the data

5.2.2 Quarry scoops

(Excavations less than 1m deep)



Photo 3: Feature 5354, a pair of Quarry scoops. The larger one is 4m by 2m, and 0.5m deep. *Photo EMSR*

For the 451 Quarry scoops of known dimensions, the mean length, width and depth are 2.7m, 2.1m and 0.4m, respectively. The mean surface area and volume are 6.9m^2 and 3.5m^3 , and the total excavated volume is $1,587\text{m}^3$. Of these, 35 were not visible when checked, and were assigned nominal (small) dimensions.

The remaining 63 Quarry scoops consist of 47 where the depth is known, but either length or width, and hence surface area is not known, 6 where the depth is not known, but length and width are known, and 10 with no dimensional data. (Where the depth is not known, the description makes it clear that the feature must be a shallow scoop.)

Chapter 5 – Combining and analysing the data

For the 47 of known depth, (mean 0.5m), the mean area from the known 451 (6.9m^2) can be used to estimate the excavated volume as 162m^3 . For the 6 of known area, but unknown depth, using the mean depth of the 449 (0.4m) gives a (negligible) estimated excavated volume of 2.4m^3 . For the remaining 10 undimensioned scoops, using the mean volume of the 451 known scoops gives an estimated excavated volume of 35m^3 .

Summing the above figures gives an estimated total excavated volume for all 514 Quarry scoops of $1,786\text{m}^3$, rounded to the nearest 1m^3 .

5.2.3 *Quarried scarps*

(Linear features defined by length and height)



Photo 4: Feature 5032, a Quarried scarp 41m long by 2m high, cut depth about 5m. *Photo author*

Chapter 5 – Combining and analysing the data

Length, height and thus face area are known for 34 of these features. The mean scarp length is 14.9m (ranging from 3m to 70m) and mean height is 1.5m (ranging from 0.3m to 12m). Mean face area is 24.1m^2 , ranging from 1.2 to 264m^2 , and total face area is 821m^2 . For the 31 of these where the thickness quarried out (the cut) has been estimated (mean 3.3m), the total excavated volume is estimated at $2,102\text{m}^3$. The other three have a total face area of 48.8m^2 . Using the average cut (3.3m) from the 31 gives an additional 161m^3 , making a total quarried volume for the 34 scarps of known face area of $2,263\text{m}^3$.

Of the remaining 24 Quarried scarps, 9 are of known height, another 2 of known length and 13 of unknown size. Substituting the unknowns with the mean values of length (14.9m), height (1.5m) and face area (24.1m^2) from the known 34, gives an estimated total face area for the 24 unknowns of 497m^2 .

If the average thickness of cut of 3.3m from the 'knowns' above is applied to the unknowns, the total excavated volume of the unknowns is about $1,640\text{m}^3$, giving a grand total estimated volume for the Quarried scarps of $3,903\text{m}^3$.

5.2.4 Quarry – type not clear

(Features which could be scarps, pits or scoops)

There are 109 features where there are insufficient data to determine the quarry feature type conclusively (without a site visit), and one where the feature was not visible. Of these, 38 are of known surface area, but unknown depth, and could be quarry pits or scoops. Size and text descriptions imply that about 20 are probably scoops, and the rest are pits.

Six features are of known depth/height (between 1m and 1.5m) but lack other dimensions.

The text descriptions imply they are probably quarried scarps. The remaining 65 features lack any dimensional information, but the text descriptions allow 32 to be identified as probable scoops, 15 as probable pits and 4 as probable scarps, with only 14 completely indeterminable.

Chapter 5 – Combining and analysing the data

Thus, in total, the 'Not clear' type probably comprises 52 scoops, 33 pits, 10 scarps, and 15 indeterminable or invisible. Using known averages to fill in the gaps, as above, results in an estimate of the quarried volumes for the 'Type not clear' of 17,700m³, excluding only the 15 indeterminable/invisible features.

5.2.5 Surface workings

(Any extensive area of shallow pits and/or low outcrops or boulders not better described otherwise, including stone processing areas).



Photo 5: Part of feature 6154, Curbar Edge Millstone Working Area. The measure is 1m. *Photos author*

These features are assumed to be quarries, in the sense that stone has been worked and removed, but where there is little or no (visible) evidence of excavation. They are defined by their text descriptions and surface area, which are known for 44 and not known for 35. The known 44 occupy 39,000 m². If we assume the unknown 35 are similar, then the total surface

Chapter 5 – Combining and analysing the data

area of these 79 features is about 70,000m². 39% are located between 50m and 100m from a routeway, more like scoops and scarps, rather than pits (see section 5.3, *Distance to Routeway*, below). As many features are no more than isolated or scattered boulders with some evidence of processing, this is not surprising. The few major sites are all close to routeways.

It is not possible to estimate a volume of worked stone for this group of features, but it is likely to be significant. Sites are identified by part-worked boulders and incomplete or damaged millstones, and the much larger quantities of successfully extracted millstones and building stone are no longer present. The estimated working area of 70,000m² is therefore likely to be a considerable under-estimate.

5.2.6 *Limitations - backfilling*

It is normal quarrying practice (in larger quarries, at least) to backfill spoil into parts of the quarry that have already been worked out (Stanier, 2000, 20-21). This can make an abandoned quarry appear smaller than it really was, and hence all the above calculations produce a *minimum* value for the excavated area and volume.

Chapter 5 – Combining and analysing the data

5.2.7 Quarrying volumes summary

Table 5.3 summarises the quarrying volume calculations and estimates from the discussion above. Appendix 2 sets out the calculations in more detail.

Quarry feature type	Dimensions known	Dimensions not fully known	Total	Est. quarried volume (x1000m ³)
Quarry pits	267	29	296	131.1
Quarry scoops	451	63	514	1.8
Quarried scarps	34	24	58	3.9
Quarry - type unclear	0	110	110	17.7
Surface workings	44	35	79	NK
All quarries	796	261	1057	154.5
<i>Table 5.3: Summary of quarry features dimensional analysis</i>				

The Quarry pits are responsible for at least 85% of the total calculated quarried volume, with the next largest group, the scarps, representing only about 2.5%. Of the material excavated from a Quarry pit, 15%-30% is probably spoil (see section 5.4), indicating a useful quarried volume of less than 100,000m³, which is a minimum, given the uncertainties, but likely extent, of backfilling. The average density of gritstone was measured by the author as 2.3 (±0.1) kg/litre (tonnes/m³), but clay is less dense (between 1.0 and 1.7 kg/m³, according to SImetric, 2014). The above volume therefore equates to more than 200,000 tonnes of material.

5.3 Distance to routeway

Quarry products are generally large and heavy, and most must be transported off the moors to their markets. Heavy transport, such as carts, will cause tracks in the ground, and regular use will cause rutting, which the quarrymen would have to repair. Quarrying thus causes new

Chapter 5 – Combining and analysing the data

hollow ways and tracks to develop, to connect the quarries with established roads and tracks.

The degree of association between a type of quarry and the routeway network is thus an indicator of the lifetime and importance of that quarry type.

To summarise briefly from Section 4.4.2 of the methodology, the collective term “routeway” is used here to mean any mapped track, path, hollow way or road in the survey area. Using ArcGIS 10.0, the location of each feature was cross-referred to the combined routeways data, to produce an estimated distance of the feature from the nearest routeway, in the ranges 0-25m, 25-50m, 50-100m and 250-500m. (The buffer boundaries actually begin at the lower bound +0.01m, but this is omitted for simplicity, as measurements are not accurate to this precision in any case). A few parts of the survey area (on Leash Fen) lay over 500m from a routeway, but none of these contained any quarry features.

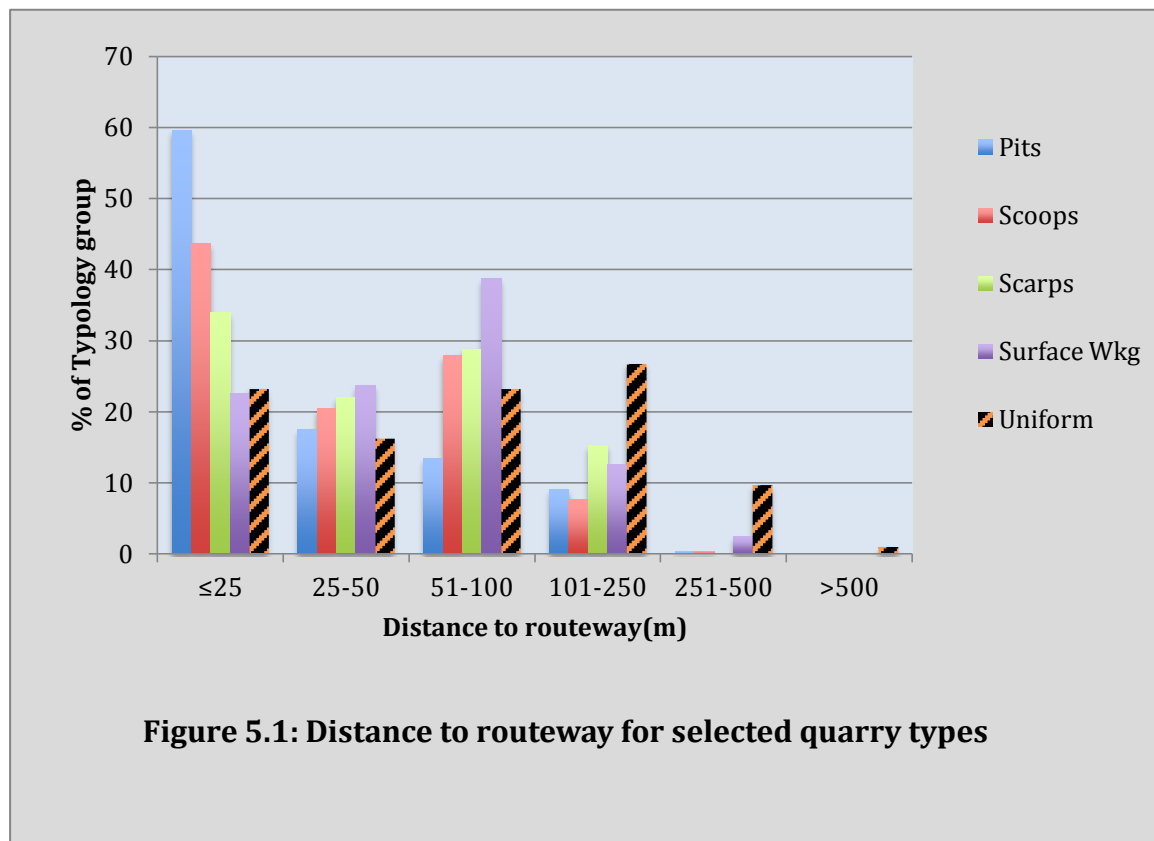
Table 5.4 lists the distribution of routeway distances by quarry feature type (using the new typology), and compares it to the relative proportions of the survey area at each track distance range (the topographical distribution).

		Proportion of quarry features at each distance (%)				
Distance to routeway (m)	Proportion of survey area at each distance	Quarry pits	Quarry scoops	Quarried scarps	Surface workings	<i>All features</i>
≤25	23.2%	59.6	43.7	33.9	22.5	44.8
25-50	16.2%	17.5	20.5	22.0	23.8	20.3
50-100	23.2%	13.5	27.9	28.8	38.7	23.8
100-250	26.7%	9.1	7.6	15.3	12.5	10.6
250-500	9.7%	0.3	0.4	0	2.5	0.5
>500	1%	0	0	0	0	0
Table 5.4: Distribution of routeway distances by quarry type, using the new typology.						

Chapter 5 – Combining and analysing the data

There is a bias towards being close to a routeway, which is strongest for Quarry pits (the larger quarries) and weakest for surface works (most of which are isolated, worked boulders). Significantly fewer quarry features of all types are located more than 100m from a routeway, compared to the topographical distribution. Quarry scoops comprise half of all quarry features, and therefore dominate the overall distribution.

Figure 5.1 shows how routeway distance varies for the three main quarry types, and for surface workings, compared with what would result from a uniform topographical distribution ('Uniform' in the legend). Performing a χ^2 test confirms that there is a vanishingly small probability that quarry locations are unrelated to the track positions (i.e. correspond to a uniform distribution).

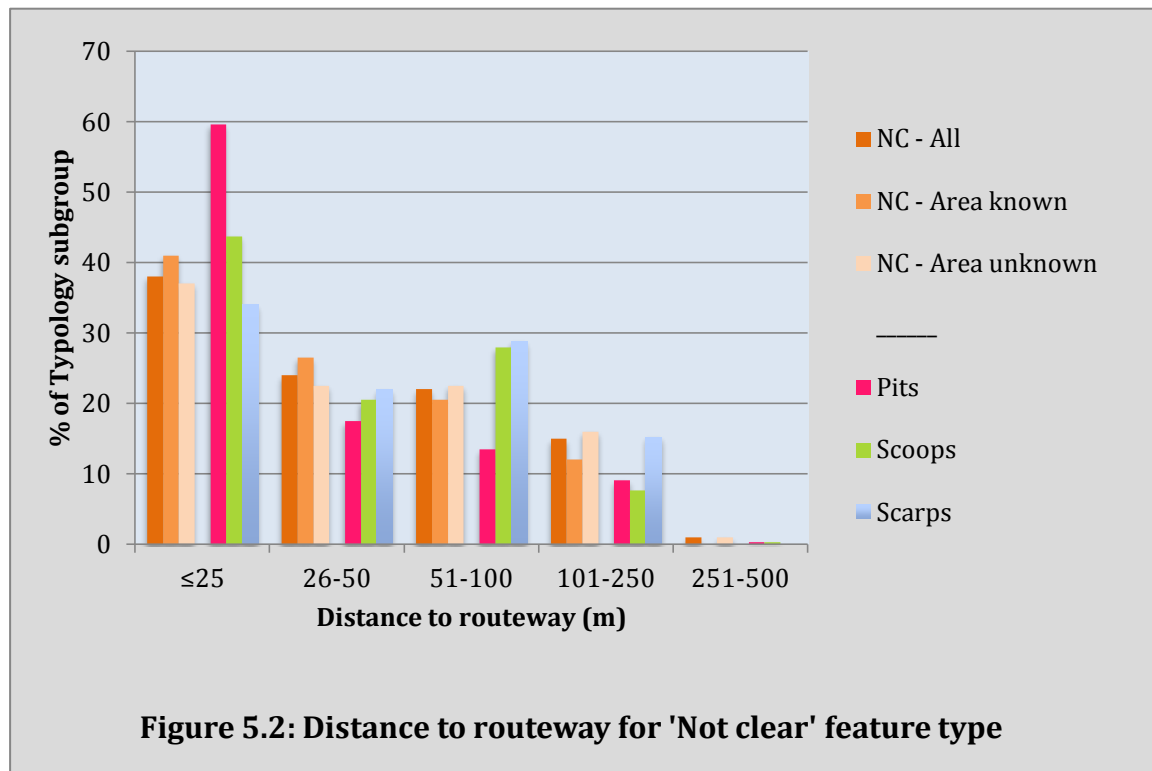


Quarry pits are clearly concentrated close (<25m) to routeways, while scoops and scarps tend to be more evenly distributed out to 100m away. This is not unexpected, as durable

Chapter 5 – Combining and analysing the data

trackways are more likely to develop close to larger quarries than smaller ones. (Surface workings were discussed in section 5.2.5)

Figure 5.2 gives the routeway distance distribution for the 109 'Type not clear' features (excluding the one that was not visible). The bars representing the features where the area is known (34), and not known (75) are very similar to each other. In section 5.2.4, we estimated, from the known dimensions and text descriptions, that these quarry features comprised 33 pits, 52 scoops and 10 scarps, with 14 unknowns.



If we use the data in Figure 5.1 to calculate what the routeway distance distribution would be for our estimated mixture of types within the 'Not clear' group, we get 50% at <25m, 20% at 26-50m and at 51-100m, and 10% at 101-250m. This is pleasingly close to the figures for the real 'not clear' type in Figure 5.2 (38%, 24%, 22% and 15%), and indicates that the methodology has some validity.

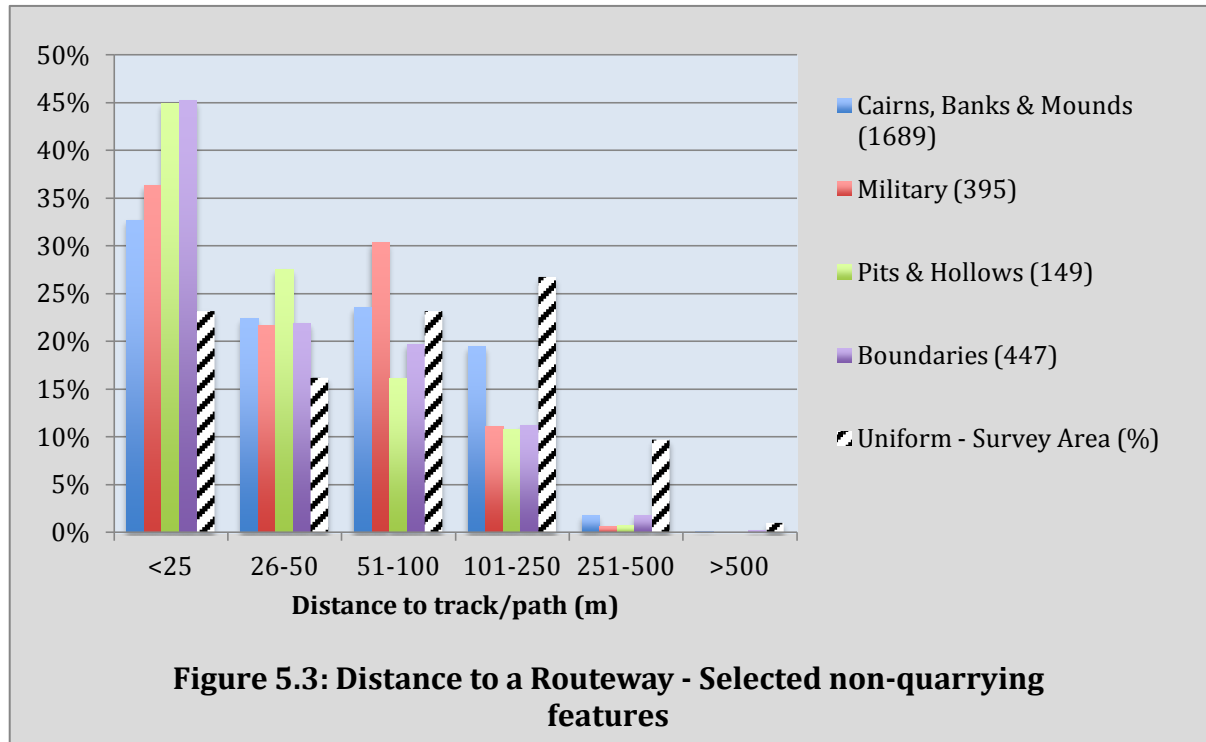
Chapter 5 – Combining and analysing the data

To explore the significance of the routeways data further, the multiple ring buffer was used to plot routeway distances for all the non-quarrying features in the original East Moors database. The features were grouped into a small number of broad categories to enable comparison. The first observation was that only 93.5% of routeways in the all-features database were $\leq 25\text{m}$ from a routeway in the combined routeways shapefile. The other 6.5% (40 routeways) were missing from the shapefile. A few of these “missing” routeways were examined in more detail, and it transpired that they were listed in the East Moors feature database, but were missing from the original EMSR shapefile, and thus represent an error in the survey data. It is not evident what effect this error has on the data, but it could be significant.

All the other features were closer to routeways than a uniform distribution would imply, but there were significant differences. Less than 35% of agricultural and estate management features, and of cairns, banks and mounds were $\leq 25\text{m}$ from a routeway, while 64% or more of ditches, drains, structures other than buildings and water management features were $\leq 25\text{m}$ from a routeway.

Chapter 5 – Combining and analysing the data

Figure 5.3 compares the routeway distance distributions for the larger groups of features with a uniform distribution of features across the survey area. Pits, hollows and boundaries lie somewhat closer to routeways than cairns, banks, mounds and recent military features.



Comparing the non-quarrying features with the routeways data in this way has identified an error in the survey data, but has also shown that, in general, the routeways analysis is valid, by confirming the intuitive expectation that boundaries, ditches and drains are more likely to be associated with routeways, than (say) cairns, banks and mounds.

5.4 Spoil heaps

Twenty-five Spoil heaps have been recorded as separate features, of which 10 are of known size. Many quarry records include reference to adjacent spoil heaps, which are not separately recorded, so these 25 are only a (probably random, unrepresentative) selection. Three heaps are about 10,000m³ in size, one is 280m³, and the other six are all less than 100m³. Little can be sensibly deduced from this small sample, other than that the spoil volume is considerably greater than 30,000m³.

Chapter 5 – Combining and analysing the data

In order to explore the question of quarry spoil further, one typical small Quarry pit (ID No. 6762, OSGB Grid Ref. SK 29505 75023) was surveyed in more detail, using tape, level and plumbline. The feature (Photo 6) consists of a small oval pit situated on a gentle slope, with evident spoil around the downhill side. Figure 5.4 shows a sketch plan and two sections of the feature. From these, the volume of the pit and spoil heap were estimated at 13m^3 and 2.2m^3 respectively, indicating an extracted volume of 10.8m^3 , and a spoil to pit ratio of 17%. Given likely losses to weathering, and infilling of the pit over the years since abandonment, all measurements are approximate, and the spoil to pit ratio in particular is likely to be higher, probably in the range 20%-30%.



Photo 6: Feature 6762, a small Quarry pit with surrounding spoil heap. *Photo author*

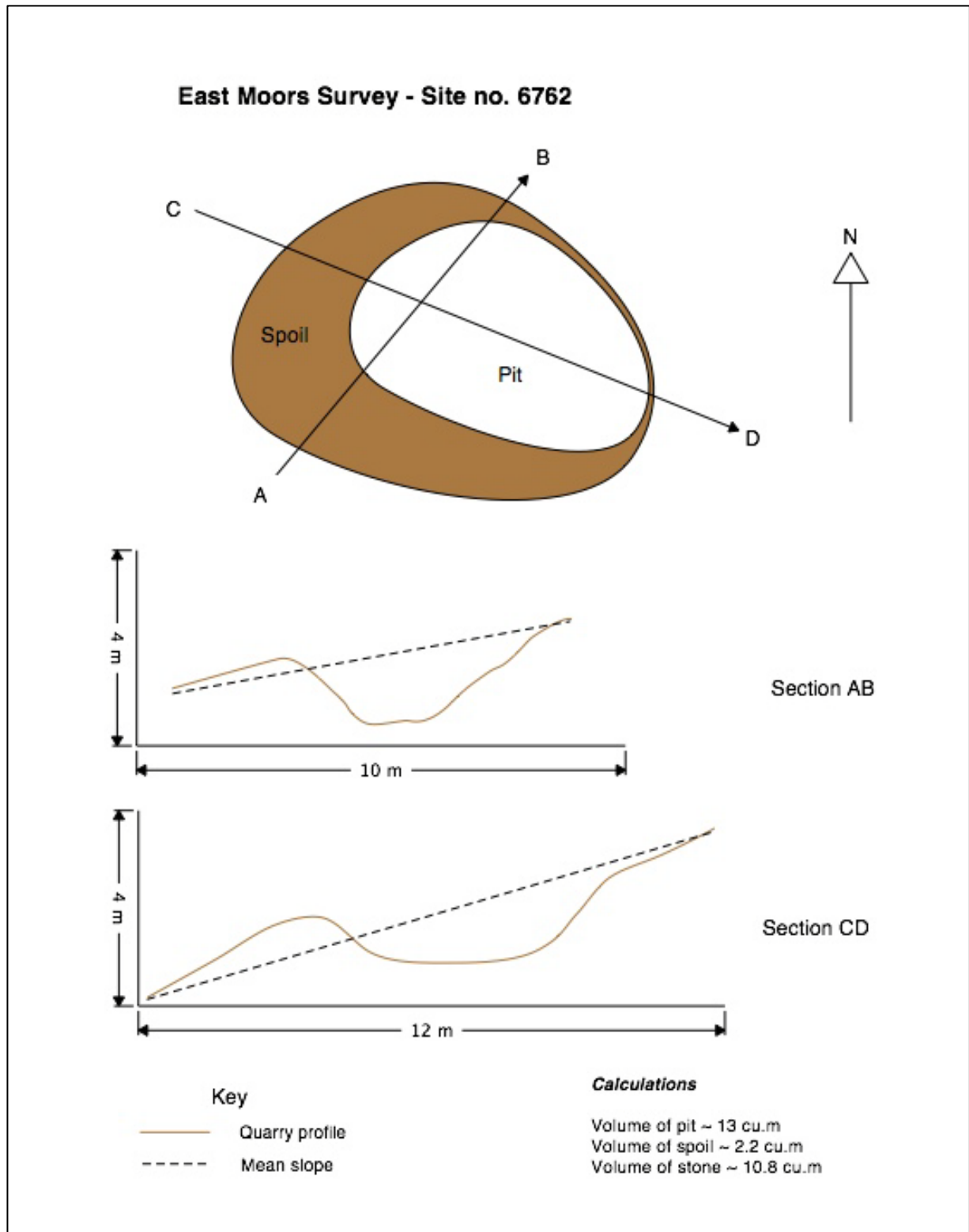


Figure 5.4: Sketch plan of a small Quarry pit - Feature No. 6762

Chapter 5 – Combining and analysing the data

5.5 Bell pits

These are so called because of their shape when dug. A vertical shaft was sunk, and then the excavation continued horizontally around the bottom of the shaft, creating a bell or bottle-shaped space underground. Spoil was heaped around the top of the shaft, leaving a gap for access and removal of product. When extraction was complete, the bell pit was usually refilled with spoil (Crossley, 1990, 204). They were most often used to extract minerals such as coal or iron ore rather than stone, before modern mining techniques were introduced. After abandonment, the surface settled, leaving a saucer-shaped hollow with a central depression where the shaft was. EMSR identified 28 bell pits, of which 18 are dimensioned. They are all small features, with the ‘saucer’ between 1m and 4m in diameter, and up to 1.5m deep. Estimating the extracted volume is difficult, but seems unlikely to exceed 100m³ in total. Since they are more accurately a form of mining (ibid.), I propose to exclude them from further consideration, leaving only 1,057 true quarries within the scope of this work.

5.6 Structures and ‘other’ features

Four ‘quarrymen’s shelters’ are listed. They are all small and ruinous. The four ‘other’ features are probably related to quarrying, but of an uncertain nature.

5.7 Quarrying and topography

Plotting the positions and sizes of the quarry features on a Digimap contour map (Edina, 2014) shows some clear associations (Maps 9 – 12). Unsurprisingly, Quarried scarps are found, mostly, on the steep gritstone Edges of the west and south of the study area, with the rest on smaller, gentler scarps further east. Quarry pits are mostly found in the same places as the scarps, perhaps indicating that they are both exploiting broadly the same geological strata, but using slightly different techniques.

Chapter 5 – Combining and analysing the data

Quarry scoops are more widespread and more evenly distributed than the Quarried scarps and Quarry pits, with relatively fewer clustered near the scarps discussed above.

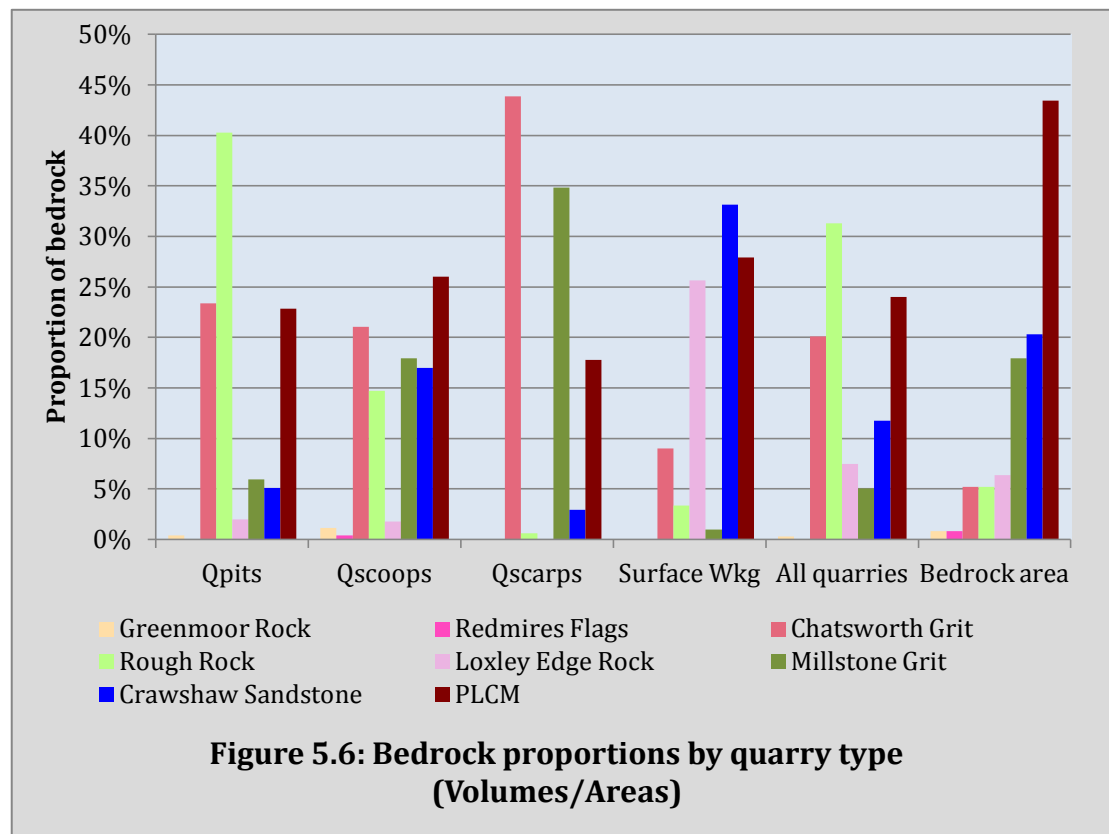
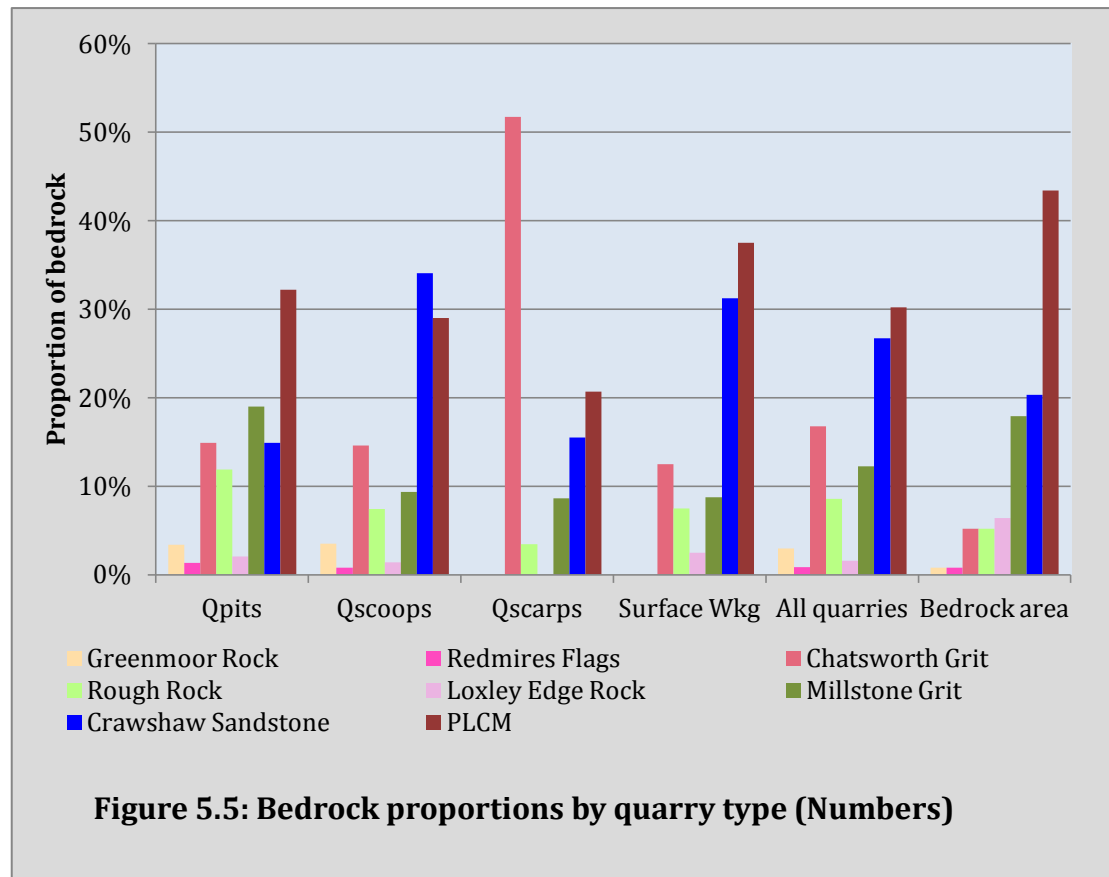
Surface workings, more than half of which are worked boulders, tend to avoid the scarps, and are to be found mainly in flatter areas. Large boulders are to be found scattered below the scarps in many places, a product of climatic conditions at the end of the last ice age (Dalton, Fox & Jones, 1999, 38), so this is consistent with opportunist boulder harvesting, as well as the need to site post-quarrying stone processing areas on relatively flat land.

5.8 Quarry types and bedrock geology

The relationship between quarry type and bedrock geology was explored using the data acquired from the geological Digimap (Edina, 2014) via ArcGIS (Maps 13-16). Eight different bedrock types were identified in the study area. Millstone Grit and Pennine Lower Coal Measures (PLCM) are classed as mudstone/siltstone/sandstone, and the rest as sandstone (Edina, 2014). The results are shown below by both numbers (Figure 5.5) of quarry features and (Figure 5.6) the calculated volumes (for Quarry pits and scoops) or areas (for Quarried scarps and Surface workings), compared to the relative area of each bedrock type in the study area. The sample with known dimensions (77% of the 1,057 quarries in scope) is considered good enough to justify this comparison.

The plot using quarry numbers (Figure 5.5) is more a reflection of the relative distribution of the bedrock geology across the study area (43.4% of it is PLCM) than an indicator of what the quarrymen were particularly interested in, but clearly the Chatsworth Grit Edges were very attractive to those quarrying the scarps.

Chapter 5 – Combining and analysing the data



Chapter 5 – Combining and analysing the data

The chart comparing excavated volumes/areas (Figure 5.6) is more informative. Greenmoor Rock and Redmires Flags do not appear in significant quantities. While Chatsworth Grit is still a popular choice for a Quarried scarp, Millstone Grit is now also very important. Rough Rock is now clearly the most popular choice for the larger Quarry pits, and through them, dominates the 'All quarries' figures. While, from the numbers, Quarry scoops seemed to be dominated by Crawshaw Sandstone and PLCM, Figure 5.6 shows a much more equal spread across five main rock types. This is consistent with Harris's (1971, 81-94) comment that Chatsworth and Millstone grits were the best for millstone making, but were also widely used in construction. Eden, Stevenson & Edwards (1957, 172-173) also confirm this, and that Crawshaw Sandstone and Loxley Edge Rock also made good building stone, as did Greenmoor Rock, although this is rare in the study area. They also confirm (ibid., 167) that ganister was worked and made into refractory bricks at Moor Edge, at the north-eastern edge of the study area (OS grid reference SK 295790), on the PLCM, which also furnished clay for common bricks throughout the Sheffield area (ibid., 175).

Although Quarry pits and Quarried scarps appear to utilise the same topographical areas, the bedrock types differ in one particular respect. Many Quarried scarps exploit the Millstone Grit, with almost none on the Rough Rock, while the opposite is the case for the Quarry pits, other rock types being broadly similar. This may only reflect the observed tendency of the Millstone Grit to form (easily quarried) prominent scarps in the landscape, while the Rough Rock appears to weather to a more rounded landform, where pit excavation would be necessary to win the rock.

Surface workings are harder to interpret, but they appear to be spread more evenly across the landscape, perhaps reflecting the more random nature of the work – quarrying and shaping of isolated boulders, for the most part, and as such, less related to the underlying geology than either an excavation or a scarp.

Chapter 5 – Combining and analysing the data

In summary, we can see, by combining the geological data with the quarried volume calculations, that the quarrymen mostly concentrated their efforts on the best sandstones for building and millstones. These rocks were also suitable for most other purposes, such as drystone walling and hardcore for roadmaking.

5.9 Quarry product type

The quarry product was only identified at 104 (<10%) of the features. Of these, 24 were isolated millstones or building stones, 30 were at quarry pits and 26 at quarry scoops. Map 17 shows how millstones predominated in the west, around Gardom's and Froggatt Edges, and clay was only extracted in the north-east around Brown Edge (near Totley). Building stone and hardcore quarries were more evenly distributed, but curiously the sites said to be possible peat cutting did not correspond with the surface peat deposits noted on the OS Geological map. Based on the geology, many of the pits in the north-east, on the PLCM, are likely to be related to clay working, while most of the rest, on various forms of sandstone, probably produced hardcore or building stone. Millstones are only made from the harder Millstone and Chatsworth Grits (Harris, 1971, 81-82), while building stone quarries can make use of the sandstone strata within the PLCM and Crawshaw Sandstone.

5.10 Chapter summary

A new quarry typology was developed, and used to relate the distribution of quarry types to geology and topography, and to determine how closely each type was related to the proximity of a routeway. The larger Quarry pits dominated the data, amounting to 85% of the total excavated volume of 154,500 m³, and were located, on average, closer to routeways than other types. Unsurprisingly, they sought out the better sandstones in preference to the more widespread Pennine Lower Coal Measures, and were often located on or close to outcrops and scarps of those sandstones. An unknown, but probably significant, volume of stone was

Chapter 5 – Combining and analysing the data

extracted in surface workings, from isolated boulders, mostly on the gentler slopes below the scarps. Millstones were mainly quarried in the south-west of the study area, claypits of all sizes were concentrated in the north-east, and other forms of quarrying were more evenly distributed.

6. Discussion and conclusions

Stone has been quarried on the Eastern Moors since Medieval times and indeed earlier, but mostly all we have now from the earliest times are the grave slabs and other gritstone artefacts, as the oldest quarries have either disappeared under more recent workings, or have weathered such that they are no longer recognizable. Almost all the quarrying features identified in EMSR were classed by the surveyors as post-medieval or later. The oldest datable features were the 'domed' millstones, which were in production from the 15th to the late 18th centuries.

Local villages such as Baslow were extensively rebuilt in stone, mostly gritstone, from the late 17th to the 19th centuries (author, personal observations), mostly from local quarries, given the great expense of long-distance transport. Building in stone remains a requirement today, under the planning rules of the PDNPA, but cheaper transport means the stone now comes from larger commercial quarries further away. The focus of the industry was thus originally on a low volume, high value craft product (millstones) and later moved to a higher volume, medium value product (building and paving stone), until cheaper transport costs made such quarrying uneconomic. In parallel, there has always been (arguably from prehistoric times) a use for local stone in (dry stone) field wall construction and for metalling paths and roads. The latter was particularly significant when the local turnpikes were under construction in the 18th century (Dodd & Dodd, 1974, 113). However these two uses were of low economic value, and any quarrying was of necessity close to the point of use, and transient.

The typology devised for this study has aided analysis of the data in several ways. We have seen how most of the stone quarried came from the larger quarry pits, with a basic trackway or other path nearby. Good building stone, such as Chatsworth Grit and Greenmoor Rock,

Chapter 6 - Discussion and conclusions

was sought out, especially where they outcropped in the 'Edges', except in the north-east, where clay, ganister or coal was easily available. The commoner quarry scoops are more widely distributed, but represent a much smaller proportion of the volume of stone extracted. Surface workings represent an unknown, but potentially large proportion of product, especially millstones.

We have made a crude estimate that the visible features represent at least 200,000 tonnes of useful material removed, and another rough estimate that the average quarrying workforce in the mid 19th century was about 40 men. It is tempting to divide one crude estimate by another rough figure, to produce an output rate of about 50 tonnes per man-year, but we cannot assume that all the known tonnage was extracted in the 19th century, nor that the unknown tonnage was small. The '50 tonnes per man-year' deduction (a low, but not unreasonable figure) indicates only that the calculated quarry volumes and census estimates are compatible with each other, and not wrong by orders of magnitude. In chapter 3, we saw that a millstone maker could produce about 24 millstones in a year, weighing around 20-25 tonnes, which is compatible with this estimated output rate.

Millstones are a much higher value (per tonne) product than building stone, which is worth much more than the same weight of rough walling stone, so the available income per tonne extracted declined from the 17th to the 20th centuries. The Eastern Moors study area supported about 40 men, and their families, during the 19th century, and possibly more than that in the 17th century, when millstone making was at its peak. This is similar to the numbers employed in agriculture and gamekeeping, although neither figure is large compared to the total population of the area of about 1,100 (Table 3.2). Activity increased when European wars made trade more difficult, and decreased in peacetime, coming to an end in the early 20th century. Hardly anyone works on the moors today, except for a few stockmen, the occasional archaeologist, and park rangers, who regulate the hundreds of daily visitors.

Chapter 6 - Discussion and conclusions

In summary, this research has demonstrated the following:

- Stone has been quarried on the moors from prehistoric times, but there is no evidence of the early quarries. Historical accounts exist from the 15th century and abandoned domed millstones of 15th-18th century are quite common, but features are difficult to date more precisely than this.
- Business records give an insight into the economics of local quarrying from the 15th to the 19th century, and census data tells us that about 40 men worked the quarries on the moors in 19th century, about half of them full-time. It is likely that more worked there full-time while millstone-making was at its height in the 16th-17th centuries, when a good living could be made, comparable to building industry workers today.
- Of 1,177 features identified from the EMSR as quarrying-related, 1057 were confirmed as apparent quarries, of which 497 already had adequate dimensional data. A further 360 were visited, from which 321 could be measured, giving a measured sample size of 818, or 77%.
- A new typology, classifying quarries into four basic types, demonstrated that the 296 larger Quarry pits were responsible for most (85%) of the quarried volume, and were mostly (65%) located close ($\leq 50\text{m}$) to a routeway.
- Quarry pits and Quarried scarps tended to be located on the better quality sandstones, while the smaller Quarry scoops and Surface workings were more evenly distributed across the landscape. The largest single feature, however, is a clay-pit, within the specialized clay and brick-making area in the NE of the survey area.
- The calculated extracted volume of the visible quarry features is more than $154,000\text{m}^3$, representing about 200,000 tonnes of product. The true total is likely to have been much more than this.

7. Recommendations

EMSR contained a number of recommendations, principally aimed at the conservation of the archaeological features of the Eastern Moors (May & Badcock, 2011, 43-53), which are fully supported, but not repeated here. They also recommended the development of information/guidance for the public (ibid., 55) and suggested ten further archaeological surveys (ibid., 55-56, Section 11.1), including this one. This dissertation has explored quarrying on the Eastern Moors in more detail (suggestion No. 3), and contributed a little to knowledge about hollow ways on Big Moor (suggestion No. 7), but leaves more to be done, in particular:

- To visit and measure (at least) the remaining 109 quarry features where the type is unclear due to lack of dimensional data, and the 29 Quarry pits of unknown volume, so that a full picture of the most significant quarrying features is recorded.
- If the EMSR's first suggestion (to explore millstone making in more detail) is taken up:
 - To extend quarry surveying into areas on the periphery of the large millstone making centres, just outside the survey area, and also on to Baslow Edge, to ensure the local picture is complete
 - To survey in detail one or more of the larger quarries, with the aim of better understanding production methods, and the likely type and volume of quarry products extracted there.
- To produce a guide booklet specifically on quarrying on the Eastern Moors, given its wide extent and local significance, particularly in the recent past.

Appendix 1 - Calculating areas and volumes

Appendix 1. Calculating areas and volumes - a note on length, width, depth/height and form factor

The length of a feature is defined as the greatest horizontal dimension, and width as the horizontal dimension perpendicular to the length. Depth or height is the vertical dimension, usually taken as the estimated mean value. We also need a measure of the plan shape of the feature – which I define as the form factor.

The surface area of a feature is then calculated as:

$$\text{Area (A)} = \text{Length (L)} \times \text{Width (W)} \times \text{Form Factor (FF)} \quad [\text{equation 1}]$$

For example, a square or rectangular feature has $FF = 1$, as $A = L \times W$.

For a circular feature, $A = \pi R^2$, where R = radius. If D = diameter, then $D = 2R$ and $A = \pi D^2/4$. In this survey, a circular feature would have $L = W = D$, and $FF = \pi/4 = 0.785$, rounded to 0.75 ($3/4$), as this is not a high-precision dataset. Similarly, an oval feature, where $A = \pi R_1 R_2 = \pi LW/4$, also has $FF = 0.75$ (where R_1 and R_2 are the major and minor semi-axes).

A triangular feature has $FF = 0.5$, as $A = LW/2$. Shapes intermediate between these can be assigned an intermediate value. Where a single feature consists of several elements, the form factor can exceed 1. For example, a set of three similar, rectangular pits has $FF = 3$, while a set of eight similar oval pits would have $FF = 6$ (0.75×8).

Using the above definitions, the dimensions and shape were extracted from the original raw feature descriptions (see table 3.1), or estimated if depicted on the 1st edition OS 1:2500 map, or noted if a feature was visited. The Bento database then calculated the feature surface area (A) using equation 1, and volume as area (A) x depth. Although only relevant for scarps, it also calculated the face area = Length x Depth/Height. It could also perform counts, and

Appendix 1 - Calculating areas and volumes

calculate means, standard deviations, maxima and minima as required, for any selection of quarry features.

Appendix 2 - Quarried volumes calculations (table)

Appendix 2 Quarried volume calculations			Averages						Totals	
Type	Sub type	No.	L	W	FF	D/H	Area	Volume	Area	Volume
Quarry pits	Exceptional	1	200	100	1	2.0	20,000	40,000	20,000	40,000
	Known volume	266	10.9	6.6	.88	2.0	102.9	325.7	27,276	86,312
	Unknown volume, depth known	29				1.6	102.9			4,774
	All Quarry pits	296								131,086
Quarry scoops	Known volume	451	2.7	2.1	.87	0.4	6.9	3.5	3,117	1,587
	Unknown volume, depth known	47				0.5	6.9			162
	Unknown volume, surface area known	6	1.2	0.9	.88	0.4	1.0		6.0	2.4
	No dimensions	10						3.5		35
	All Quarry scoops	514								1,786
Quarried scarps	Known face area & cut width	31	15.4	3.3	.89	1.5	24.9	67.8	772	2102
	Known face area, cut width not known	3	9.3		1.0	1.3	16.3		48.8	161
	Known face area -all	34	14.9			1.5	24.1		820.8	2263
	Length only known	2	3.5			1.5			10	33
	Height only known	9	14.9			1.3			174	574
	No dimensions	13					24.1		313	1033
	All Quarried scarps	58							1,318	3,903
Quarry - type unclear	Area known, depth/height not known	38	6.2	3.9	.86		32.8		1,247	
	Only depth/height known	6				1.2				
	No dimensions/not visible	66								
	All type unclear	110								17,700
All quarries	<i>(Excluding the 79 Surface workings)</i>	978	6.3	3.8	.86	1.0	54.3	133.2		154,475
<i>All dimensions in m, m², or m³. Figures in black – as measured/calculated: figures in red – estimated using averages for missing data</i> <i>Area means surface area, except for scarps, when it means face area</i>										

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Maps

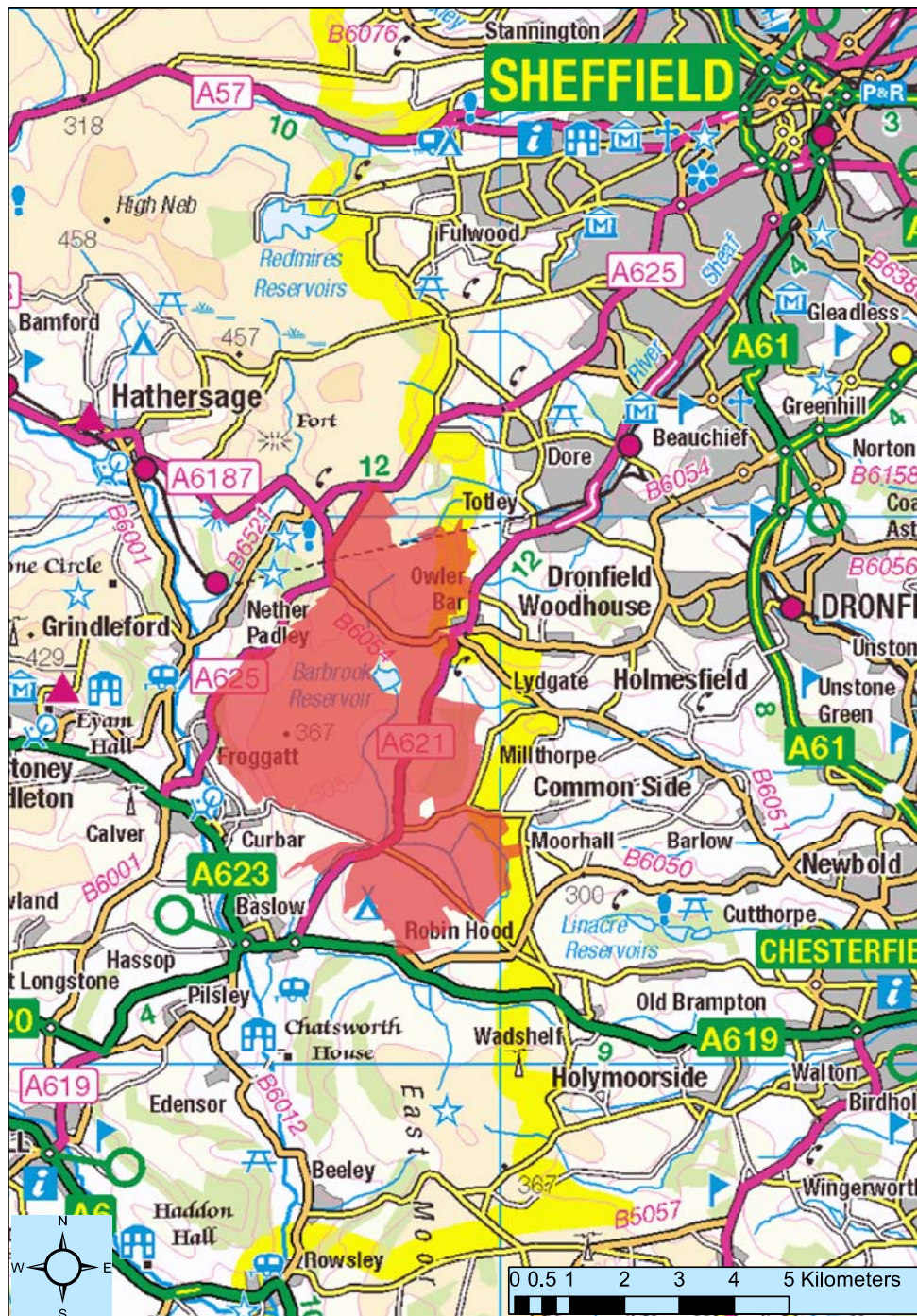
All the maps in this section were prepared using ArcMap 10.0 (ESRI, 2010). Ordnance Survey topographical, geological and historical maps were obtained from Digimap (Edina, 2014). A number of GIS shapefiles were provided with EMSR (May & Badcock, 2011), and are individually acknowledged. All other shapefiles were generated from the new database and drawn up by the author.

List of Maps

1. Location map
2. East Moors Survey area – local topography
3. Routeways in and villages near the survey area
4. Routeways and the multiple ring buffer
5. Intensively worked areas in the study area
6. Sampling grid
7. Example of a fieldwork location map
8. Quarry features before and after fieldwork
9. Quarried scarps and contours
10. Quarry pits and contours
11. Quarry scoops and contours
12. Surface workings and contours
13. Quarried scarps and geology
14. Quarry pits and geology
15. Quarry scoops and geology
16. Surface workings and geology
17. Locations of known quarry products
18. Civil parishes and villages

Maps

East Moors Survey Area - Location Map

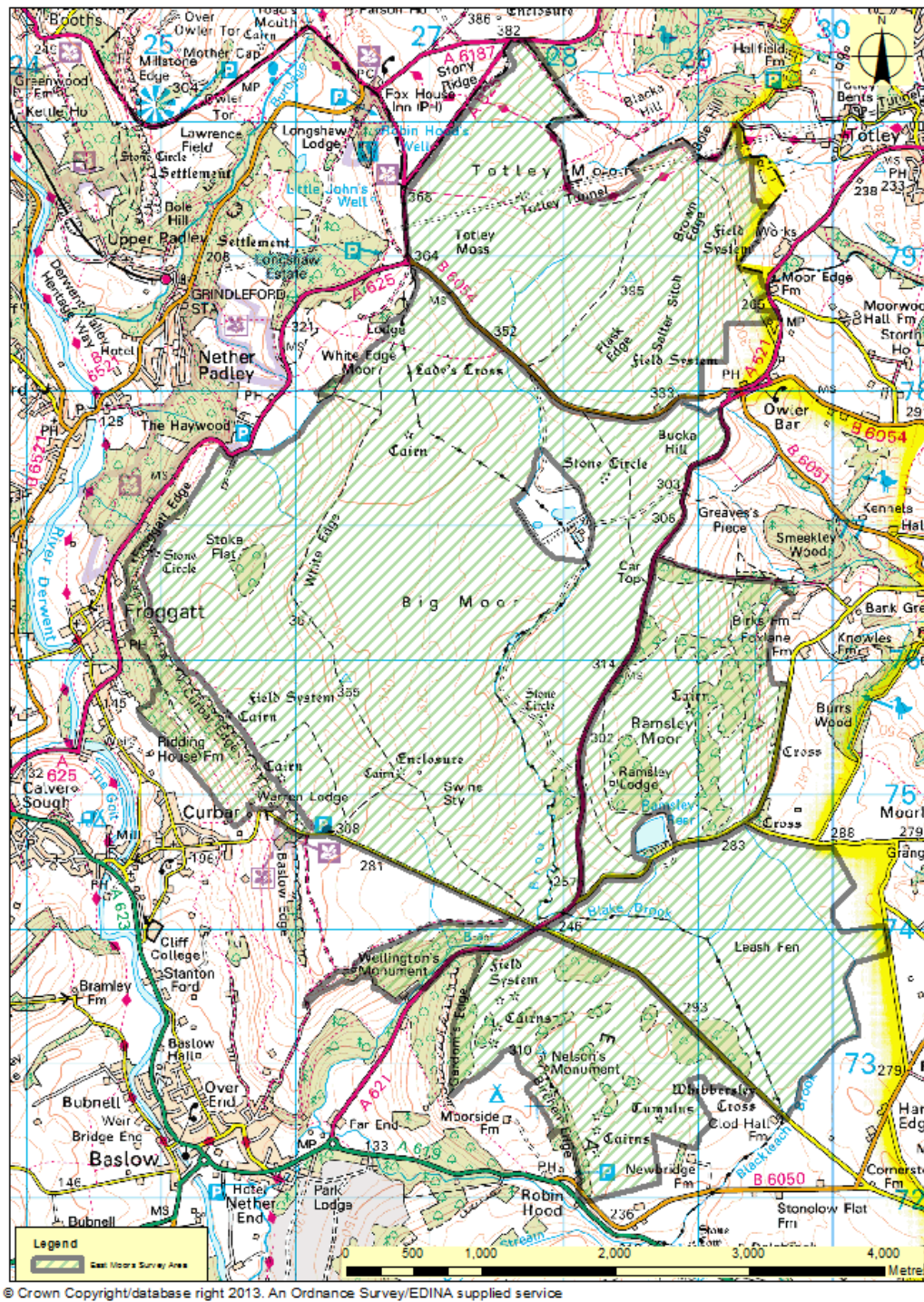


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Map 1: Location of the East Moors survey area. Sources: Basemap - Edina (2014, Digimap 1:250,000); Survey area shapefile – EMSR (2011).

Maps

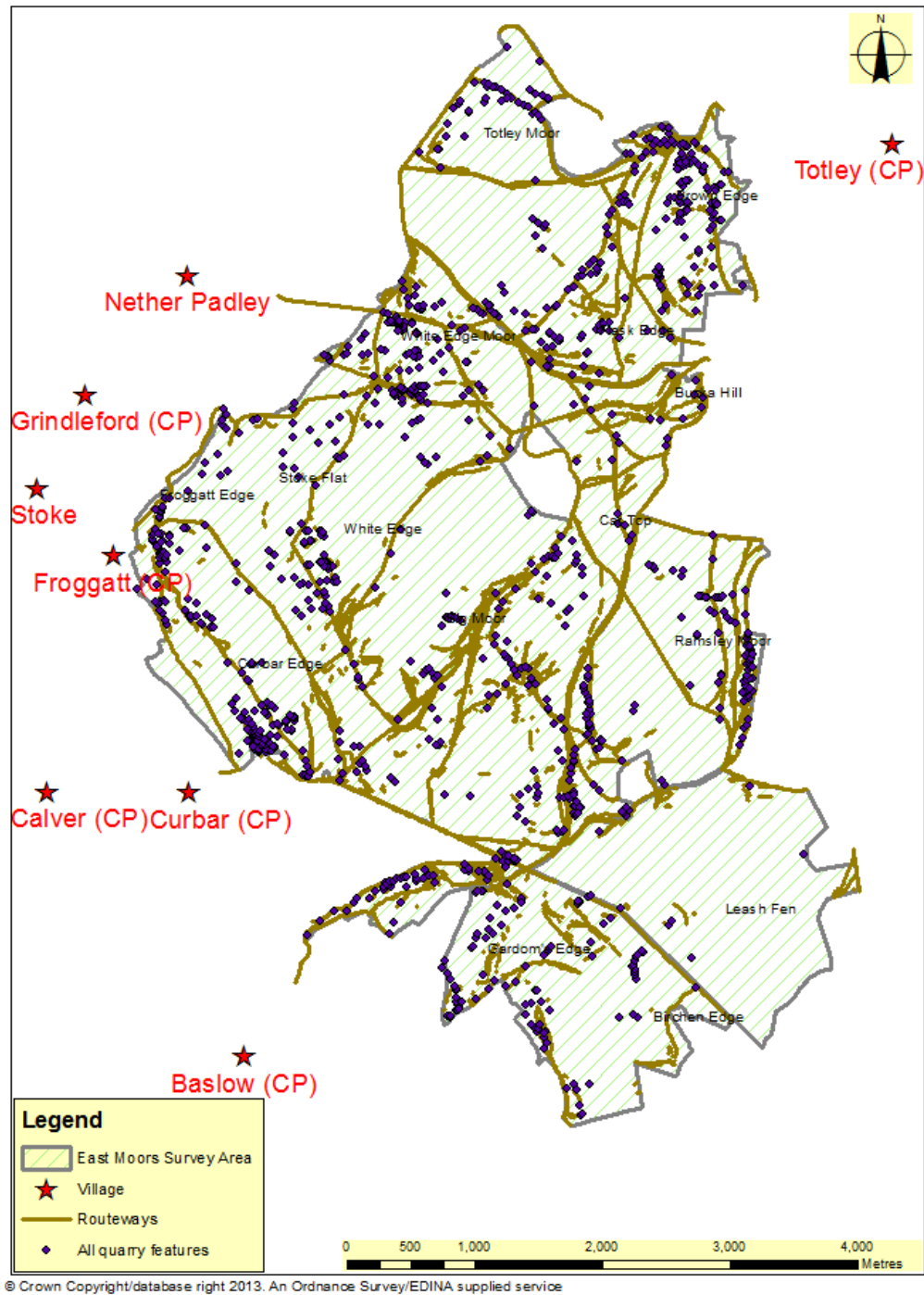
East Moors Survey Area - Topography



Map 2: East Moors Survey Area - local topography. Sources: Basemap - Edina (2014, Digimap 1:50000); Survey area shapefile - EMSR (2011).

Maps

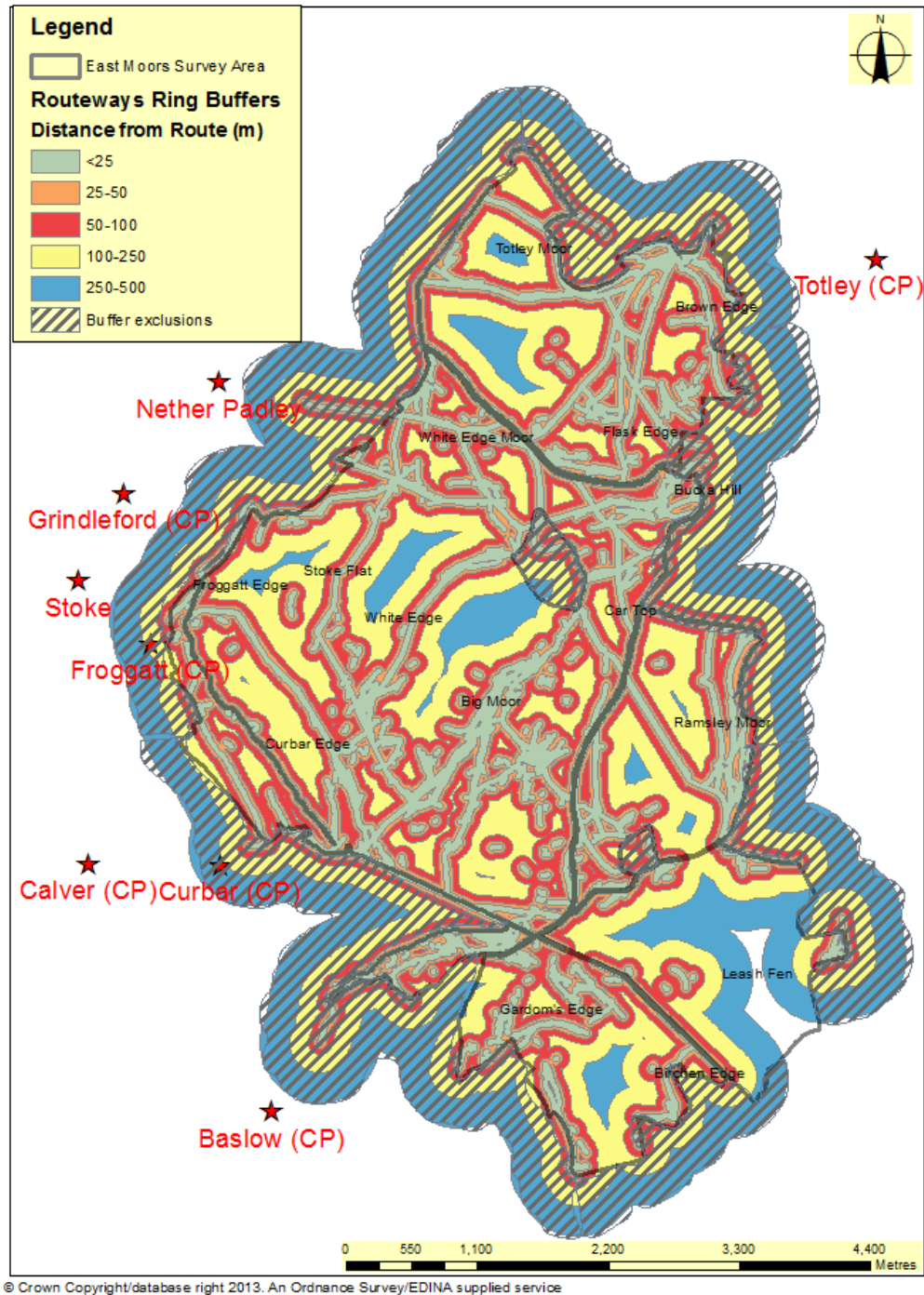
Routeways, Villages and quarry features around the survey area



Map 3: Routeways in the survey area. *Sources:* Basemap - EMSR (2011); Routeways - Edina (2014, Digimap 1:25000), EMSR (2011), Dodd & Dodd (1974), Radley (1963, 40, Fig 9).

Maps

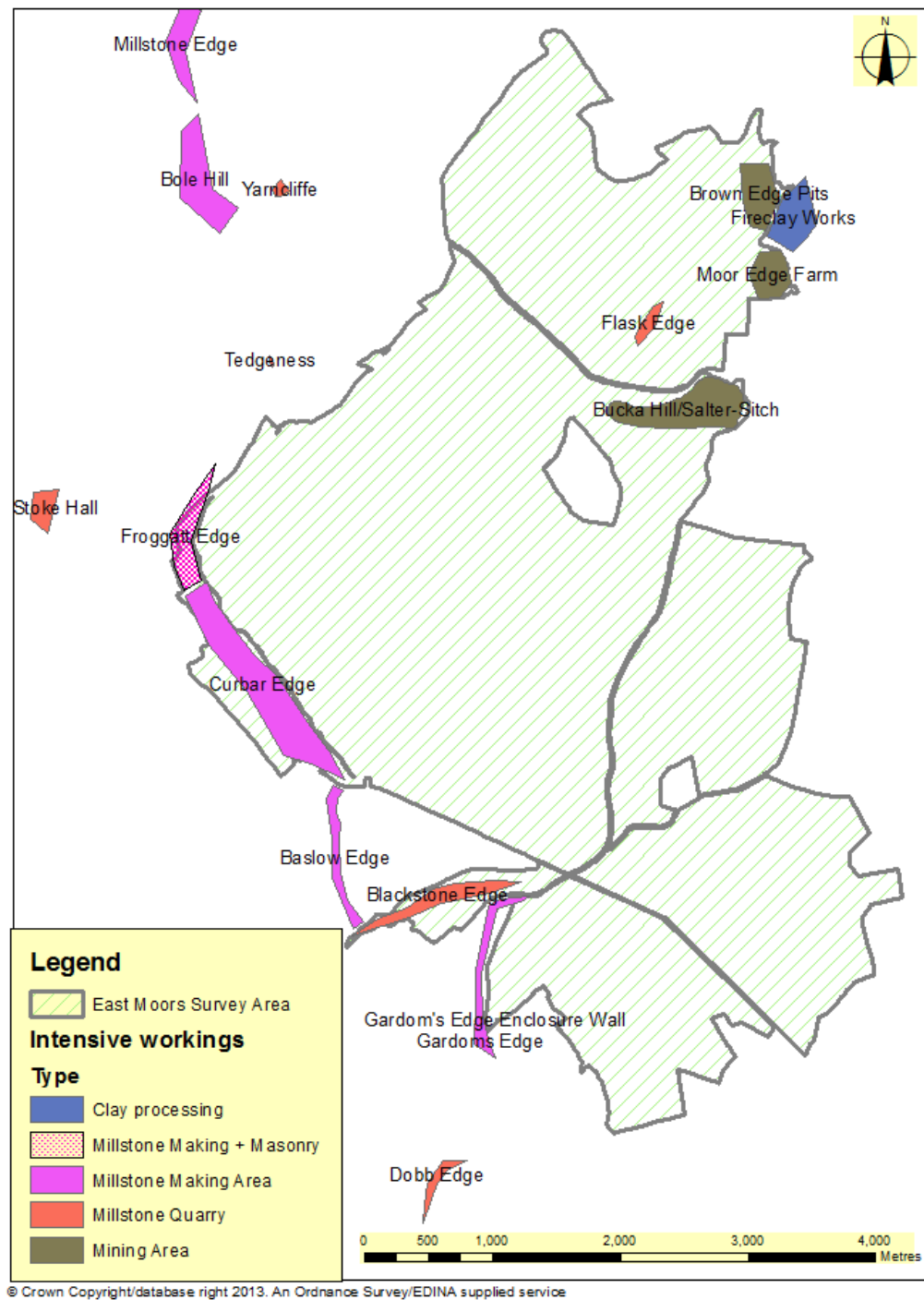
Routeways, Ring Buffers and the Survey Area



Map 4: Routeways and ring buffers. The “<25” green lines follow the routeways. The cross-hatched area indicates areas of buffer outside the survey area. *Sources:* Basemap - EMSR (2011); Routeways - Edina (2014), EMSR (2011), Dodd & Dodd (1974), Radley (1963, 40, Fig. 9); Ringbuffer - author.

Maps

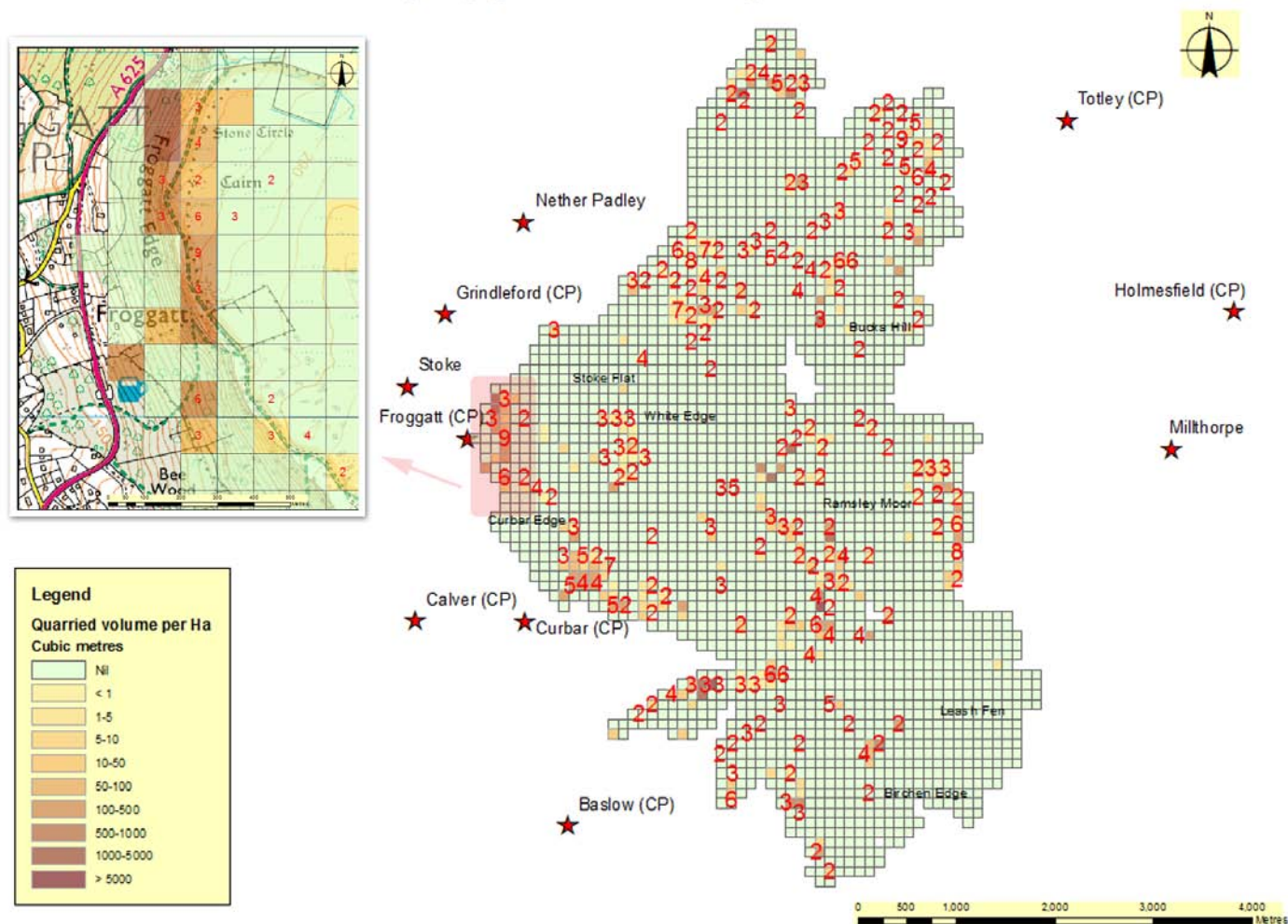
Intensively worked areas in and near the survey area



Map 5: Intensively worked areas. *Sources:* Basemap - EMSR (2011); Millstones data - Tucker (1985, 45, Fig.2 and 55-56, Tables 1 and 2); Masonry data - Farey (1811, 418 and 433); Mining data - EMSR (2011) and Farey (1811, 190-212); Fireclay data - Farey (1811, 451).

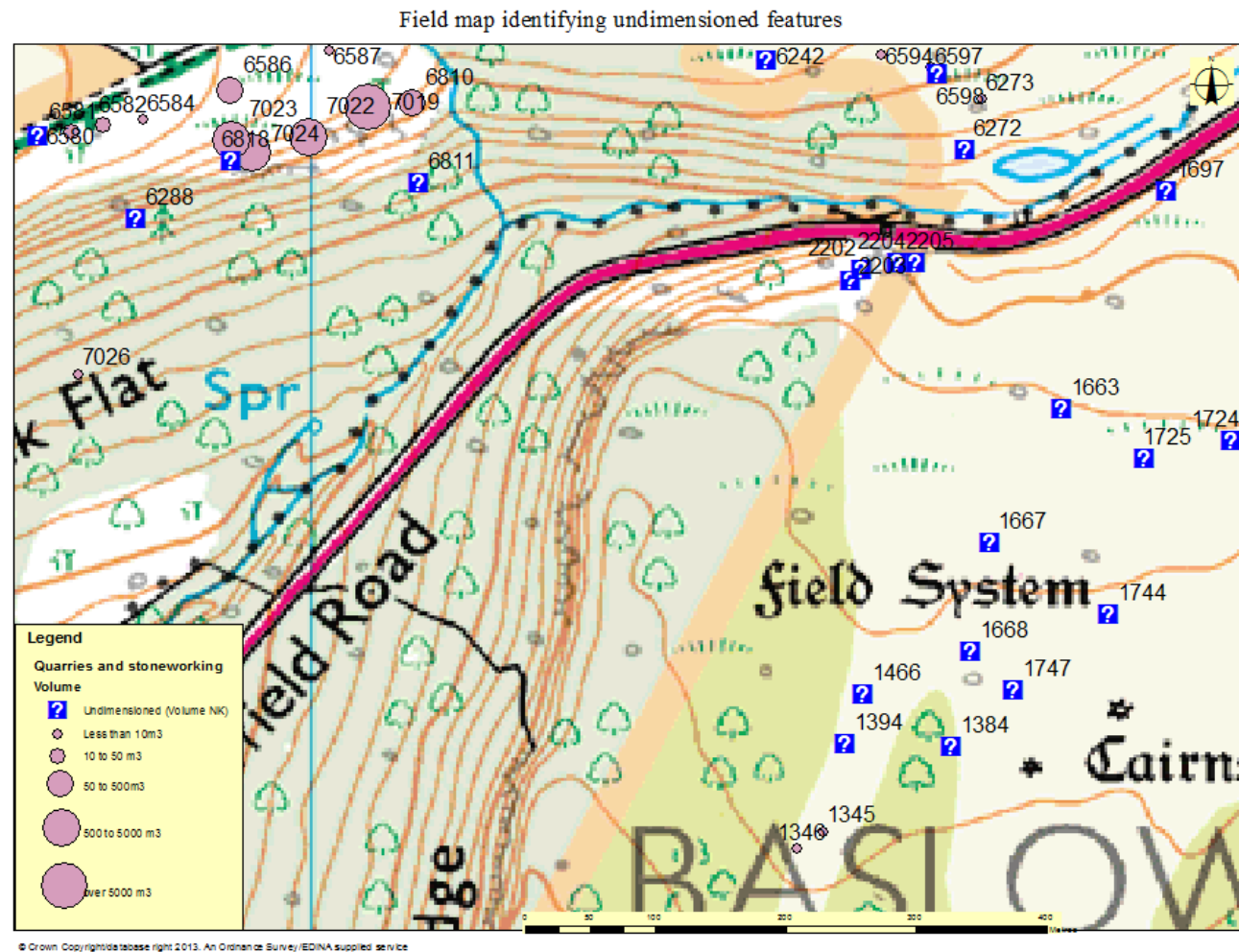
Maps

Sampling grid Grid - 1 Ha squares



Map 6: Sampling grid. Brown shading indicates known quarried volume, red number indicates number of features, per hectare square. Sources: Basemap – EMSR (2011); Detailed map - Edina (2014, Ordnance Survey 1:25000); Grid and shading scheme - author.

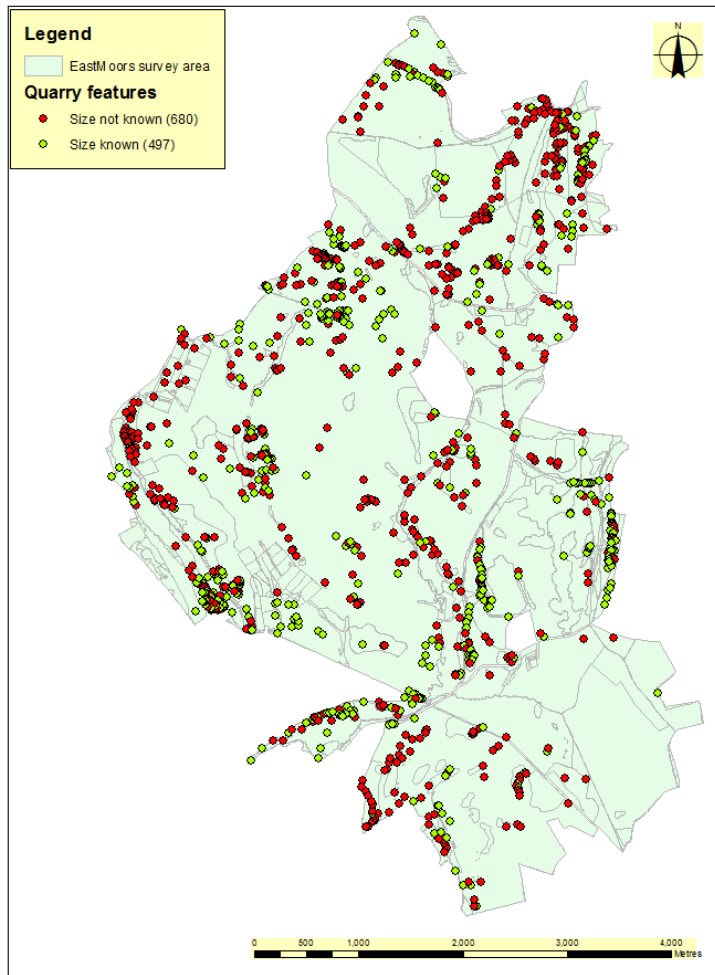
Maps



Map 7: Example of a fieldwork location map. Sources: Basemap - Edina (2014, Digimap, OS 1:25000); Feature data – EMSR (2011), after processing in author's new database

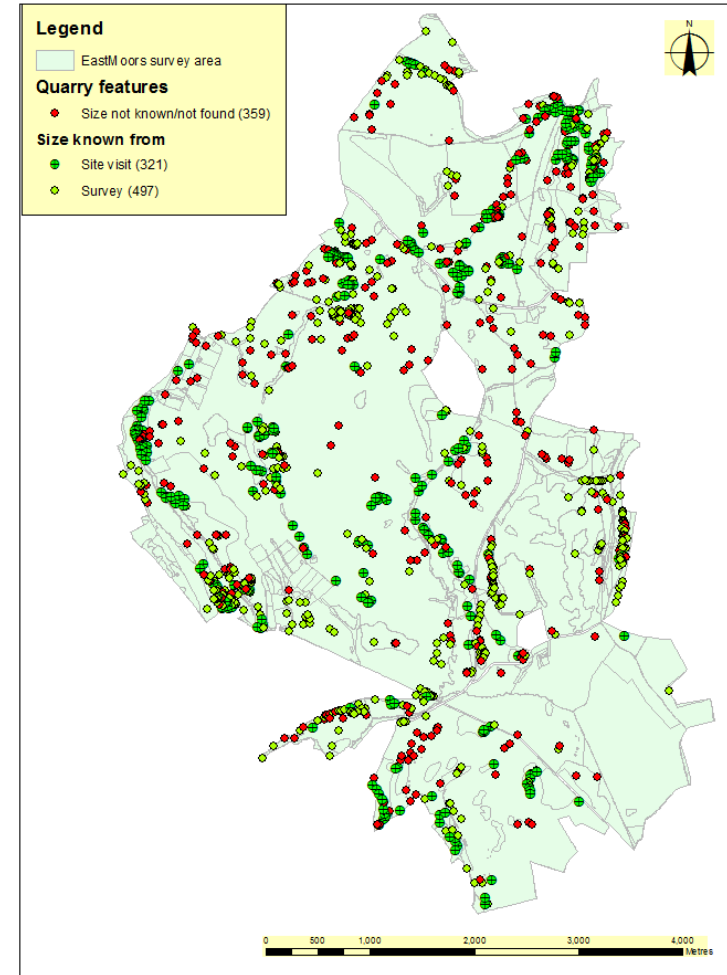
Maps

Quarry features - before fieldwork



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Quarry features - after fieldwork



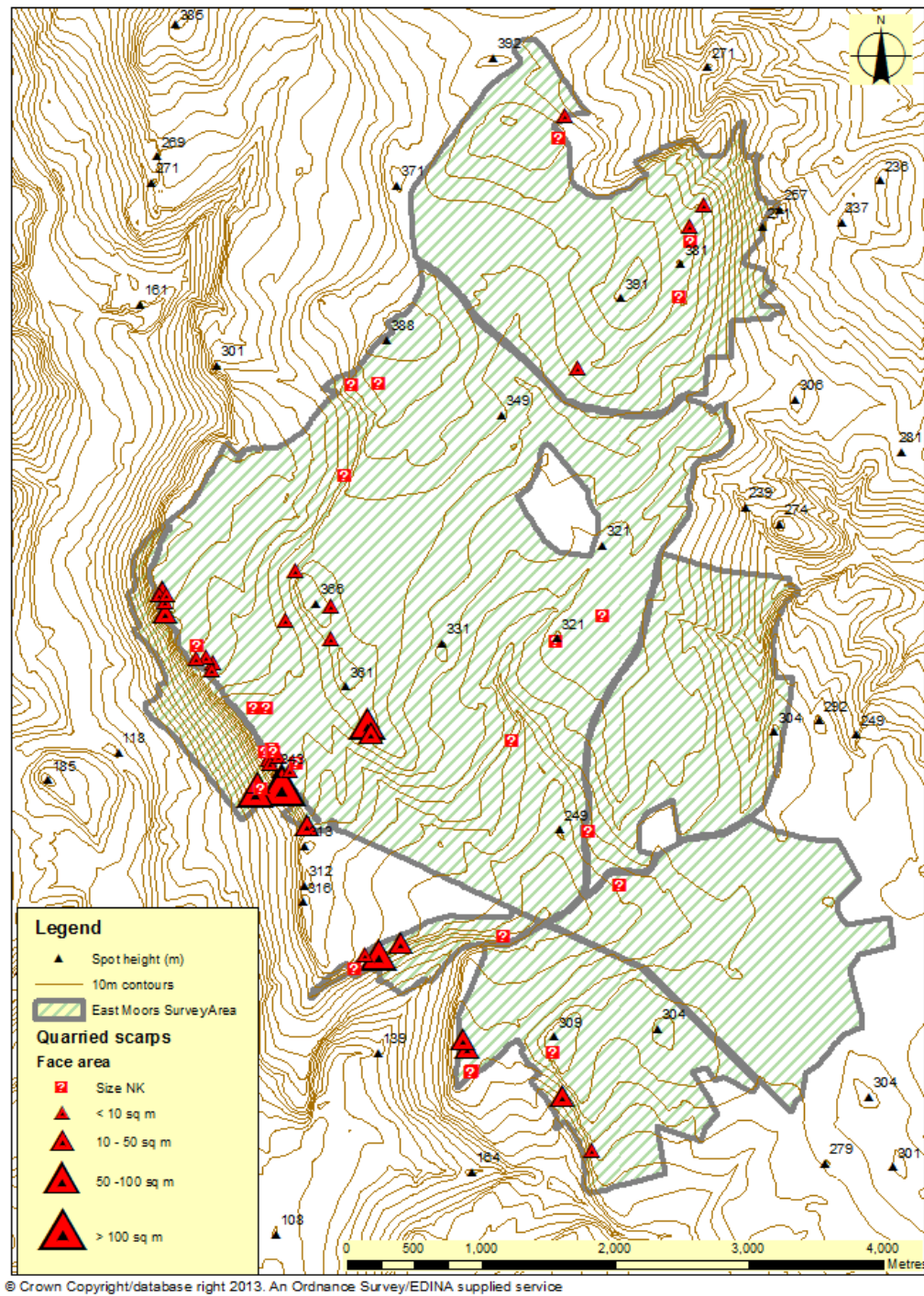
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Maps 8a and 8b: Survey area showing distribution of features of known size, before (8a, on left) and after (8b, right) the fieldwork.

Sources: Basemap - EMSR (2011). Feature distributions – EMSR (2011), after processing in author's new database, to include additional quarry dimensions gathered by author for map 8b.

Maps

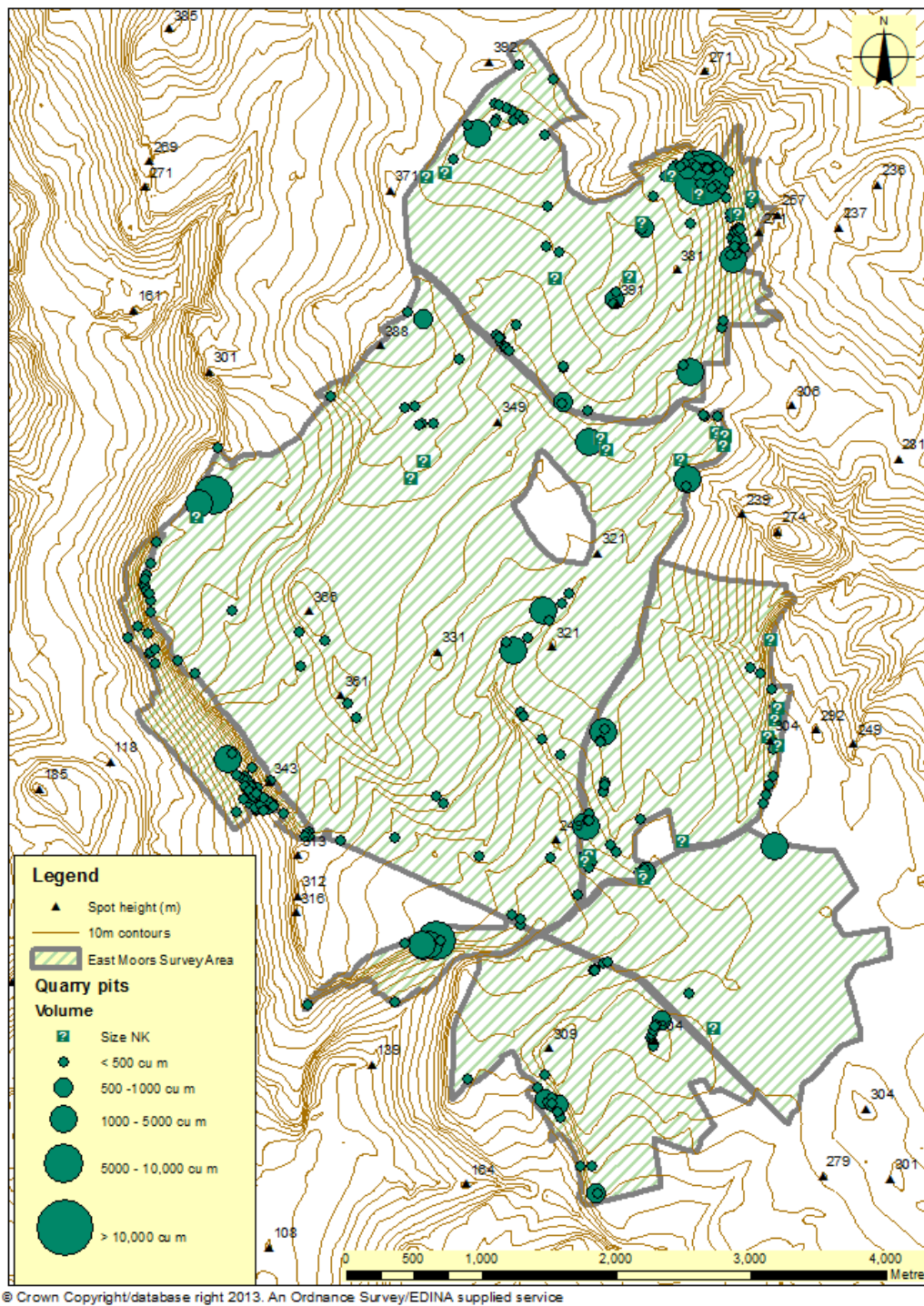
Quarried Scarps and 10m contour map of the study area



Map 9: Contour map of the survey area, showing locations of Quarried scarps by size.
Sources: Basemap - Edina (2014, Digimap contours shapefile); Feature distribution – EMSR (2011), after processing in author's new database to include new size data.

Maps

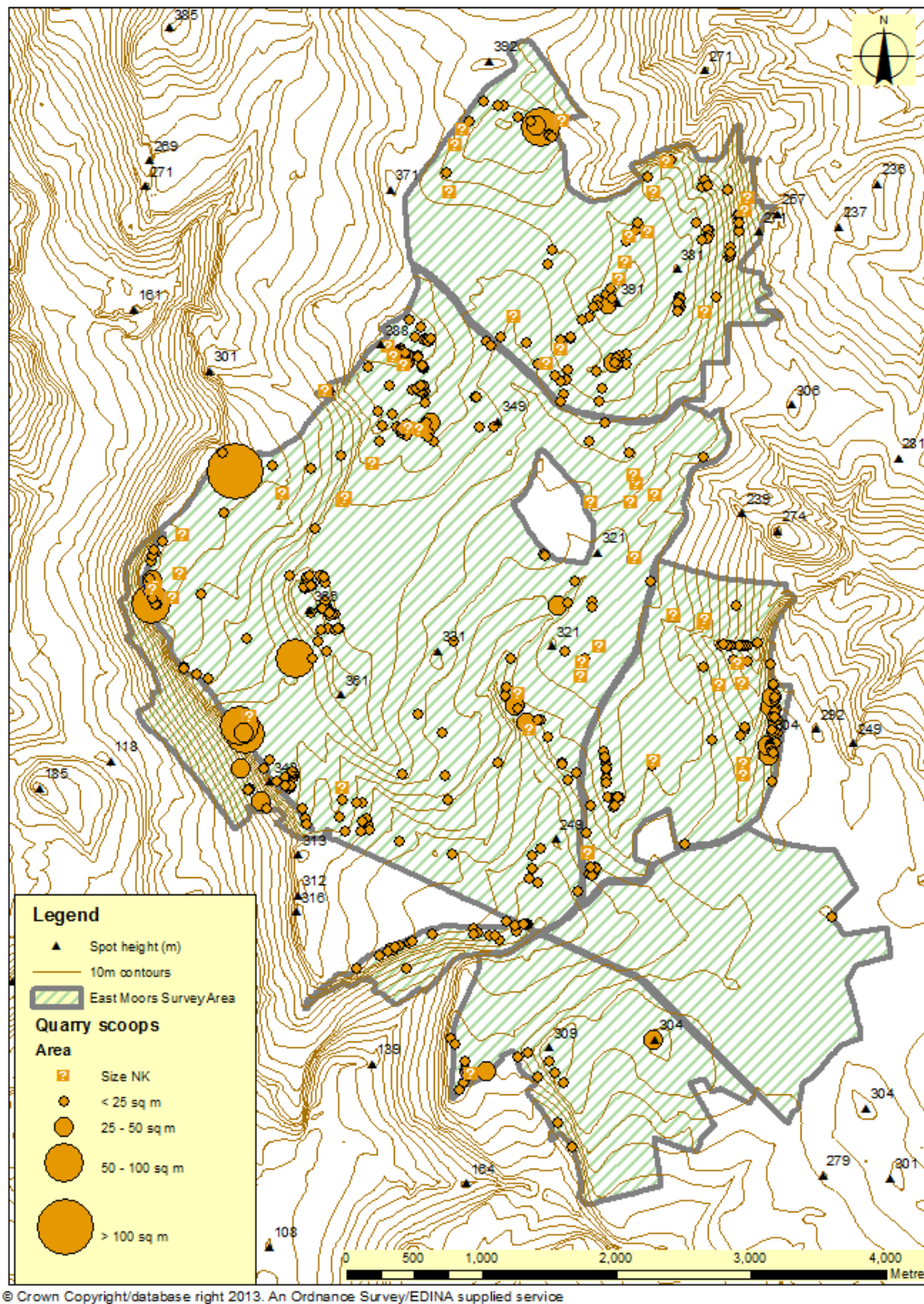
Quarry Pits and 10m contour map of the study area



Map 10: Contour map of the survey area, showing locations of Quarry pits by size.
Sources: Basemap - Edina (2014, Digimap contours shapefile); Feature distribution – EMSR (2011), after processing in author's new database to include new size data.

Maps

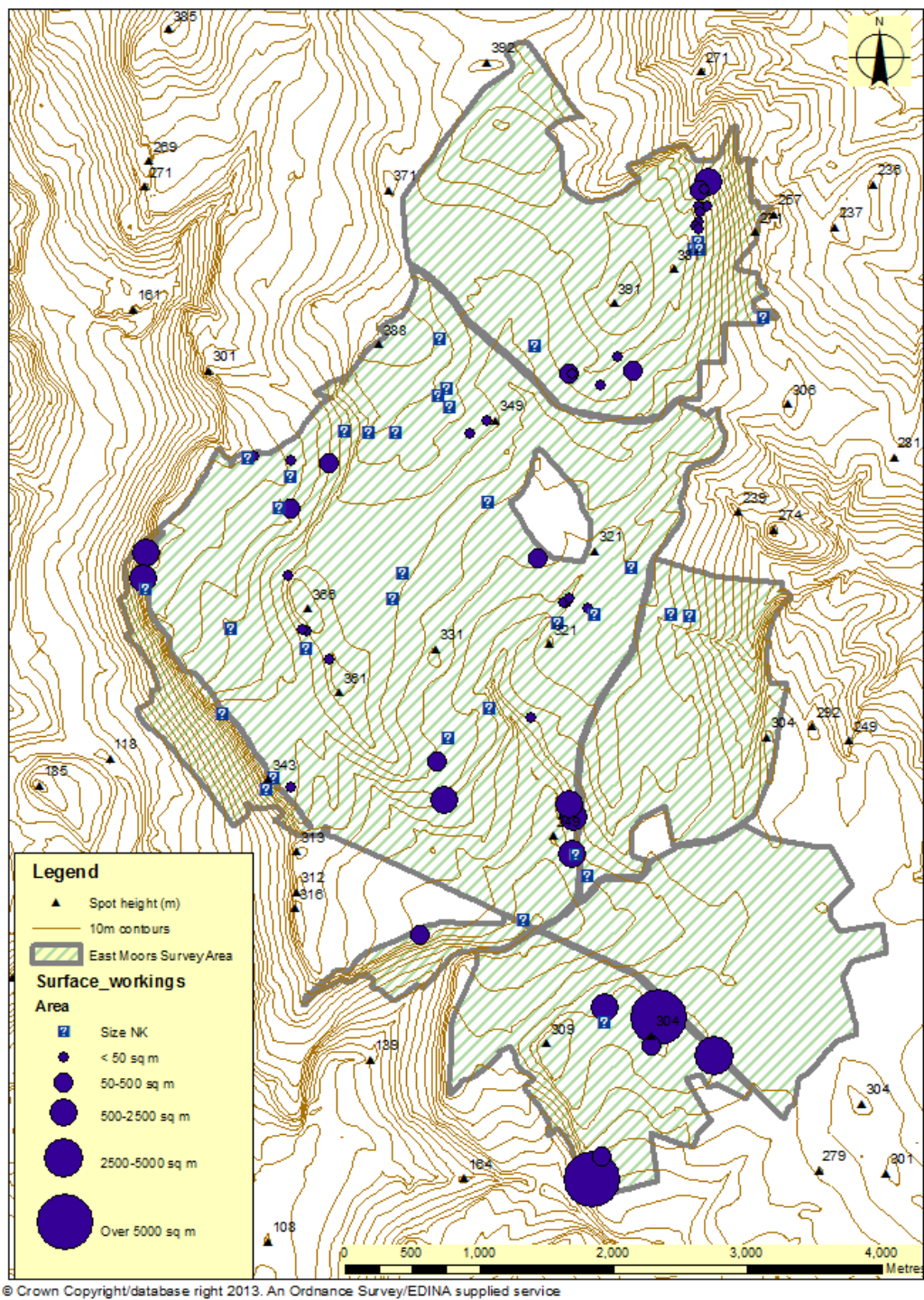
Quarry Scoops and 10m contour map of the study area



Map 11: Contour map of the survey area, showing locations of Quarry scoops by size.
Sources: Basemap - Edina (2014, Digimap contours shapefile); Feature distribution – EMSR (2011), after processing in author's new database to include new size data.

Maps

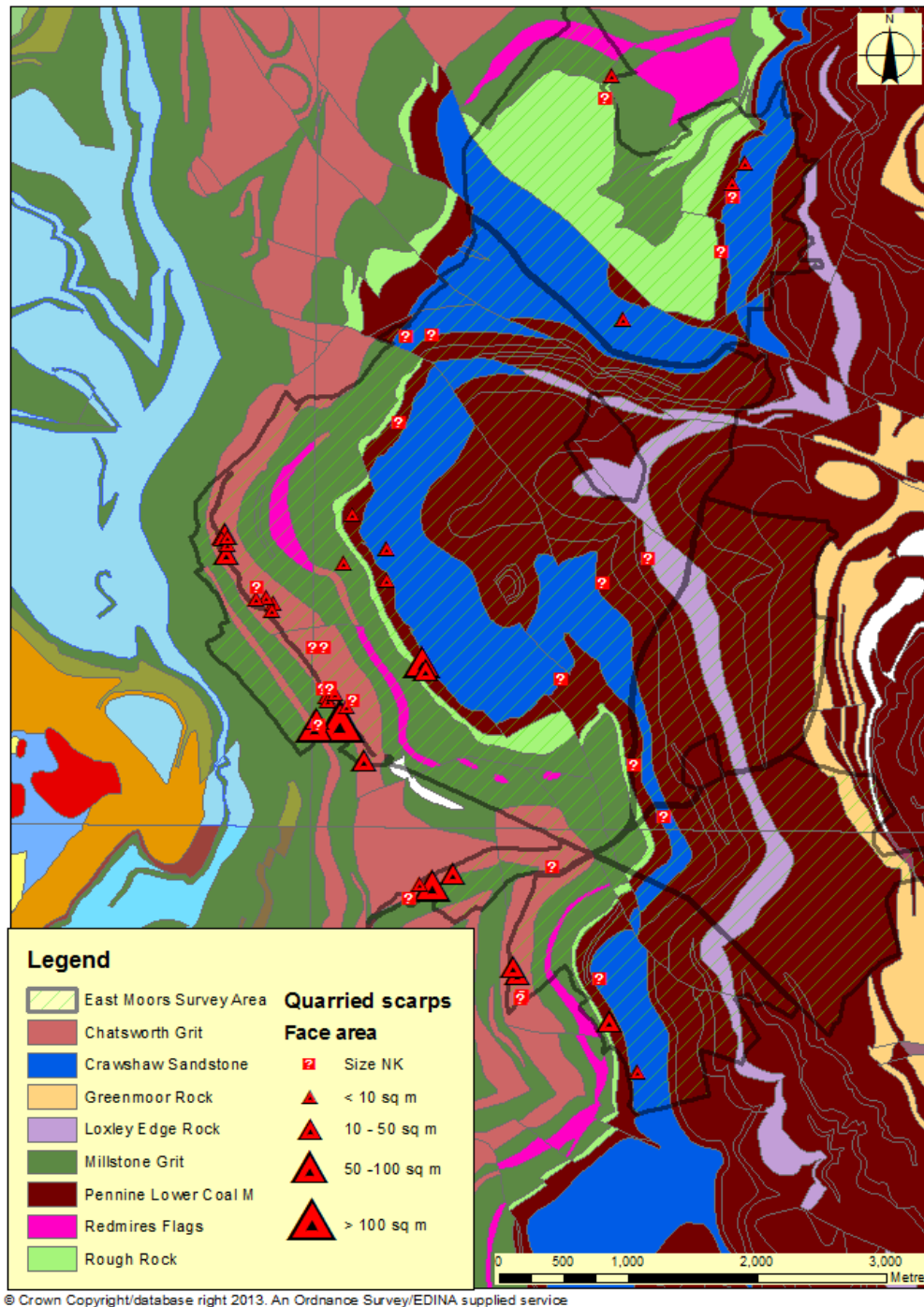
Surface Workings and 10m contour map of the study area



Map 12: Contour map of the survey area, showing locations of Surface workings by size.
Sources: Basemap - Edina (2014, Digimap contours shapefile); Feature distribution – EMSR (2011), after processing in author's new database to include new size data.

Maps

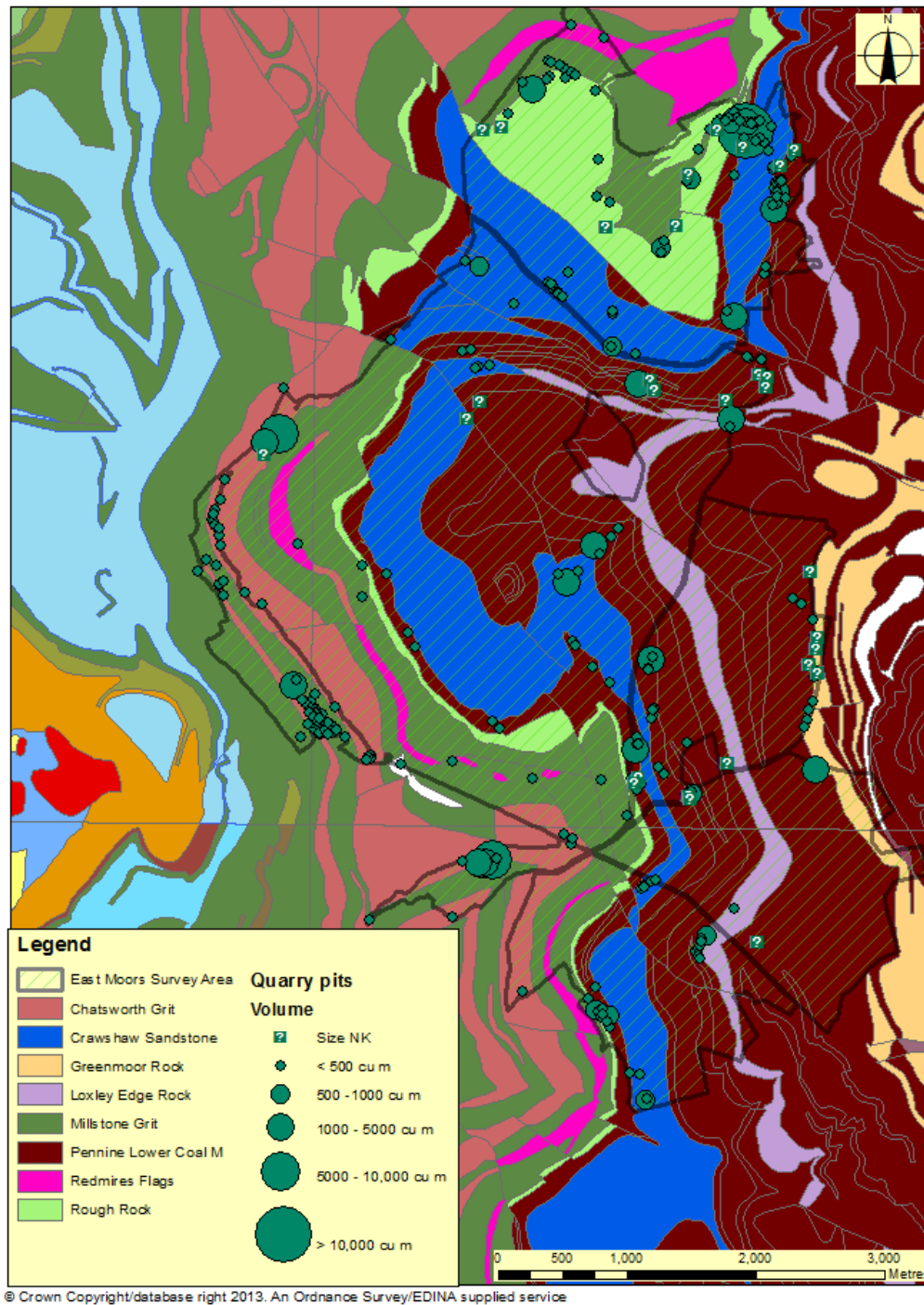
Quarried Scarps and geological map of the survey area



Map 13: Geological map of the survey area, showing locations of Quarried scarps.
Sources: Basemap - Edina (2014, Digimap geological map); Feature distribution – EMSR (2011), after processing in author's new database to include new size data.

Maps

Quarry Pits and geological map of the survey area

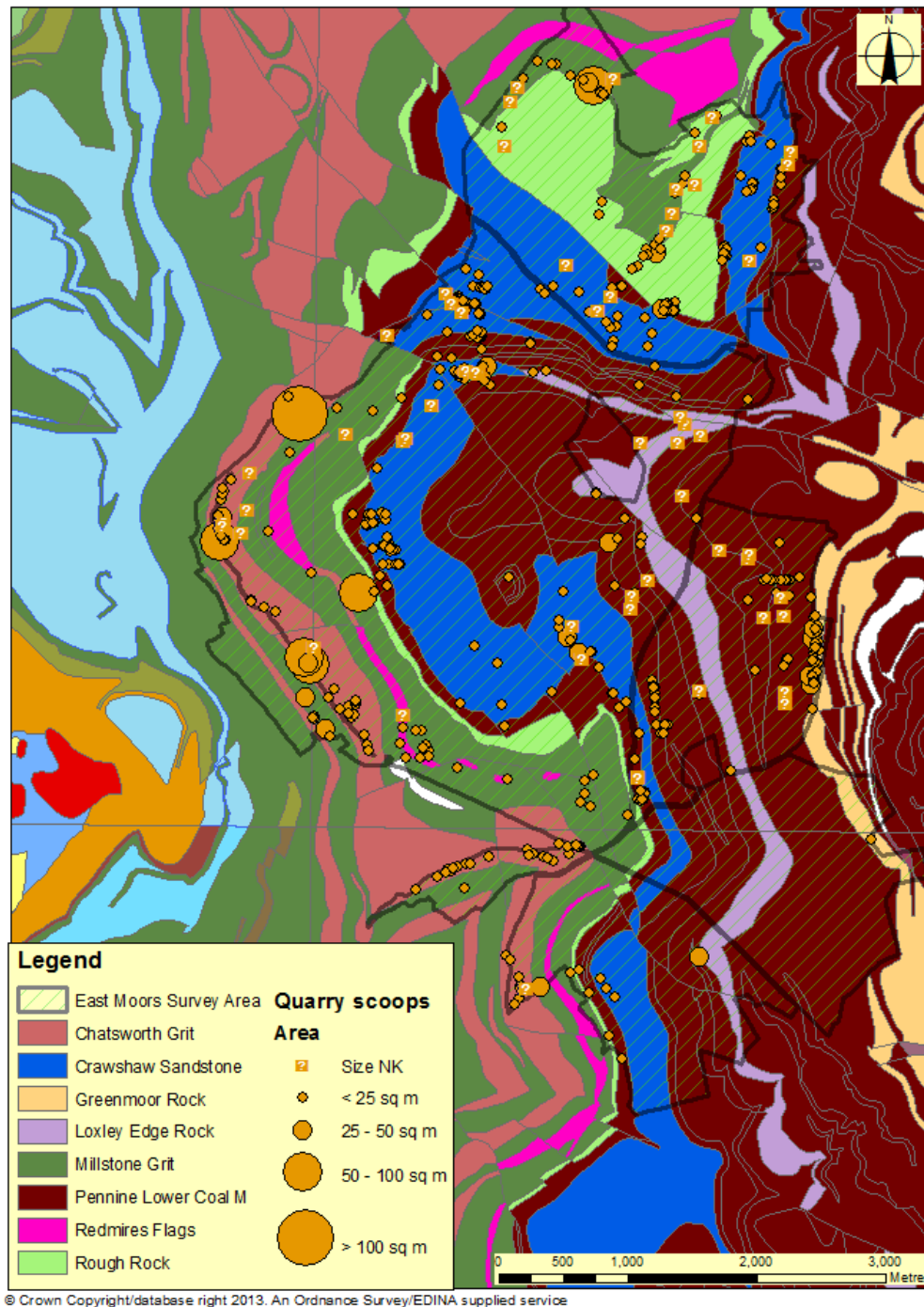


Map 14: Geological map of the survey area, showing locations of Quarry pits.

Sources: Basemap - Edina (2014, Digimap geological map); Feature distribution – EMSR (2011), after processing in author's new database to include new size data.

Maps

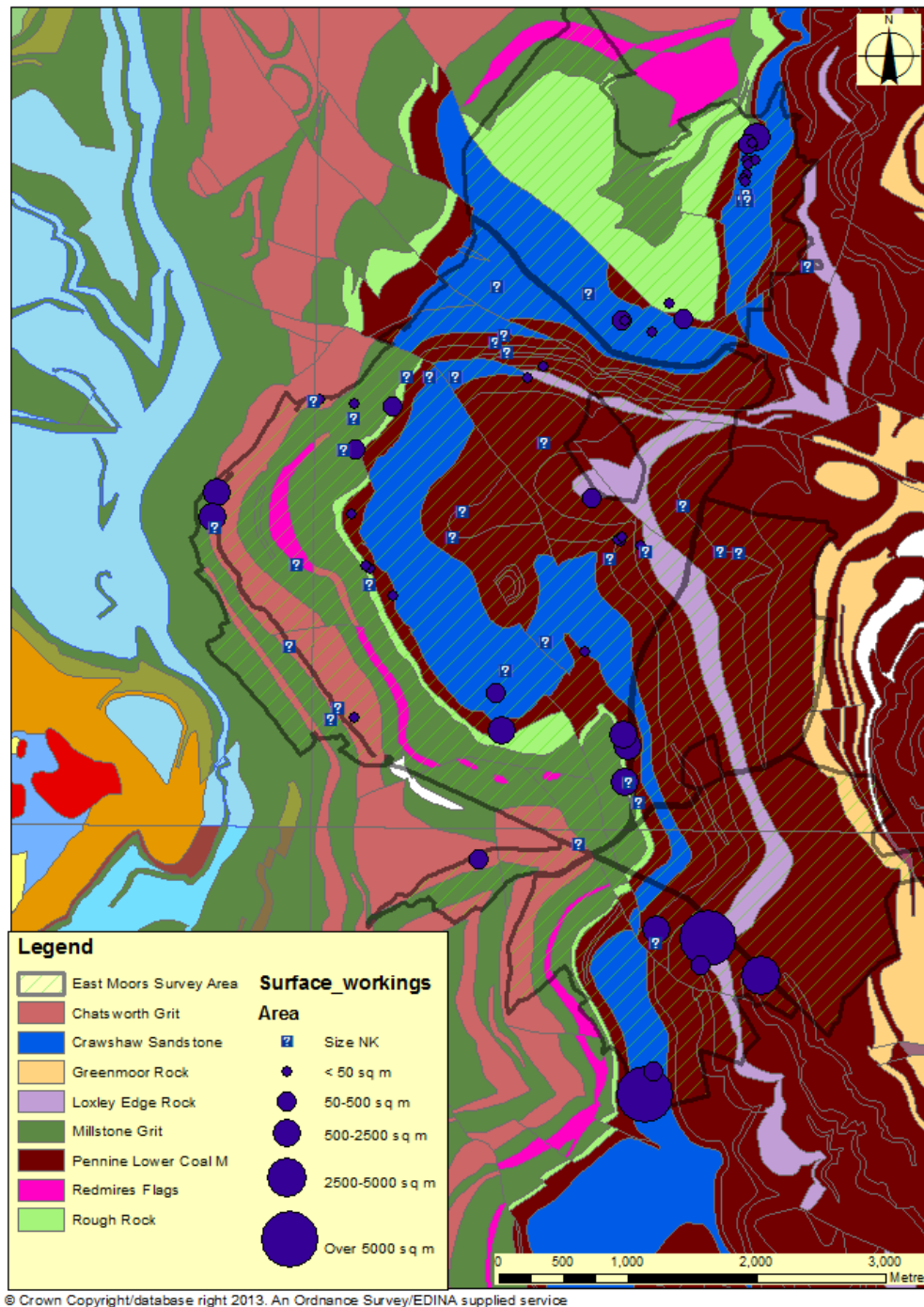
Quarry Scoops and geological map of the survey area



Map 15: Geological map of the survey area, showing locations of Quarry scoops.
Sources: Basemap - Edina (2014, Digimap geological map); Feature distribution – EMSR (2011), after processing in author's new database to include new size data.

Maps

Surface workings and geological map of the survey area

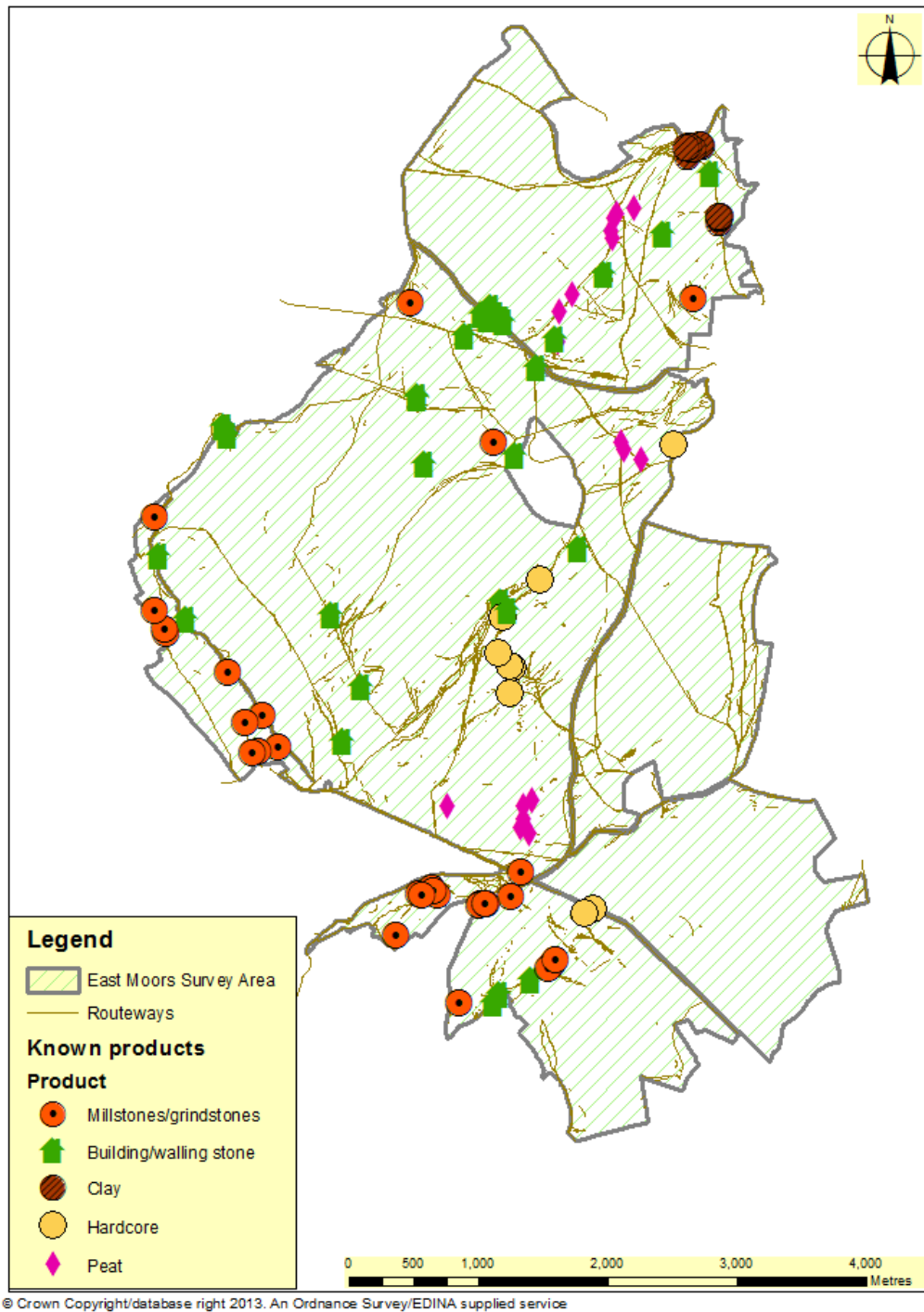


Map 16: Geological map of the survey area, showing locations of Surface workings.

Sources: Basemap - Edina (2014, Digimap geological map); Feature distribution – EMSR (2011), after processing in author's new database to include new size data.

Maps

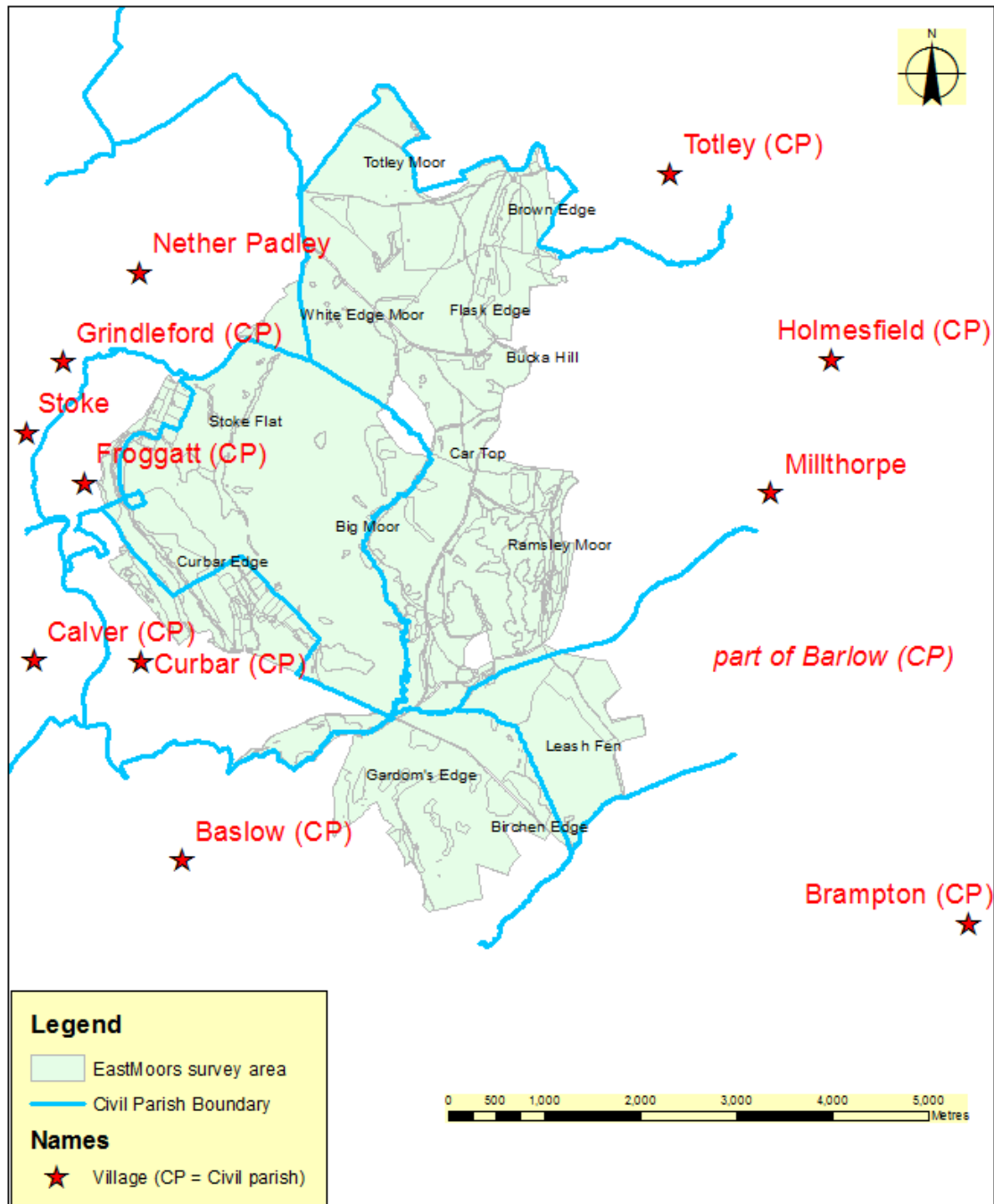
Known Products



Map 17: Features where the quarry product is known. *Sources:* Basemap - EMSR (2011). Product data - EMSR (2011) and author.

Maps

Civil Parishes (CP) and Villages around the survey area



Map 18: Civil parish boundaries and larger villages near the survey area. The central/western part of Big Moor is not in any parish. *Sources:* Basemap - EMSR (2011); Parish boundaries and village locations - Edina (2014, Digimap boundaries and OS 1:25000)