Silver Mining in England and Wales, 1066-1500

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Doctor of Philosophy

2003

Volume 1 of 2

Silver Mining in England and Wales, 1066-1500

Submitted by Peter Frederick Claughton, to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Economic and Social History, March 2003.

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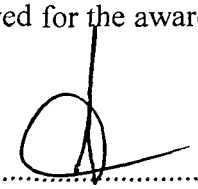

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Abstract

The increasing commercialisation of the economy during the late medieval period, 1066 to 1500, ensured a continued requirement for silver in coinage. Local sources of silver-bearing ores were exploited throughout the period; in the upland areas of England, adjoining parts of Wales and, later, in the South-West of England.

This thesis examines the role of silver in the economy, the nature of locally mined silver-bearing ores and their relationship to other mining activity in the period. The available evidence is interpreted to provide an estimate for the silver mined in the early part of the period, identifying significant production for the Northern Pennines in the 12th century. Better documentation from the 13th century onwards allows the output of silver from the Devon mines to be charted through to the end of the period.

The techniques and technology of silver mining, smelting and refining are explored, starting with the position prior to the medieval period. With the benefit of surviving records, principally those of the English Crown, the technology applied from the late 13th century is examined in some detail; including the relationship with the availability of labour, particularly its influence on the introduction of mechanisation in the latter part of the period. Ownership of the silver-bearing minerals and organisation of working, from regulation according to custom through to the direct involvement of the Crown are examined in detail, along with the move to entrepreneurial investment in mining. The status of the miners and the opportunity for dual occupation are also considered.

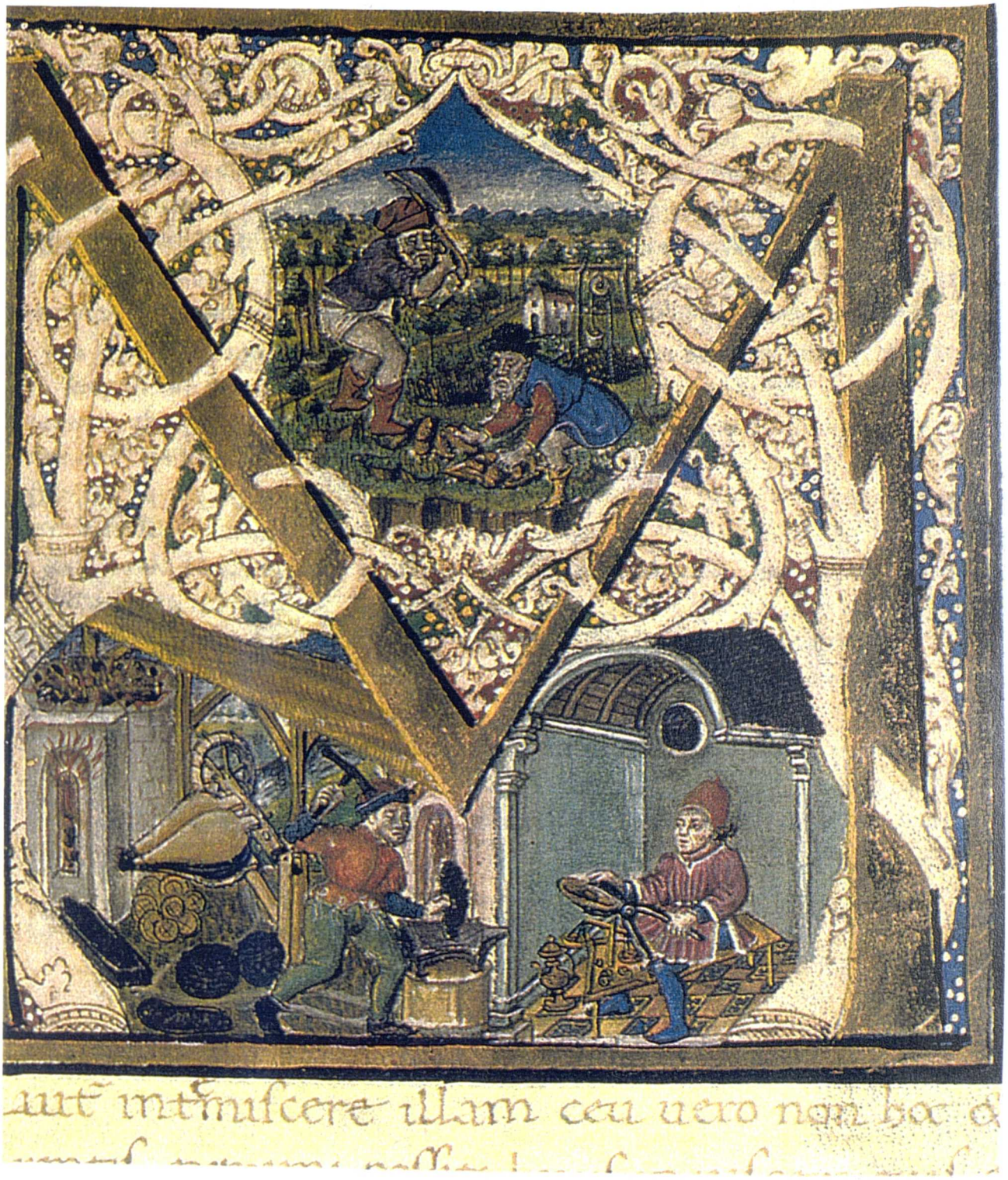

Figure 1

Miners (top) and the lead/silver smelting process (bottom left), mid to late 15th century.

Illuminated initial letter from Pliny the Elder, Historia Naturalis, Book XXXIII, On the properties of metals (National Art Library, MSL/1896/1504).

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Introduction

Since the end of the 17th century the United Kingdom as a whole has produced some 1145 tonnes of silver and, at its peak in the late 1860s, accounted for nearly 2% of world annual production. This output was derived as a secondary product from the smelting and refining of lead ores. The 95,500 tonnes of lead ore concentrate smelted and refined in 1869 produced 25.8 tonnes (802,457ozs) of silver and 74,400 tonnes of lead. With the former worth £208,980 and the latter £1,396,488, it is evident that silver was playing a supporting but not a leading role in the mining and processing of lead ores.[1] But was that the case in the period 1066 to 1500 ?

On recent historical evidence, the view has been that lead ores, particularly in the uplands including the Pennines, were low in silver and, whilst some might be produced on occasions, lead was of primary importance. Only in the south-west of England was there a historic legacy of silver production through the late medieval and into the early modern period.

> *Kings, princes, bishops, and other great landlords in the western part of Europe were not backward in encouraging prospectors. Where silver-bearing ores were discovered, as in Devon and Alsace, they were exploited as vigorously as in Central Europe.*[2]

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1 Merrill, *Silver Production*, p. 49; Ridgeway, *Silver*, Table 16; Schmitz, *Metal Production and Prices*, pp. 94, 146, 277 and 290. Burt, et al. *Devon and Somerset Mines*, p. xxi. In this thesis modern silver production is expressed in metric measure (tonnes or kilograms) or in Imperial measure (ounces avoirdupois), whereas production before 1500 is in Tower pounds (350 g), in ounces (at 12 to the pound), or in Marks (of 8 ounces). An exception is made in the case of figures for the silver yield before 1500 which are expressed in Imperial and metric measure (ppm) to allow for comparison with modern production (see Appendix 15 below).

2 Nef, 'Mining and metallurgy', p. 438.

How the relatively large sums paid for the *farm* of the 'mine of Carlisle', in the Northern Pennines, during the 12th century should be reconciled with low level silver production had not been answered satisfactorily. The evidence for production levels is examined below along with that for the technology employed and the organisation of mining. The development of silver mining is charted from the Conquest in 1066; from an industry working shallow deposits found across the uplands of Somerset, the Welsh border and the Pennines from Derbyshire to the Scottish border; to the exploitation of deep seated deposits in the south-west of England. During the period to 1500 silver mining was transformed from an artisanal industry, to a centrally managed operation utilising the latest technology. This thesis explores the processes which influenced that transition.

The place of silver in the history of non-ferrous metal mining in England and Wales has not been disregarded by earlier historians. They have, however, largely focused on its role in post medieval mining, particularly during the early modern period as the basis for monopolist rights and, later, in the late 19th century when it was seen as a supplement to lead production. In 1952 Nef provided the first comprehensive overview of metal mining in the medieval period.[3] He brought together the available evidence to make an assessment of the impact of mining on the European economy which leant heavily on the contribution made by the mining of silver-bearing ores. This was a significant turning point. Earlier authors had concentrated on specific metals or geographical areas. Tin was well served by the work of Lewis and Hamilton Jenkin.[4] Gough's work on the Mendip mines covered the working of silver-bearing lead ores in the medieval period.[5] He also touched on the role of silver in the opening up of mines in mid Wales in the 16th and 17th

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3 Nef, 'Mining and Metallurgy'.

4 Lewis, *The Stannaries*; Jenkin, *The Cornish Miner*.

5 Gough, *Mines of Mendip*.

centuries.[6] Most early works tended to be antiquarian in their approach, collecting together information but making little attempt to analyse and fit it into an overall view of the economy. As early as 1923 the techniques and processes employed in medieval non-ferrous mining and smelting were reviewed by Salzman, but he made little differentiation between those of the silver-lead and basic lead industries. This lack of clarity was perpetuated by Rees in 1968.[7] Salzman did later provide a detailed account of silver mining using primary sources from the limited period 1327 to 1337 as part of a larger survey of 'the English government at work', published in the United States, but it has been largely ignored by other historians of the subject.[8]

Since the 1950s there have been a number of regional histories of lead mining which have touched on the medieval period and silver bearing ores.[9] The only detailed study covering mining at a national level is Burt's study of the lead mining industry.[10] Whilst covering the mining of silver-bearing ores, it is confined to the period after the removal of the Crown monopoly in 1689/93. By that time silver extraction had become a mere adjunct to the lead industry. It does however place the industry in a national context, highlighting it as an important sector of the economy. Only two authors have examined British non-ferrous metal mining in the medieval period in detail. Hatcher has concentrated on tin mining and its trade, considering its relationship to the medieval economy.[11] Blanchard has focused his attention on lead in the medieval and early modern periods, particularly its

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6 Gough, *The Superlative Prodigal.*

7 Salzman, *English Industries*; Rees, *Industry before the Industrial Revolution*, inadequate footnotes and referencing make this a difficult secondary source to use.

8 Salzman, 'Mines and Stannaries'.

9 For example, Raistrick and Jennings *Lead Mining in the Pennines*; Lewis, *Lead Mining in Wales*; Kirkham, *Derbyshire Lead Mining.*

10 Burt, *The British Lead Mining Industry.*

11 Hatcher, 'A diversified economy'; Hatcher, *Rural Economy*; Hatcher, *Tin Production and Trade.*

relationship to copper/silver production in continental Europe during the latter period.[12] Some of Blanchard's work on the mining of silver-bearing ores in England in the 15th century was incorporated in his monograph on international lead production and trade.[13] The mining and processing of silver-bearing ores, from the Northern Pennines in the 12th century, were addressed in two articles.[14] His most recent work on mining, metallurgy and minting is contained in his volume on Afro-European production in the 12th and early 13th centuries.[15] The issues he raises regarding silver production, and the mining and processing of agentiferous lead and tin ores, are considered below.[16]

Historians with an interest in bullion supply and its relationship to the medieval economy have also touched on the mining of silver in Europe. Spufford, in particular, mapped the major sources of newly mined silver in his major work on money in medieval Europe.[17] His emphasis is on continental Europe as the major source of supply. This interpretation is continued in his latest work, where he makes no reference to sources in England beyond briefly acknowledging the unique involvement of the English Crown in the late 13th century.[18]

In the 1970s Hatcher and Blanchard began a debate about the structure of non-ferrous metal mining which focussed particularly on the evidence for dual occupation and the transition to industrialisation from the latter part of the medieval through the early modern

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12 Blanchard, 'International Bullion Crisis'; Blanchard, 'Resource depletion'; Blanchard, 'The British silver-lead industry'.

13 Blanchard, *Lead Production and Trade*.

14 Blanchard, 'Lothian and beyond'; Blanchard, 'Technical implications'.

15 Blanchard, *Afro-European Supremacy*, (part of a 4 volume work, of which 3 and 4 have yet to be published).

16 See, in particular, Chapter 3, Section 2.1, Chapter 4, Section 3, and Chapter 6, Section 2, of this thesis.

17 Spufford, *Money*.

18 Spufford, *Power and Profit: The Merchant in Medieval Europe*.

period. Following on their work economic historians, Burt in particular, have looked at the non-ferrous metal mining in much the same terms as the early textile industry. They have identified a multiplicity of small scale operations and evidence for proto-industrialisation.[19] Both Kiernan and Wood have countered this with evidence for substantial capital investment in mining, employing a full time labour force, in the Peak District of Derbyshire by the middle of the 17th century.[20] The relevance of dual occupation, and the concept of proto-industrialisation, to silver mining is considered further in Chapter 6, Section 5.5, of this thesis.

The processing, smelting and refining, of silver-bearing ores has suffered from a similar lack of attention, particularly when compared with the ferrous sector.[21] Kiernan's recent work comes closest with a detailed examination of the historical evidence for the technological changes affecting lead smelting in the first part of the early modern period.[22] Unfortunately little archaeological work has yet been carried out on early lead smelting sites and virtually none on those related to silver-lead.[23] Assumptions about the smelting of silver-bearing ores, based on the view that they share a similar ore base with the primary lead industry, have ignored the complexity of some of those ores. This thesis therefore provides a detailed assessment of developments in the smelting of silver-bearing ores in Chapter 4, Sections 4.8 and 4.9.

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19 Blanchard, 'The miner and the agricultural community'; Blanchard, 'Rejoinder; Stannator Fabulosus'; Blanchard, 'Labour productivity and work psychology'; Hatcher, 'Myths'; Gill, 'Mining and proto-industrialisation'; Burt, 'International diffusion'; Burt, 'Transformation'; Burt, 'Proto-industrialisation'.

20 Kiernan, *Derbyshire Lead Industry*; Wood, *Politics of Social Change*.

21 Craddock, *Early Metal Mining and Production*.

22 Kiernan, *Derbyshire Lead Industry*.

23 Cranstone, David. 'Conclusions: the way forward'; Hamilton, *Assessment of Early Lead Working Sites*.

Overall the published, and unpublished, work on silver mining in England and Wales between 1066 and 1500 can be best described as fragmentary. Many authors have touched upon the subject but none has examined it in its entirety or set it in the context of the medieval economy. In providing an overview of the industry during that period, focusing on the issues which are relevant to its development, this thesis fills a significant gap in the historiography of non-ferrous metal mining.

Most medieval history has been written from a non-economic perspective and those economic historians who have studied the period have largely concentrated on the agricultural sector. The history of medieval industry has not been ignored and the historiography of lead mining has been referred to above. Hatcher has produced the authoritative work on early coal mining, bringing together many threads of research to provide a clear analysis of the industry.[24] A history of the medieval iron industry was written by Schubert in 1957 and its development has been re-examined by a number of authors since that date including Cleere and Crossley.[25] These are referred to below in Chapter 1, Section 4; but it is the export industries which have attracted most attention. Hatcher's contribution on mining and the trade in tin has been touched upon above (p. 13) and is considered further below.[26] Whilst the subject of tin has not been revisited on that scale by historians, the archaeologists, particularly Gerrard, Greeves and Austin, have expanded our understanding of its mining and processing using the field evidence.[27]

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24 Hatcher, *Towards the Age of Coal.*

25 Schubert, *Iron and Steel.* Crossley, 'Medieval iron smelting'. Cleere and Crossley, *The Iron Industry of the Weald.*

26 See Chapter 1, Section 4.2.

27 Gerrard, *The Early British Tin Industry.* Greeves, 'The Devon tin industry'. Austin et al., *Tin and Agriculture in the Middle Ages and Beyond.*

Most medieval industrial history has, however, concentrated on wool and textiles, which dwarfed all other sectors in employment, value of output and exports. Carus-Wilson and Coleman focussed on those industries in their analysis of the export trade in 1963 and one has only to look at the bibliographies in the major works on the medieval economy to see the breadth of recent research into the subject.[28] It is the strength of both wool and cloth exports, and their ability to draw continental silver into the English economy, which is of importance to the subject of this thesis. When, in 1982, Bridbury stated that '*The early history of clothmaking is buried in irretrievable obscurity. Only scattered references to clothmaking survive from the period before the thirteenth century*', he might have included wool growing and their export trade.[29] Quantifying the level of exports prior to the availability of statistical evidence from the regular levy of customs duties after 1275 is a difficult, near impossible, task. The evidence for exports, in the 13th century and earlier, has been presented by Lloyd, Chorley and others, and both Harvey and Nightingale have related those exports to the quantity of silver entering the English economy.[30] This high value export trade is considered to be the major source of silver entering the English economy. Domestic supply was assumed to be insignificant. This thesis will, however, show that silver from mines in England and Wales could sometimes be quite important.

Silver had a significant role to play in the late medieval economy, an economy which was increasingly dependent on money and trade.[31] This needs to be considered alongside the sources of supply and the geological conditions which determine access to newly mined

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28 Carus-Wilson and Coleman, *Export Trade*. See for example the bibliographies in Miller and Hatcher, *Towns, Commerce and Crafts*, or Bolton, *Economy*.

29 Bridury, *Medieval English Clothmaking: An Economic Survey*.

30 Lloyd, *The English Wool Trade in the Middle* Ages. Chorley, 'English Cloth Exports'. Nightingale, 'The Evolution of Weight Standards'. Harvey, 'The English Trade in Wool and Cloth, 1150-1250'.

31 Britnell, *Commercialisation*, pp. xiii-xvi.

silver in England and Wales. Mining of silver was not carried out in isolation from other minerals and the development of other mining sectors is briefly outlined in the closing sections of the first chapter. An account of the documentary sources available for a history of silver mining is given in the following chapter. Those sources are then combined with secondary evidence to assess the scale of production and determine the relative influences on the progress of mining in three key areas, technology, ownership, and organisation.

On the question of production it is argued that silver from the Northern Pennine mines in the mid 12th century, although difficult to quantify, made a significant contribution to the supply of silver in the English economy. This is considered against the debate on late 12th / early 13th century inflation, recently joined by Latimer.[32] Output from the Devon mines in the two centuries after 1292 is much easier to quantify but, at lower levels and with a markedly higher circulation of coin, failed to have the impact of that from the Northern Pennines 150 years earlier. The real impact of the Devon mines was in the precedent set for the operation of an important sector of non-ferrous mining from the end of the medieval through and into the modern period.

An extensive range of techniques are shown to have been used in mining across Europe by the beginning of this period. How those techniques were employed in silver mining is an issue addressed in this thesis. The use of mining, and smelting, techniques is investigated against a background of demographic and organisational changes. New, and reintroduced, technology is considered in the light of current views on diffusion and the presumed dominance of central European mining in the technological base available to

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32 Latimer, 'English Inflation'.

the industry. In doing so, this thesis contributes to the debate touching on the technical competence of English non-ferrous metal mining in the immediate post medieval period.[33]

The role of the English Crown is a key issue in the development of silver mining during this period, 1066-1500. It is demonstrated below that the transition to centrally managed capital intensive operations hinged on ownership and the organisational changes initiated in the 13th century. It was these changes which, from the late 1290s, permitted the industry to utilise the technology necessary for deep mining. This was achieved with the financial and organisational backing of the Crown during a fifty year period of direct working when control of mining was removed to central authority. Its subsequent retreat from direct involvement brought with it further changes in management and conditions: the introduction of external finance and the application of innovative technology which were to influence the development of non-ferrous mining over the next three to four hundred years.

What effect did the organisational changes have on the workforce in silver mining? Under the Crown, and subsequently their lessees, the workforce was increasingly reliant on management for employment in this sector of mining. The possible proletarisation of the workforce is therefore considered in the light of reduced opportunities for dual occupation and links with agriculture, particularly as men were pressed into service from other mining fields.

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[33] Burt, 'International diffusion'; Burt, 'Transformation'.

Chapter 1.

Silver Mining in Context.

1. Silver in the economy

The properties of silver metal, its purity, lack of taint, and its resistance to corrosion, meant that it was valued for use in decorative work and as high quality tableware. Those properties also led to silver, along with gold, being ordained for spiritual use. By the 14th century most churches possessed a silver chalice for the celebration of mass. The upper echelons of medieval society were also increasingly using silver tableware.[1] However, although used widely for such purposes in the period 1066 to 1500, it was through its use in coinage that the supply of silver had its greatest effect on the English economy. In the late medieval period England had perhaps the most stable currency in Europe, based on high quality silver.[2] A growing use of cash transactions during the medieval period meant that silver had an increasingly important role to play in the economy. The availability of silver has traditionally been explained in terms of receipts from the export of wool.[3] This, however, ignores the supply of locally mined silver which was, at times, probably large enough to have an impact on the economy, national and local. In England and Wales, in the period under consideration, the silver came from argentiferous lead ores which were smelted and the resulting metal refined in a cupellation hearth, using charcoal as fuel, to isolate the precious metal.[4]

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1 Glanville, *Silver*, p. 7; Hatcher and Barker, *British Pewter*, pp. 25-27 and 60-61.
2 See pages 21-22 below.
3 For example Prestwich, 'Edward I's monetary policies and their consequences'.
4 For a full description of the smelting and refining processed see Chapter 4 below.

The late Anglo-Saxon period is characterised by the growing use of coin in commercial transactions. The use of coin had been abandoned in Britain after the departure of the Romans.[5] After its tentative reintroduction in the 7th century the quality of English coinage rapidly improved. From Offa's reforms of the 8th, through to the 10th century that coinage was based on good quality silver. Pennies of Aethelred's reign averaged around 20 grains of 92% silver.[6] This quality was maintained, with occasional lapses of only short duration, throughout the medieval period. The increased use of coin is marked by a growth in the number of mints, from 37 active in the mid 10th century, growing to over 75 in the period immediately prior to the Conquest in 1066.[7] Although there were concentrations of mints close to the Channel ports and around Mendip, the spread was such that the majority of the population of England, south of the Wash, was within a short distance of a mint. The frequent recoinages of the late Anglo Saxon period were continued by William after the Conquest. He also retained a firm royal control over minting with its associated profits.[8] In the early 12th century Henry I increased central control by reducing the number of mints as a means of combating forgery and adulteration. He also strengthened the established standard for coinage by setting a new slightly higher weight for the penny at 22 grains of silver.[9] The penny was the standard English silver coin through the late medieval period. It was minted at a rate of 240 to the pound of silver in the mid 13th century, rising to 450 to the pound by 1500.[10] This rate of debasement was remarkably low when compared with continental European currencies

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5 Spufford, *Money*, p. 9.
6 Metcalf, 'The Ranking of Boroughs, Appendix II, p.205.
7 Spufford, *Money*, Maps 10A and 10B.
8 *Ibid.*, p. 94.
9 Blackburn, 'Coinage and Currency under Henry I: A Review'.
10 Craig, *The Mint*, App. 1. The Tower pound of 5,400 grains (*Ibid.*, p. 102).

such as the *sous or denier tournois* of France which deteriorated from 80 to the pound sterling in 1204 to 220 to the pound in 1299.[11]

During the disruption of Stephen's reign the control of minting arrangements broke down. Mints were established outside of crown control and the occupation of the northern border counties by the Scots gave them the wherewithall for a separate currency. The accession of Henry II (1154) and the withdrawal of the Scots brought a return to Crown control over minting in England. His reign was marked by a further reduction in the number of mints, a movement continued by subsequent English kings. There was also a drastic reduction in the frequency of recoinage from an average of every 1.8 years during the early part of Henry I's reign.[12] This ran counter to moves in some continental European states, such as Bohemia, where princes sought to boost revenues by increasing the frequency.[13] Thereafter English coin was 'immobilised', produced for long periods and renewed only when found to be defective through wear and tear or the influx of foreign coin.[14]

The amount of silver coin in circulation in the late 12th century is difficult to gauge. Mayhew suggests a figure of around £250,000 by 1205 (see Fig. 2 below). Bolton cites the 'massive' amount, £60,000, raised by taxation in 1207 as an indicator of the large amount of coin available at that period.[15] An increased flow of silver into the English economy is in evidence in the latter part of the 12th century as commodity prices began to

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11 Spufford, *Money*, p. 209. See also *ibid.*, p. 295, Table 5, for the long-term changes in twelve major currencies 1300-1500.

12 Blackburn, 'Coinage and Currency', p. 152.

13 Chibnall, *Anglo-Norman England*, pp. 88-9 and 101; Spufford, *Money*, pp. 94-5; King, 'Introduction', p. 25-6.

14 Spufford, *Money*, p. 95.

15 Mayhew, 'Money and Prices', p. 125, Table 1; Bolton, 'Inflation', p. 5. Also see Allen, 'Currency' and Fig. 11 below for a range of estimates on the volume of currency.

rise. Harvey noted a combination of rising prices, wages and the growing prosperity of the boroughs rather than a disproportionate rise in the price of foodstuffs. This led him to conclude that the inflation of circa 1180 to 1220 resulted from increased monetary supply rather than from demographic pressure, the demand for land and poor harvests.[16]

If we are to accept that the inflation was driven by an increased supply of silver then we must consider the source of supply. Recent writers, whilst more inclined to accept that an increase in money supply contributed to inflation in the late 12th century, have still regarded it as an external influence. Spufford notes a gradual increase in the amount of

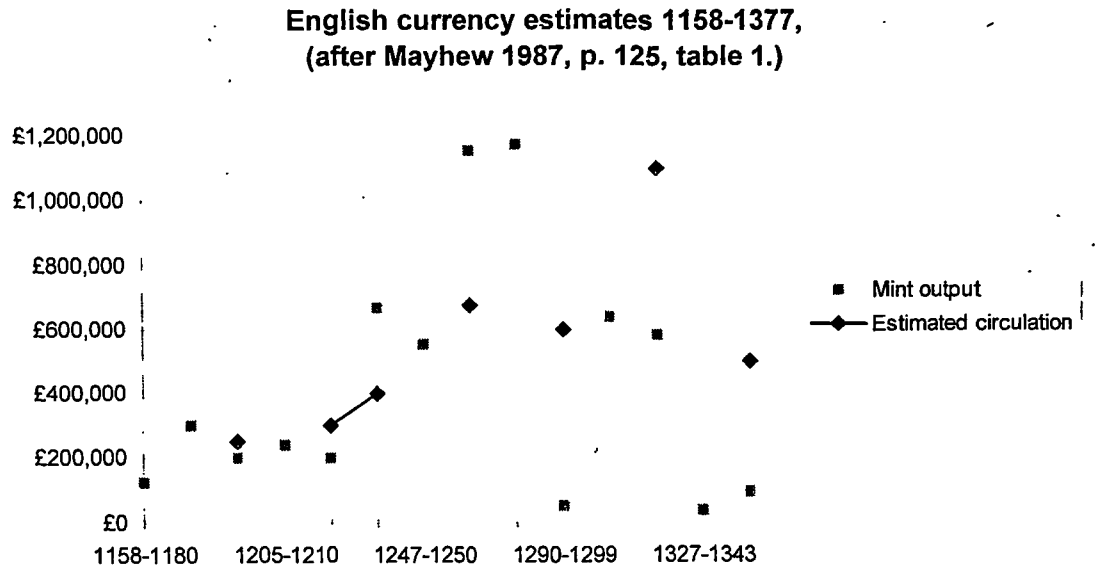

Figure 2 (based on data in Mayhew, 'Money and Prices', p. 125, table 1.)

coin minted after 1160, accelerating from 1180 onwards to six to eight times previous levels. More coin being produced than the economy could absorb. A major source of that

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16 Harvey, P. D. A., 'English Inflation'. See also Allen, 'English currency'.

increase is seen as imported, newly mined, silver from the continent.[17] That view is supported by Nightingale in her assessment of the evolution of the pound Sterling and the silver penny as the English units of account and exchange.[18] She maps out a route for German silver imports into England in the 11th and 12th centuries. The low level of minting activity in Flanders suggests that the Flemings were paying for English wool with silver in bar form. Silver which was obtained through trading links between the Meuse valley metal industries and the German mining region of the Harz. However, as that trade had been established for a century or more before the rapid inflation of the late 12th century, it still remains possible that the increase in coinage was initiated by a home based production of silver.

Those trading links with the Low Country were the major source of silver noted by Henry of Huntingdon.

> *'Britain is also rich in metallic veins of iron, tin and lead. Some of these contain silver also, though not so commonly; silver, however, is received from the neighbouring parts of Germany, with which an extensive commerce is carried on by the Rhine in the abundant produce of fish and meat, as well as fine wool and fat cattle which Britain supplies, so that money appears to be more plentiful there than in Germany itself, and all coins introduced into Britain by this traffic are of pure silver.'* [19]

Huntingdon draws to a large extent on the writings of Bede but the above appears to be based on contemporary experience and, as he wrote in the early 12th century, before an

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17 Spufford, *Money*, pp. 196-7 and 244. His supporting examples are, however, dated from the early to mid 13th century.

18 Nightingale, 'The Evolution of Weight Standards'.

19 *The Chronicle of Henry of Huntingdon*, p. 2.

increase in silver production from the Northern Pennines was widely known. According to Robert of Torigini that increase occurred between 1130 and 1135, shortly before the Scots occupied the border counties.[20] Control of the mines in Tynedale - the 'mine of Carlisle' - and the mint at Carlisle then passed to the Scottish king until recovered by Henry II in 1157. There is then evidence, based in a rapid increase in the farm of the mine, for a further peak in production from the Northern Pennines in the 1160s.[21]

Blanchard has already suggested a substantial output of silver for this period, over 16 tonnes of silver per annum for Durham alone at the peak of production in the 1160s.[22] The effects of such a large output would have been considerable, particularly when it is set against Mayhew's estimate of coin in circulation which amounted to only 87.5 tonnes of silver.[23] This thesis, however, provides a much lower but nevertheless significant estimate of output which in contributing to an increase in money supply should be considered amongst the causes of the inflation evident in the period 1180 to 1220. Harvey, drawing on the work of several researchers, pointed out that the inflation was confined to England and continental Europe was unaffected, even in Normandy with its close links to the English Crown. Spufford, however, notes a general rise in prices across Europe and links this to increased output from central European silver mines in the late 1160s. Also, Latimer now points to the greatest inflationary effect in England being felt in the early years of the 13th, rather than the late 12th, century and links it to the release of large

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20 *Eulogium*, vol. III, p. 64; *Chronicles of the Reigns of Stephen, Henry II and Richard I*, vol. IV, p. 123.

21 For estimates of production from the Northern Pennine mines in the 12th century, see Chapter 3, Section 2.3, below.

22 Blanchard, 'Lothian', p. 30, fig 2.1 and *Afro-European Supremacy*, p. 600, fig. 2.2.

23 See Fig. 2 above.

money-holdings in the face of doubts over the future value of the coinage.[24] The possible contribution of Northern Pennine silver to increased money supply, and the availability of silver coin to be hoarded, is considered further in Chapter 3 below.

Miller and Hatcher are, however, more sceptical, seeing a release from restraints imposed by custom and a possible increase in population as contributory factors in the late 12th / early 13th century inflation.[25] They explain the continued increase in prices, at a much slower rate, over the following century primarily as a consequence of an increased flow of bullion received in exchange for the export of wool and metals. Those price increases were, however, accelerated in the crisis years of the 1310s by poor harvests.[26]

A simple monetary explanation is not available for the downturn in prices after 1320. For some observers this, and the abandonment of arable land in some parts of England, is seen as evidence for a gradual fall in population levels in the three decades to 1348.[27] Exports of wool appear, on fragmentary evidence, to have initially fallen but recovered by the 1330s.[28] Production of tin, a principal export metal, increased significantly, in excess of fifty percent, between 1320 and 1348 although Derbyshire lead production, which had reached a minor peak in 1300, gradually declined to the 1340s.[29]

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[24] Harvey, 'English Inflation', p. 26. Spufford, *Money*, pp. 243-6. Latimer, 'English Inflation'.

[25] Harvey, 'English Inflation', pp. 16-18; Miller and Hatcher, *Rural Society and Economic Change*, p. 69.

[26] *Ibid.*, pp. 64-69

[27] Bolton, *Economy*, pp.190-2. For an illustration of the range of estimates of English population at this period see Hatcher, *Plague*, p. 71, fig. 1.

[28] Carus-Wilson and Coleman, *Export Trade*, p. 122.

[29] Blanchard, 'Derbyshire lead production', p.125; Hatcher, *Tin Production*, App. A, p. 156, based on tin coinage for Cornwall only. See Section 4 below for further detail on trends in non-ferrous production.

Any monetary benefits from exports were more than negated by the increasing drain on the economy caused by the expenditure of Edward III on warfare. Within two years of the outbreak of hostilities with France, in 1337, the king had already borrowed at least £300,000 towards the cost of the war in addition to that raised through parliamentary grants of taxation.[30] In the late 13th century, Edward I had pursued an equally aggressive foreign policy, perhaps not on the same monetary scale as his grandson but still requiring the export of some £350,000, largely in coin, in 1294-8. This was done without initiating a prolonged period of deflation although the exports amounted to nearly threequarters of the silver minted in the recoinage of 1279-81, at the beginning of his reign. The vacuum created was quickly filled by an increase in the circulation of foreign coin and legislation in 1299 sought to re-establish control over the currency. Action which culminated in a partial recoinage of the following year when £262,000 was minted, largely from foreign coin. As with previous re-coinage the quality of the specie issued encouraged further imports as foreign merchants sought to exchange foreign silver for sterling.[31] The period of deflation which affected the first half of Edward III's reign was marked by a much reduced stock of coin. Wartime expenditure was compounded by an exchange rate which favoured the export of silver and no recoinage was ordered to rectify the situation. Minting levels were at their lowest level for nearly two centuries.[32]

Edward's interference in the wool trade, with a view to increasing revenue, hindered the recovery of the export trade already hampered by high livestock mortality rates. Losses of sheep, resulting from the morrains following on the poor harvests in the decade prior to

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30 Bolton, *Economy*, p.195-6.

31 Prestwich, 'Edward I's monetary policies', pp. 407 and 411-3.

32 Craig, *Mint*, App. 1; Mayhew, 'Money and Prices', p. 125, Table 1 (see Fig. 3 below).

1322, had perhaps a greater short term impact than that amongst the human population.[33] The assumption by antiquarians that silver mined in Devon financed the wars of both Edward I and II, is invalid. The contribution they made is dwarfed by the cost of the conflicts and thus the amount of coin in circulation had fallen considerably by mid-century.[34]

The position of silver in the economy was also altered by the introduction of the first English gold coin minted on a regular basis in 1344. The move to an English currency based on gold was the culmination of a long term metallic imbalance between Europe and the Arab world. For a century and a half the demand for silver in the Arab world had created a disparity in exchange rates that encouraged an underlying shift of silver stocks south and east of the Mediterranean, with gold moving north and westwards in return.[35] A growing stock of Hungarian gold was already circulating in north-western Europe in the 1330s and Edward had used gold, 1.5 million florins borrowed from Florentine merchants, to subsidise his allies in the war against France.[36] Gold increasingly reached England as merchants substituted florins for the silver ingots used in wool purchases, particularly as the value of gold was set higher in England than on the continent. At a ratio of 1:12, gold to silver, gold was of only minimal use in most commercial transactions. Nevertheless gold coins continued to be minted at total values far greater than those for silver, Fig. 3 below. Initially they were based on the leopard, a florin sized piece, but later the noble, equivalent to the double leopard and valued at 6s. 8d. sterling,

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33 Miller and Hatcher, *Rural Society and Economic Change*, p. 60; Bolton, *Economy*, pp. 180-206.

34 Britnell, *Commercialisation*, pp. 179-80 and Table 5. See Chapter 3, Section 2 for further discussion.

35 Spufford, *Money*, p. 272, Graph II.

36 *Ibid.*, p. 277-8.

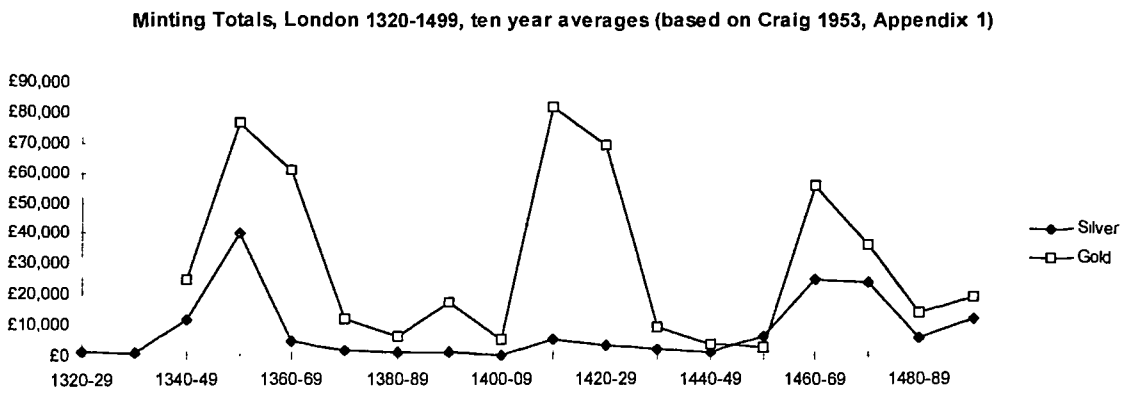

Figure 3 (based on data in Craig, *Mint*, appendix 1.)

became the standard English gold coin through to the end of the medieval period.[37] Thereafter gold was increasingly singled out as the object of mineral searches.[38]

The drastic fall in population resulting from the Black death of 1348-9 and the subsequent recurring outbreaks of plague marked a significant turning point in the English economy. Stocks of silver and gold continued to have an effect on the economy but the underlying influences over the next two centuries were population levels and the demand for land. By 1400 the English population was between 45 and 51 per cent of its level in 1348.[39] Despite high mortality the agricultural economy initially displayed surprising buoyancy. Sufficient people survived to occupy the land left vacant by those who died in the plague and little land was taken out of cultivation on a permanent basis prior to 1400. Initially there were rises in both commodity prices and wages reflecting a shortage of manpower. However, a combination of legislation, the Ordinance of Labourers of 1349 and the Statute of Labourers of 1351, and renewed production contributed to their stabilisation. At

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37 Craig, *Mint*, pp. 64-73.

38 British Library (henceforth BL) Add Mss 24513; *Issues of the Exchequer, Henry III to Henry VI*, p. 205.

39 Hatcher, *Plague*, p. 71, Fig. 1.

the recoinage of 1351-56 there was between £500,000 and £700,000 in circulation. This restored the balance in money supply and there were signs of increased spending. The industrial sector had a mixed experience. Mining activity in particular was disrupted.[40] Production of tin fell drastically but recovered to unprecedented levels by 1400. Both lead and silver production failed to recover to earlier levels.[41] Expansion in English cloth production during the first half of the 14th century had already allowed it to replace imports. After 1350 exports of cloth grew steadily to replace wool as the largest export earner by the end of the century.[42] Exports drew increased amounts of gold into the money supply as shown in Fig. 3 above. With the smallest gold coin valued at 1s 8d, equal to five days wages for unskilled labour, this presented problems for local commercial transactions.[43]

A continuing decline in the population beyond the end of the 14th century is evident as the area of land under cultivation contracted. Agricultural activity withdrew to the better land and commercial farming declined. In some areas there was gradual shift to pastoral (sheep) farming as a labour saving device to utilise unproductive land rather than a move to increase profits. For landlords maintaining income was largely a matter of good management and location. Landlords, like Sir John Fastolf at Castle Combe in Wiltshire, who promoted the textile industry found that it could provide profits for lord and tenant alike. Increased tin production provided benefits for the economy of the far South-West,

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40 See Section 4 below.

41 See Chapters 3, Section 3, and 4, Section 5 below for further discussion.

42 Britnell, *Commercialisation*, p. 180, Table 5; Miller and Hatcher, *Towns, Commerce and Crafts, 1086 - 1348*, p. 410-1; Carus-Wilson and Coleman, *Export Trade*, pp. 138-9; Hatcher, *Tin Production*, App. A; Blanchard, 'Lead production', p. 127.

43 Britnell, *Commercialisation*, p. 179. For similar rates paid in silver mining see Public Record Office (henceforth PRO) *Exchequer Accounts*, E101/266/25, Counter roll of Robert Courte and John Hays on the account John Fogge knight, ... silver mine of Bereferrers ... 10 July 20 Edward IV to 10 July 21 Edward IV.

stimulating the market for agricultural produce. These were just part of the long term shift in wealth to areas of industrial activity, particularly in the south and west of England. However, as Hatcher has shown, the overall trend to 1500 was punctuated by periods of poor performance in most sectors of the English economy.[44] These depressions were in part triggered by deficiencies in the supply of bullion, particularly the supply of silver.

The shortage of silver from the late 14th century through to the third quarter of the 15th century was not a peculiarly English problem. Minting of silver dipped to low levels across Europe in 1395-1415 and again in 1440-50 as mine production declined. Inevitably the shortage encouraged renewed searches for new silver-bearing resources or means of extending the life of known deposits. Scarcity was exacerbated by hoarding as men were reluctant to spend what they could not replace. Some bullion might be converted to plate for the same reason, thus taking coin out of circulation, although Britnell suggests that such a tendency was no greater in the 15th than it was in the 13th century.[45] The recoinage of 1421-22 and legislation in 1429-30 requiring full payment in bullion for all wool exports only improved the English money supply temporarily. With a shortage of bullion in continental Europe the legislation only served to disrupt the wool trade. This, combined with the interference to trade from warfare, resulted in the export of wool falling to its nadir in the late 1430s.[46]

Whilst the wool trade soon recovered, the early 1440s marked the start of a drastic downturn in cloth exports which did not recover until the late 1470s. It was during this

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44 Bolton, *Economy*, pp. 207-245 and 269; Hatcher, 'The great slump of the mid-fifteenth century'.

45 Britnell, *Commercialisation*, pp. 180-1.

46 Carus-Wilson and Coleman, *Export Trade*, p. 123.

period that the English population probably reached its lowest levels for three centuries and the amount of silver in circulation was also at its lowest. London was the only minting centre in north-west Europe to remain open.[47] During the 1450s it actually increased its output of silver coin, using newly mined metal from Devon, when silver briefly overtook the production of gold coin. In other parts of Europe marginal deposits, as near Brussieu in the Lyonnais mountains, were only viable due to the scarcity of silver.[48] New European silver deposits did not become available until the late 1460s and these were quickly drawn into the English economy through rapidly increasing cloth exports. Population levels, however, did not rise significantly until well into the 16th century. Similarly the prices of consumables, which had remained low throughout the 15th century, rose briefly in response to the influx of European silver in the late third quarter of the century but thereafter rose only slowly before 1500.[49]

There is evidence of a strong correlation between the supply of silver and prices throughout the late medieval period. Surpluses in the 12th century led to inflation. Scarcity in the late 14th and through the 15th centuries contributed to a prolonged period of low prices. The underlying effects of population change and the demand for land were important, particularly after 1350, however they cannot explain the short term fluctuations in the economy. Increased use of gold coin did sustain export trade and the financing of foreign conflict in the second half of the 14th century; but gold could not replace silver in domestic commercial transactions until prices rose significantly in the 16th century.

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47 Spufford, *Money*, p. 357.

48 Benoit, *La Mine de Pampailly*, p. 54, fig. 56.

49 Phelps-Brown and Hopkins, 'Seven centuries of the price of consumables', p. 299, Fig. 2; Day, 'The great bullion famine of the fifteenth century'; Hatcher, *Plague*; Spufford, *Money*, pp. 339-362; Hatcher, 'The great slump'.

2. Silver: its sources and centres of production.

Silver is found in a number of forms, not all of which were commercially exploited in the late medieval period. In its native form, as prills of pure silver, it has never been found in quantities of economic significance, although it does feature as a component in some silver-bearing ores. The silver haloids, complex ore assemblages in which silver is the prime constituent, were also limited in their occurrence and were not exploited in Europe during this period. It was the base metal ores, lead and copper, in which silver was the secondary component which were the principal resource exploited. Argentiferous lead ores were the principle source of silver in England and Wales throughout the period under consideration. In continental Europe that was also the case until the introduction of the 'saigerprocess' into copper processing in the late 14th / early 15th century.[50] Once developed, the 'saigerprocess' permitted the extraction of silver from argentiferous copper ores on a large scale, underpinning the boom in production of the 16th century.[51]

2.1 Europe

Prior to the 10th century much of northern Europe's silver supply came from mines in Asia, east of the Aral Sea, north of Afganistan. This was supplemented by European production from shallow lead deposits. For example the Frankish mine at Melle, near Nantes, supplied mints in that area until at least the late 9th century. But it was central and

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50 See Chapter 4, Section 4.8.4 below for a description of the 'saigerprocess.'

51 Blanchard, 'The British silver-lead industry', p. 183.

eastern European mines which provided the bulk of silver produced during the late medieval period although there were significant producers elsewhere on the continent.

The discovery of rich silver-lead deposits in the Harz Mountains, at Rammelsberg near Goslar in Saxony in the late 10th century, when the mines of central Asia were in decline, established Germany as the major producer: a position maintained through much of the late medieval period. As mining in the Harz expanded, along with other lesser deposits opened up in the Black Forest, German silver reached every corner of the continent. Production there reached its peak in the second decade of the 11th century but by 1040 was in rapid decline. For the next century European production relied on residual production from the Harz and that from lesser deposits, including those of northern England. The shortage of silver was demonstrated by a reduction in the weight and quality of coin across continental Europe.[52]

Relief came in the late 1160s with fresh rich deposits opened up near Freiberg, in Meissen, and, shortly afterwards, at Freisach in the eastern Alps augmented by an expansion in production from lesser deposits at Montieri, in Tuscany. These mines were to sustain production for nearly a century before the centres of production shifted south and east.[53] By the late 13th century new silver was coming from mines at Iglesias, in southern Sardinia, Jihlava, south-east of Prague, and lesser deposits at Schemnitz and Göllnitz, in Zips; Rodna, in Transylvania (both areas now part of modern Hungary); Brskovo, in the Balkans; and Longobucco, in southern Italy.[54] Production cycles for the richer mines were short and by the early 14th century outputs were eclipsed by that from

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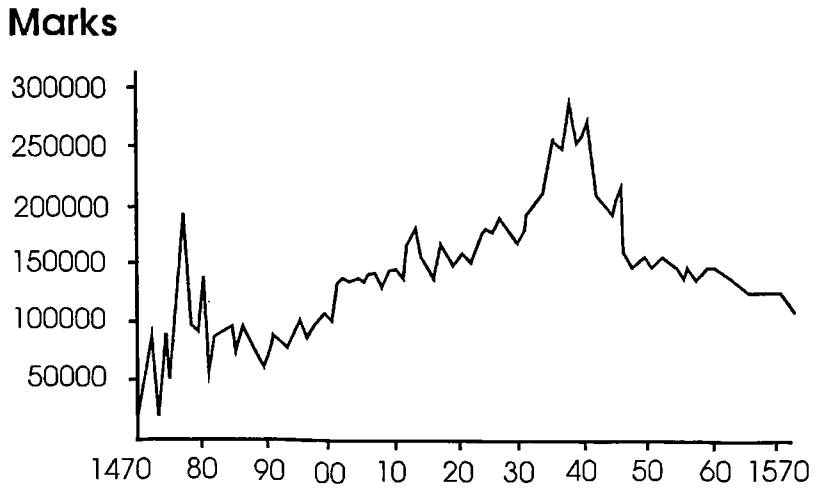
52 Spufford, *Money*, pp. 74-105 and Map 9.
53 Nef, 'Mining and metallurgy', p. 435.
54 Spufford, *Money*, pp. 109-131

the Bohemian mine at Kutná Hora. However, many of the lesser mines continued in production. In Tuscany, Montieri was replaced by new, but short-lived, workings at the nearby Roccastrada mines. Balkan production reached its zenith in the mid 15th century but was eventually lost to European markets by the advance of the Ottoman Empire.[55]

As central European output, based on argentiferous lead deposits, declined in the late 14th



Central European Silver Production at the end of the Medieval period.
(After Blanchard 1995, fig. 1)

Figure 4 (after Blanchard, *Lead Production and Trade*, fig. 1.)

/ early 15th century the shortages were again felt across the whole continent as many mints closed. Revival came in the latter part of the century as new drainage technology allowed deeper working of known deposits and, more important for future production, fresh sources derived from a new ore base were opened up. Then the old lead based deposits took on a new role as key suppliers to the technology developed to extract silver from argentiferous copper deposits being exploited in central Europe. Lead was an

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[55] Cirkovic, 'Production of Gold, Silver and Copper', p. 52

essential element in the 'saigerprocess', required to draw out silver from copper. The use of argentiferous lead then had the added bonus of supplementing the silver recovered from copper.[56]

Extraction of silver from copper ores was not new but was brought to effective, if ephemeral, commercial levels in Slovakia at the turn of the 14th century. As new deposits

Figure 5 (based on references cited in the text.)

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[56] Blanchard, *Lead Production and Trade*, pp. 15-22.

were opened up in central Europe (Bohemia and Saxony) in the mid 15th century the process was to have a significant impact on European silver production. This initial central European boom could not be sustained and output quickly fell back to a base line supported by continued production from Slovakia and Thüringia (Meissen). The base line, with central European output (primarily from the mines of the Erzgebirge), rose steadily thereafter until, in the late 1520s, that from the Erzgebirge expanded rapidly to take silver production to new and unsurpassed heights.[57]

2.2 The British Isles

At what date man was first attracted to the working of silver bearing deposits in the British Isles is unknown. Whilst Bronze Age mining activity is now known at various sites particularly in north and mid Wales, it is generally assumed that it was copper that was being exploited despite, in the case of the Cwmystwyth workings in mid Wales, the close proximity of massive lead deposits yielding a workable proportion of silver.[58] However, the discovery in Scotland of lead beads dating from 1600 - 2000 BC. does indicate that the lead ores could have been attractive to Bronze Age man. The extraction of silver from lead by cupellation is known to have been practised in the eastern Mediterranean area some 500 to 1000 years earlier and silver was also being recovered from the leached zone above copper deposits at the Rio Tinto mines in Spain during the Late Bronze Age.[59]

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57 Cipolla, *Before the Industrial Revolution*, p. 175.

58 For an overview of Bronze Age copper mining in Britain and Ireland and its relationship with other metal resources see O'Brien, *Mount Gabriel*, pp. 229-251.

59 Hunter and Davis, 'Early Bronze Age lead'; Tylecote, *History*, p. 38.

The Romans were well aware of Britain's mineral resources and within a few years of occupying the southern part of the island they were working lead mines on Mendip and had established a presence on the gold mining site at Dolaucothi in south Wales. These, along with lead deposits in Yorkshire, Derbyshire, Shropshire and Wales, were worked throughout the Roman occupation and it has been suggested that the lead was exploited in part for its silver content. Yet none of the areas produced ores particularly rich in silver during modern working. The argument for silver working was largely based on the abbreviation EX ARG found as part of the inscription moulded on some Roman pigs of lead of varying date and provenance. This was taken to mean that the lead had been desilvered. However it is evident that many of the pigs so inscribed had a higher silver content than others without the inscription. Furthermore, that the lead in all pigs marked EX ARG would have been refined was eliminated by the discovery of fragments of galena, which could not have survived cupellation, in some of those pigs. Which leaves the origins of the EX ARG inscription unresolved and subject to further research.[60]

However, there appears to be little doubt that the Romans did refine silver from lead by cupellation on Mendip; large amounts of the by-product litharge has been found on sites dated to the occupation at Green Ore and elsewhere but the source of the silver-bearing ores is unknown.[61] Pockets of silver-rich lead ores did occur on Mendip, as is evident from the occasional reference to silver extraction during the medieval period, but whether there was sufficient to sustain a prolonged period of Roman silver mining is doubtful

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60 Annels and Burnham, *Dolaucothi Gold Mines*; Tylecote, *Prehistory*, p. 61-70.

61 Williams, 'St Cuthbert's Roman Mining Settlement'; Elkington, 'The Mendip Lead Industry'; Ashworth, 'Report on Romano-British Settlement and Metallurgical Site'.

particularly when they had other far richer sources on the Iberian peninsula.[62] Silver extraction during the Roman occupation was probably largely confined to a small number of richer deposits on Mendip and elsewhere, as in Shropshire.[63] After their departure the practice was probably discontinued until a renewed demand for silver in coinage from the 8th century onwards stimulated activity.

Significant silver production in the British Isles in the late medieval period came from two areas in England, the Northern Pennines in the 12th century and Devon from the late 13th to 15th centuries. There were, however, other lesser sources in Scotland, Ireland and the Isle of Man, as well as England and Wales, which had contributed to the local supply of silver during the early medieval period and continued to do so after 1066.

Amongst the sources in Scotland there were some with the potential for export to a wider market. Whilst in occupation of the Northern Pennine, Carlisle mines in the mid 12th century the Scots had ready access to the silver produced but at other times had to rely on limited sources from shallow lead deposits. Of these Glenorchy, in 1424, is the only mine in mainland Scotland specifically identified as a source of silver.[64] Islay, in the inner Hebrides, was possibly a greater source of silver from argentiferous lead deposits on the shores of Loch Lossit in the north-east of the island. Archaeological evidence of, as yet, undocumented mining around 1360 when the island was the seat of the Lords of the Isles suggests a potential output of lead and silver of more than local significance. At that period the Scottish Crown would have had little control over production on Islay and the

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62 Edmundson, 'Mining in the later Roman Empire and beyond'.

63 Bayley and Eckstein, *Metalworking debris from Pentrehyling Fort.*

64 Harvey, 'Lead Mining in Medieval Scotland', p. 126. Cochran-Patrick, *Coinage of Scotland*, p. xlv; Cochran-Patrick, *Early Records*, p. 2.

silver was probably exported.[65] It was not until the early 17th century, and the development of the Hilderston mine, that there was significant silver production on the Scottish mainland.[66]

Irish production of silver was similarly centred on lead deposits. Mines in the area of Silvermines in county Tipperary were being exploited by miners from Italy in 1288 and miners from Devon were sent across to develop unnamed silver workings in the early 14th century. The English Crown maintained a close interest in alleged discoveries of precious metals in Ireland throughout the late medieval period but it was not until the 16th/17th centuries that there is evidence of sustained production from the co. Tipperary deposits and lesser deposits near Clomines in co. Wexford.

Other offshore sources of silver were found on the Isle of Man. Mines in the Foxdale area of the island possibly contributed significantly to late 13th century production and, as with that produced on Islay, probably exceeded local demand: adding to the circulation of precious metal for coinage on the periphery of Europe.[67]

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65 Cressey, *Early lead mining*. Cressey and Coles, 'Metal mining in NE Islay.

66 Meikle, 'The melting, fyning and stamping Mylnis at Linlithgow'.

67 For silver-bearing locations in Britain see Ridgeway, *Silver*; for Ireland see Cole, *Metalliferous Mines in Ireland.*

2.3 England and Wales

Measured against central European production in the latter part of the medieval period, the total amount of silver mined in England and Wales was small. However, taken in a national context it was of real relevance to a high specie using economy. Up to 75% of coin in circulation at the end of the 12th century possibly came from local sources. The local contribution had, however, fallen to much lower levels by the 14th century.[68]

As in continental Europe, native silver is found in only a few locations and then only in small amounts. By far the largest proportion of silver is found combined with the lead ores galena (lead sulphide) and cerussite (lead carbonate) and to a much lesser extent copper ores along with the complex tetrahedrite ores found in conjunction with some lead deposits. The more complex silver haloids are found but are confined to a small group of mines in East Cornwall.

Whilst lead ores are found over much of upland Britain, in only a few areas did the ores mined in the post-medieval period contain sufficient silver to justify refining. Prior to the introduction of the Pattinson process in the mid 19th century it was generally accepted that ores containing less than 8 ounces of silver per ton would not pay refining. However, Pattinson's process allowed economic recovery of silver at values of 2 to 3 ounces per ton.[69] Blanchard has stated, based on 15th / 16th century writings including Agricola, that the normative yield of silver-lead ores was 8 to 12.5 ounces per ton of ore. Despite the problems of converting ore production expressed in volume measure to meaningful

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68 See Chapter 3, Section 2.3, Section 2.4.1, and Table 3 below.

69 Percy , *Metallurgy*, vol. 3, pt. 1, p. 121.

figures for silver yield, it is clear that the major English mines of the medieval period were exceeding that norm throughout their productive life.[70] Those areas within England and Wales which produced silver in the medieval period are shown at Fig. 6 below.

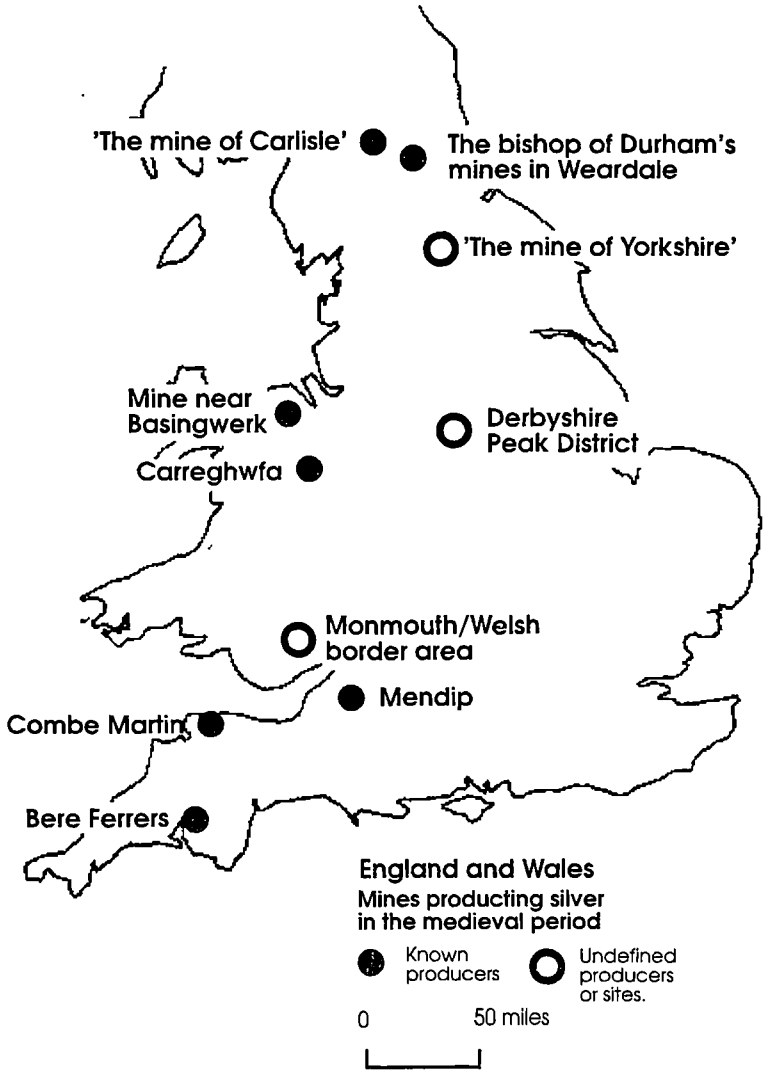

Figure 6 (based on references cited in the text.)

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[70] Blanchard, *Lead Production and Trade*, p. 196. See Chapter 3 below for details of production and silver yields.

The earliest to be exploited on a large scale were the Carlisle mines in and around that area of the Northern Pennines now known as Alston Moor. From the second quarter of the 12th century silver from these and other mines in Durham passed to the mints at Carlisle, Newcastle, and elsewhere; and, during the Scottish occupation, to Bamburgh and other mints operated by the Scottish Crown. The coin produced had a wide circulation and an economic effect outside the immediate locality. But with their demise in the late 12th / early thirteenth century there was no reliable home source of silver in England and Wales until the Devon mines at Bere Ferrers (also known as Birland and sometimes, incorrectly, as 'the Bere Alston mines') and Combe Martin were opened up in the 1290s.

Production in Devon peaked in 1297 and remained high through the first two decades of the 14th century, but then tailed off before being totally disrupted by the Black Death. Renewed working in the latter part of the century with a much reduced output was curtailed in the late 15th century as the limits of contemporary drainage technology were reached. There was to be a short but productive revival at Combe Martin in the late 16th century and Treworthie, in Cornwall, was also the subject of renewed interest at that time. Both being amongst the mines which were investigated throughout the medieval period without showing lasting promise. There was to be no other substantial production centre until the mines in mid Wales (Cardiganshire) were opened up in the second half of the sixteenth century. Subsequently it was these mines, along with deeper deposits opened up in the Northern Pennines and again in the South-West which became the major source of silver in the nineteenth century. Although mines in the South-West produced over 6.5 million ounces of silver in the second half of the 19th century (26.98% of UK production), the evidence set out below suggests that very few of them made a contribution before

1500.[71] That is reinforced by recent archaeological investigation which shows that significant 19th century producers in the Teign valley and the rich shallow prospect at Loddiswell, Devon, were unworked in the late medieval period.[72]

3. Geological background.

There is considerable variation in the geology and mineralogy of silver-bearing deposits across England and Wales. The bulk of early, pre 13th century, production came from lead deposits in rocks of Carboniferous age. These were shallow deposits, enhanced by the effects of secondary enrichment, and easily worked. Deposits in the older rocks in Devon and mid Wales, although still benefiting from the effects of enrichment, were deeper seated and there exploitation came later, with changes in the technology of both mining and smelting.

Weathering and the action of surface waters on the upper parts of mineral deposits is primarily responsible for the enhanced silver content of the base ores accessible to the medieval miner. Supergene action through leaching by acidic waters partially removed the primary minerals in solution, leaving a concentration of silver in the unaffected portion. Below the area of leaching was the oxidised zone, in which the base metal deposits were enriched with carbonate minerals from the zone above. The carbonates had a lower silver content but that of the sulphide ores, i.e.. galena, which remained unoxidised was enhanced. Lower again, below the water table, was the 'zone of secondary sulphide

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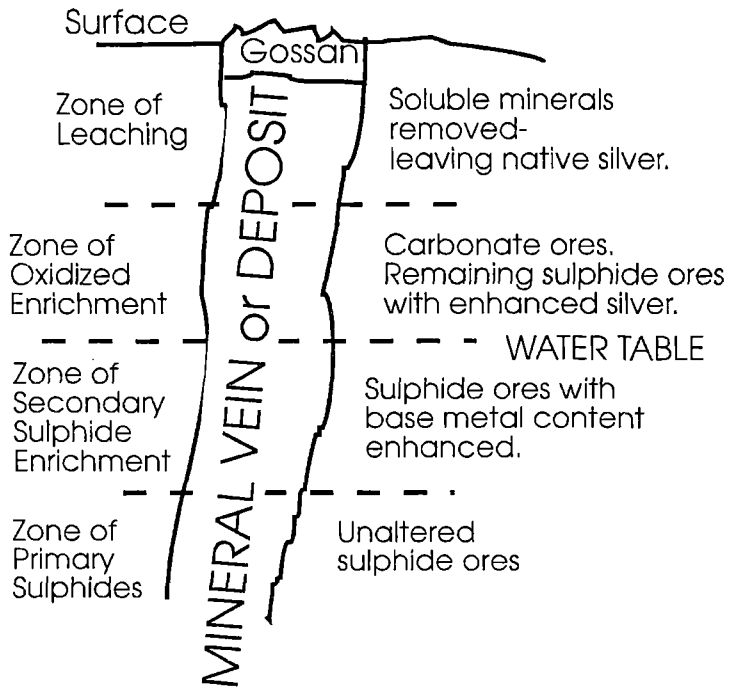
71 Burt et al., *Cornish Mines*, p. xlvi; Burt et al., *Devon and Somerset Mines*, p. xxii. See Chapter 3,.Section 2.4 and Chapter 4, Section 4.4.

72 Thorndycraft, et al., 'An Environmental Approach'.

enrichment' where the base metallic elements leached from above, but deprived of oxygen, combined with the primary sulphides to form high grade base ores without enhancing the silver content - see Fig. 7 below.

Oxidised and secondary sulphide enrichment is particularly prominent in the copper



Diagramatic section illustrating supergene enrichment (based on Edmonds et al., 1969, fig. 28)

Figure 7 (based on Edmonds, et al., *South-West England*, fig. 28)

deposits in the South-West of England. At the Bampfylde Mine, North Molton, there was an iron rich gossan / zone of leaching with enhanced silver and gold levels. Below this, but above the water table at valley bottom level, was a rich oxidised zone containing copper carbonates with up to 60% metal values, with secondary sulphide enrichment

down to between 102 and 112 fathoms (183.6 and 201.6 metres) below adit. However, precious metal values were negligible below the oxidised zone.[73]

At Combe Martin, in north Devon, there is evidence of leaching in the upper parts of the lead/zinc deposits where galena containing filaments of native silver has been recorded.[74] Cerussite, lead carbonate, is the product of supergene action on galena. Its presence in large quantities in the late medieval silver workings at Bere Ferrers, in south Devon, indicates that those mines were exploiting 'the zone of oxidised enrichment'. Numerous further examples of the enhanced silver content of lead and copper deposits are found across the South-West of England, however their potential was not fully realised in the medieval period.

The variable impact of glacial erosion meant that the effects of supergene action were more extensive in the South-West of England, but what survived in the northern counties was probably more prominent and easily detected by early miners. This may account for the earlier development of silver extraction from lead in the Carboniferous rocks of Wales and the northern parts of England.

3.1 Mendip and other deposits in the Carboniferous Limestone.

The lead deposits on Mendip, in north-east Wales, the Derbyshire Peak and the Northern Pennines are in or associated with the Carboniferous Limestone. All are fault fissure

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73 Rottenbury, *Exmoor*, p. 161.

74 Hall, 'On the mineral localities of Devonshire', p. 340.

fillings with some secondary replacement in adjacent flats or pipes and the predominant ore is galena. The Northern Pennine deposits are dealt with in detail later but the general comments below are valid for all silver-bearing deposits in the Carboniferous series.

On Mendip and elsewhere the ore now in sight is generally low in silver. However, galena is capable of holding up to 0.10 per cent of silver (35.84ozs / ton of ore) without the development of visible silver minerals.[75] In the early 18th century lead from the Ball Eye Mine, near Cromford in Derbyshire, was returning high silver values from deposits which, by that date, were deep and unaffected by enrichment close to surface. The Ball Eye ore was said to have 'realised 20 oz. of good silver to the fodder of lead at 22½ cwt.' In which case the silver values are possibly close to those where separate silver minerals might have been formed.[76] However, at an earlier date, shallow silver rich deposits have from time to time attracted attention but always proved short lived. Such deposits are principally due to the effects of leaching in the oxidised zone close to surface.

Mendip is the exception to any rule that might suggest that the early development of silver mining occurred in the areas affected by glaciation. The ice sheets did not come far enough south to have much effect on the Mendip rocks yet silver-bearing lead ores were worked there as early as the Roman occupation period. However, the lead/silver mineralisation occurs primarily in Dolomitic Conglomerate where it overlies the Carboniferous Limestone on a high plateau. This exposed location, with little overburden and good natural drainage, presented a relatively easy objective for the medieval miner.

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[75] Dunham, *Tyne to Stainmore*, p. 72 - quoting Guild, in Fairbanks, *The Laboratory Investigation of Ores*.

[76] Kirkham, *Derbyshire Lead*, p. 60. See Chapter 3 below for the problems of relating silver values in ore assays to those in metallic lead.

New silver bearing deposits in the oxidised zone continued to be identified after 1066 as miners explored the area of mineralisation horizontally and vertically. They were aided in the latter by the natural drainage available in the underlying limestone which allowed water to be diverted into natural cavities, swallow holes.[77]

3.2 The Northern Pennines

Whilst acknowledging that high silver values are found in certain isolated deposits, the view of geologists working on the Northern Pennine orefield is that historically the silver values generally varied little from those found during more recent mining activity. Lead mined in the field during the 19th century averaged around 4 to 8 ozs of silver per ton of lead metal and it was not until improvements in enrichment technique in mid century, Pattinson and later processes, that the wholesale recovery of silver became economic.

There are, however, certain veins particularly on and around Alston Moor which have returned significantly higher silver values. Some of these are known to have been worked during the late 17th and early 18th century and had attracted the attention of the Crown in the late part of the medieval period. Some silver rich tetrahedrites are known in the upper strata, possibly associated with copper and bismuth-bearing mineralisation related to the buried Weardale granite.[78] But what proportion they contributed to medieval production is unknown and it is possible that the majority of silver was recovered from lead sulphide

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77 Green, 'The Central Mendip Lead-Zinc Orefield'.

78 Ixer et al., 'Bismuth-bearing assemblages', p. 323.; Brian Young, BGS Edinburgh, pers. comm.

(galena).[79] Unlike the nineteenth century workings, which concentrated on lead deposits in the lower strata with deep drainage techniques developed using long adit levels, earlier miners only had access to shallow deposits in the upper strata where drainage was possible using limited technology. Certain mines on veins which cut through the upper strata, including the Firestone Sill, have been singled out in the past as returning high silver values. These included Fletcheras, Blagill, and Sheldon. The latter is situated on the northern, Northumberland, bank of the Derwent well to east of Alston. In 1475 silver values from these mines were claimed to range from 62 to 421 ozs per ton of metallic lead.[80] In addition particularly high silver values have been noted in lead ore from the group of veins, including the Sir John and Stow Crag veins at Tynehead, on the limestone moors forming the watershed between the South Tyne and Tees rivers. Veins in the Derwent area, including Burnhope, Healeyfield and Beldon, have returned silver values of up to 18 ozs per ton from primary deposits well below the oxidised zone. In the light of such known silver-bearing deposits it is to be expected that the oxidised zones on those and many of the lesser veins on the higher slopes around Cross Fell, Middle Fell and in the upper parts of Allendale yielded appreciable amounts of silver during the medieval period. Many of them exhibit evidence of early mining and smelting activity.[81]

The richer deposits in the oxidised zone were of limited vertical extent and soon worked out. Deeper primary sources, whilst giving respectable silver returns by 19th century standards, were less accessible and not attractive enough to justify the introduction of new drainage techniques in the latter part of the medieval period. Extensive deep working was not attempted until the eighteenth century and in second half of the nineteenth century

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79 Dunham, *Tyne to Stainmore*, pp. 69-72; Ridgway, *Silver*, p. 34.

80 *Cal. Pat. R.*, Edw. IV - Hen. VI, p. 464.

81 Dunham, *Tyne to Stainmore*, pp. 65-72, particularly Table 20.

Northumberland and Durham alone accounted for, on average, over 14% of UK silver production.[82]

3.3 The Devon mines.

Until recently the received view was that the lead / zinc / silver mineralisation in both north and south Devon occurred in the same manner as that in Cornwall. Hot mineral bearing fluids emanating from an intrusive igneous mass (granite) depositing particular metallic minerals as they cooled. Lead / zinc deposits, as the coolest, being found furthest from the granite. Although in the case of North Devon that igneous source could not be positively identified and the mineral / temperature gradient did not form a recognised pattern.[83] The mineral deposits were regarded as veins or lodes in the Cornish model and were named accordingly by the 18th - 19th century miners. A terminology which is retained throughout this work for the sake of continuity and clarity. However, recent work by geologists from the British Geological Survey in Exeter has thrown new light on the subject.[84] They have identified clear mineralised horizons in the east - west bedding of the country rocks in the north and south of the county. Mineralisation having been concentrated at those horizons by low temperature ground water movements in conjunction with north-south crosscourses.[85]

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82 Burt et al., *Durham and Northumberland*, p. xvi.

83 Rottenbury, *Exmoor*, pp. 18-21.

84 In particular Scrivener and Bennett, 'Ore genesis'. See also Beer and Scrivener, 'Metalliferous Mineralisation', pp. 121-3 and 141-2

85 Faults of limited throw; where those crosscourses cut rocks barren in minerals, as in the Culm Measures, there is no such concentration.

Whilst the controlling factors were the same, the nature of the deposits and the date of mineralisation in north and south Devon are quite different. That for the north, and the agentiferous deposits near Combe Martin, is much the earliest, earlier even than the Cornish granite intrusions.[86] Whereas the deposits in the Tamar valley area of south Devon, including those worked extensively in the medieval period, post date the granite intrusion and cut across the east - west lodes associated with that intrusion.[87]

It had long been clear that the crosscourses were a controlling factor in the lead / zinc / silver mineralisation of the Combe Martin area. The richest deposits having been found at their junction with the lodes. However it is now evident that those deposits were not true lodes, occupying fault fissures, but lenticular stratified deposits. These deposits, laid down at the same time as the country rock and probably syngenetic in origin, resulting from the venting of mineral rich fluids onto the contemporary seabed, were subsequently subject to folding and follow the same plane as the bedding of the country rock. They could extend to a considerable depth. Recent examination of workings in the area of Harris's Lode at Combe Martin has revealed the irregular openings left by the removal of such deposits either side of a north-south crosscourse. The lens in this case reached a depth of 60 metres below surface whilst a similar, parallel, ore body known as the Old Combmartin Lode was worked to 210 metres below surface in the mid 19th century. The crosscourses are now seen as the vehicle for hot fluids which effected a remobilisation of the lead, zinc and silver deposits as it did for the copper and iron minerals found elsewhere in the Devonian rocks in north Devon and west Somerset.[88] Recent work on iron mineralisation in north Devon has led Scrivener and Shepherd to suggest similarities

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86 Beer and Scrivener, 'Metalliferous Mineralisation', p. 123.

87 *Ibid.*, p. 141.

88 Scrivener and Bennett, 'Ore genesis', p. 57.

between that area and the area south of Cubert, in Cornwall, where argentiferous galena is found in association with the Great Perran Iron Lode.[89] The discontinuous nature of the lenticular deposits, the difficulty of predicting and prospecting for new deposits, may in part account for the spasmodic working of silver-bearing ores at Combe Martin.

In the Tamar valley, south Devon, the deposits are found in the crosscourses themselves: true fault fissures with well defined walls, cutting across the bedding of the country rock. Two factors affect the mineralisation in the crosscourses, the variable nature of the country rock as a host for the minerals and the south dipping east-west fracture zones or 'slides' which cut, and occasionally displace, the crosscourses.[90] As a result the productive ore bodies hade, or dip, to the south and are deeper at the southern end of the crosscourses, in the area of the 19th century South Tamar Consols and South Hooe mines. The available documentation suggest that only the eastern crosscourse, from Cleave north to Lockridge Hill, was known to the medieval miners.

Galena, lead sulphide, is the predominant silver bearing ore and is found in a matrix of gangue minerals, mainly quartz or quartz and fluorspar in the south. Cerussite, lead carbonate, is a weathering product of galena and is found in the upper parts of the deposits. In those upper parts the action of percolating surface waters has resulted in secondary enrichment increasing the silver content of these ores.[91] It is also possible that in the south at least some extremely high silver returns may have come from the complex tetrahedrites found in association with lead deposits. Tetrahedrites are found on the

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89 Scrivener and Shepherd, 'Mineralization', p. 145 and fig. 8.4.

90 Devon Record Office, 4672A/HS/R7C, Abandonment plan, South Tamar Consols, c.1856. Leveridge et al., *Plymouth and south-east Cornwall*, p. 94.

91 Scrivener and Shepherd, 'Mineralization', p. 141.

dumps at Bere Ferrers and their occurence is confirmed in smaller deposits in south Devon at Loddiswell, although the latter were evidently not worked in the late medieval period. The use of a liquation or leading process to extract silver does suggest that ores more complex than agentiferous galena or cerussite were being mined in south Devon from the late 13th century. Subsequent re-smelting of copper blackwork in the first half of the 14th century also suggests that copper/silver ores were being mined.[92]

The effects of glaciation was minimal in Devon and Cornwall. The southern limits of the major ice sheets corresponded with the present north coast of Devon and Cornwall, with small local glaciers on the peaks of the land mass to the south.[93] Therefore the full effect of supergene action was present in the oxidised zone above the water table in the Devon mines. Here were the products of the leaching action of acidic water percolating from surface; primarily the lead carbonate, cerussite, and partially dissolved suphides with enhanced silver content. The richest silver bearing deposits were found along the junction between crosscourses and the mineralised horizons. In the north particularly these diminished laterally with depth and all returned lower silver returns in depth. On the Old Combmartin Lode in north Devon the deposit was only a few metres in length at the 102 fathom level (210 metres below surface) when abandoned in 1848. Whereas that at the South Tamar Consols, in south Devon, was still at least 432 metres long at the 124 fathom level (224 metres below surface) when flooding caused its abandonment in 1856.

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92 Leveridge et al., *Plymouth and south-east Cornwall*, p. 94; and Scrivener, pers. comm.; see also Stanley et al., *Loddiswell*. For discussion on the smelting of complex silver-bearing ores, see Chapter 4, Section 4.8 below.

93 Edmonds et al., *South-West England*, p. 8 and fig. 19.

It was the upper parts of these and other smaller shallow deposits of ore which were accessible to the miners of the late medieval and the first years of the early modern period, and it was here that enrichment gave the best silver returns. They were restrained by the available drainage technology but nevertheless worked the deposits to considerable depths. They had reached 58 metres below surface at Combe Martin in the late 16th century and possibly around 83 metres at a similar date at the Bere Ferrers mines.

4. Other minerals, 1066 to 1500

At the beginning of the period under study the Domesday survey of 1086 makes only scant mention of mining. There are, however, references to metal production which imply mining activity across much of England.[94] Along with silver, lead and iron are mentioned in the survey but, strangely, not tin although subsequent documents and the archaeological evidence point to a pre-existing industry at the Conquest. This mining / metal processing activity developed during the late medieval period and the non-ferrous sector in particular contributed significantly to export earnings. By 1500 coal mining in some areas had also advanced, from a small local activity, to a point where commercial enterprise was increasingly looking to the supply of distant markets.

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[94] For example *Domesday Book*, Derbyshire 1,12-13; 15; 27-28.10,11.; *ibid.*, Cheshire FT1,1. FT2,1.

4.1 Lead mining and production

The mining of lead ores in the medieval period was linked to the production of silver until the 12th century. By at least the 1170s a separate industry was developing to cater for the demand in lead to roof the growing number of stone buildings. Prior to this the principal source for lead had probably been as a by-product of the silver refining process. Substantial amounts being procured from the Tynedale mines.[95] Between 1179 and 1183 at least thirteen shipments of lead were made from non-argentiferous sources in Yorkshire to the King's works along with ecclesiastical houses in southern England and France.[96] The Shropshire mines were also active for the same purpose at this period, and earlier if the unspecified mine let to Drogo '*minetari*' in 1162/3 was worked for lead, with metal being purchased by the Crown and shipped down the Severn from at least 1179.[97] From a similar date there had been shipments from mines in the Derbyshire Peak District and these continued into the 13th century when a market for lead was established at Boston.[98] When Edward I launched his campaigns to subdue the Welsh, 1277-95, he consolidated his hold with an extensive programme of castle building.[99] Lead for those works was drawn from a wide area. Some came from Derbyshire, the Isle of Man, and possibly from deposits in Carnarfonshire. Carnarfon Castle itself was supplied with some lead from Bristol, probably coming from the Mendip mines. Construction of Builth Castle at first drew on supplies from mines in Shropshire, close to the Welsh border near Shelve, but in 1280 was hauling lead 144 kilometres from Flint. The mines around Flint, in north-east

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95 Pages 931, and 102, and Appendix 1, below.

96 See page 91 below

97 *Pipe Roll*, PRS 6, p. 6. Page, *Victoria County History of Shropshire*, vol. 1, p. 417.

98 Kirkham, *Derbyshire Lead Mining*, p. 100. Cal. *Liberate R.* (1226-40) p. 133, 394; *Cal. Liberate R.* (1240-45) p. 240.

99 Davies, *Age of Conquest*, pp. 333-87.

Wales, were a major source of lead for the North Wales castles, with 140 carreta or cartloads (101.28 tonnes) being used on Conway Castle alone in 1286.[100]

Edward I's castle building undoubtedly gave a boost to the lead industry across England and those parts of Wales occupied by the English. Demand was maintained by further church and monastic building work, with Derbyshire lead being supplied along the south coast as far west as Exeter where it supplemented that available from silver refining.[101] Lead from the mines at Minera, in Denbighshire, served a similar market as well as satisfying the requirement for boiling pans in the Cheshire salt works through the first half of the 14th century.[102] These and other mines in north-east Wales, Derbyshire, Mendip, and parts of Yorkshire were governed by customary law which gave the miners control over production in return for a payment of a portion of the produce to the lord of the soil.[103] The use of custom to control manorial resources was commonplace in the medieval period. Where mining, particularly mining for lead and tin, differed from other resources was that it was carried out for the monetary profit of both tenant and lord. Lead mining provided a cash income for the miner but he still relied on his agricultural holding to provide a living.[104] By the end of the 13th century the linkage between mining and agriculture had been weakened by population growth and a shortage of land. This provided a pool of labour in the lead mining areas on which the Crown could draw for the silver mines in Devon.[105]

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100 Taylor, *King's Works in Wales*, pp. 294, 349, 375 and 407.
101 Erskine, *Exeter Cathedral, Part 1*, pp. 19, 50 and 78; and *Part 2*, p. xxvii.
102 Pratt, 'Minera: Township of the Mines', pp. 120-21.
103 For examples see Williams, 'Mining Laws'.
104 Blanchard, 'The miner'.
105 See Chapter 6, Section 5.2 below.

Many ecclesiastical establishments also became involved in mining. The bishop of Durham took control of lead deposits in Weardale, formerly a significant source of silver, into his own hands in the early 15th century, having leased them to outside interests over the preceding century. Production, however, was largely to satisfy the demands of the bishopric rather than the wider market.[106] Monastic houses across England and Wales worked lead deposits on their lands, from Fountains Abbey and Bolton Priory in Yorkshire to Strata Florida in mid Wales.[107] Production was largely for domestic consumption but there was an export element. Quantifying that production is extremely difficult. As Miller and Hatcher point out, the evidence is unsatisfactory and incomplete.[108] Blanchard suggests the Derbyshire production stood at not less than 391 fothers (of 2184 lbs) in 1300 but this masks a variable record over the previous hundred years. By the late 12th century new mines were opened up around Bakewell. These and other mines in the High Peak appear to have provided the bulk of Derbyshire production at its peak in about 1200 although declining over the next 50 years. But as output from one part of the Derbyshire field fell others rose to compensate, in part at least. This was to be a feature of Derbyshire and other lead fields through the late medieval period. The mines, 'grooves or groves', were shallow linear openworks or shallow shafts exploiting fissure veins, 'rakes', and associated replacement deposits, 'pipes', in the limestone. As these veins were worked out to the water table and all suitable ore exhausted, mining and smelting activity migrated to new deposits. In this way production kept pace with demand. Derbyshire output recovered to a minor peak around 1300 before declining again

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106 Drury, 'Leadworks'; Blanchard, 'Seigneurial entrepreneurship'.

107 Jennings, *Nidderdale*, pp. 58-74. Williams, *The Welsh Cistercians*, p. 78.

108 Miller and Hatcher, *Towns, Commerce and Crafts*, p. 59.

during the first half of the 14th century. A trend which, over the previous 150 years, had mirrored the demand from major building works.[109]

As with other mining activity, lead production suffered from the effects of the Black Death. Some Derbyshire mines were abandoned. In north-east Wales production from the Minera field appears to have ceased altogether and the fines paid on the Englefield mines were greatly reduced 'because a greater part of the miners were dead, and those that survived were unwilling to work'.[110] This suggests a parallel with tin production in the South-West of England, where miners appear to have abandoned mining to concentrate on working vacant agricultural holdings.[111] Derbyshire showed signs of recovery by the 1360s as the quantity of tithe ore for Hope, Bakewell and Tideswell started to rise and continued to do so to 1403.[112] There then followed a period of fluctuating output but the overall trend to mid century was one of decline until it stagnated at very low levels.[113] When recovery did come after c.1475 it did so largely to feed a new market as lead was exported to satisfy the demands of the saigerprocess in central Europe. The domestic market for new lead remained depressed well into the 16th century due largely to the availability of material recycled from redundant ecclesiastical buildings. Exports of lead, however, slowly rose during the latter half of the 15th century as the European silver producers adopted new technology to extract silver from copper ores using a form of liquation, the saigerprocess. This process consumed lead as it was added to partially

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109 Blanchard, 'Derbyshire lead production', pp. 124-125 and fig 1; Blanchard, 'Lead mining and smelting'; Riewerts, 'Lead mining'; Blanchard, *Lead Production and Trade*, p. 289, n. 2.

110 *Cal. Inq. Post Mortem,* Vol. 8, items 46 and 657. Pratt, 'Minera: Township', p.121. Lewis, 'Industry and commerce', p. 145, n. 1, quoting from PRO, *Minister's and Receiver's Accounts* SC6/1186/4.

111 Hatcher, *Rural Economy* , p. 120; see also p. 61 below.

112 Blanchard, 'Derbyshire lead production', p. 134, Table 3.

113 *Ibid.*, pp. 127-129.

reduced copper ores to combine with the silver and was then refined by cupellation.[114] Lead production, largely for export, had risen to over 650 tonnes by 1508. Some of this increase in the 1450s came as a by-product of the Devon silver mines but, as producers in Derbyshire, Yorkshire, Durham and, by the 1490s, Mendip reacted to the demands of the new market, output rose across the country.[115] Of the lead fields active prior to 1400, only north-east Wales failed to respond. Production there had been adversely affected by the suppression of the Glyndwr rising, 1400 to c.1413, such that as late as 1472/3 the bailiff at Minera accounted,

> *'for the losses and reduced rents from divers lands and tenements .... and other profits accruing to the lord from the mines which from ancient times until now have been paid by them, which several tenements and houses lying there were destroyed during the attacks and incursions made by the lord King's rebels from parts of Wales and have not been repaired because of the absence of many tenants and because of the poverty of the same tenants and up to this time have lain in the lords hands'.*[116]

Mines to the north in co. Flint were farmed out in 1423 for a mere £3 18s. 9d. and in 1509 those at Holywell and Vaynol failed to yield a profit as no one was willing to work them.[117]

The mines of north-east Wales did not see renewed production of any substance until the 17th century. By that time the customs by which they had been governed had fallen into

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114 See Chapter 4, Section 4.8.4 for further details of the saigerprocess.

115 Blanchard, *Lead Production and Trade*, pp. 289-313. Gough, *Mendip*, pp. 59-63.

116 Pratt, 'Minera: Township', p. 122-3 quoting PRO, *Minister's Accounts* SC6/1235/14.

117 Lewis, 'Industry and commerce', p. 145, n. 1.

disuse, allowing the lord of the soil to gain full control over production.[118] Output from other lead fields, in Derbyshire, Mendip and parts of Yorkshire, continued to grow after 1500 and survived the depression in prices caused by the release of large amounts of monastic roof lead onto the market in the 1530s. Their customary law also survived, regulating production in some cases until embodied in statute law in the 19th century.[119] As new centres of lead production developed outside the lead fields governed by custom during the early modern period they did so on a scale not available to the medieval industry. The land owners and entrepreneurs working deposits in mid Wales, Shropshire and the resurgent fields of the northern Pennines and north-east Wales from the 17th century onwards controlled both the produce and the means of production, allowing them to make full use of external finance for technological developments.[120]

4.2 Tin mining and production.

Although tin only contributed a small proportion to total overseas trade in the late medieval period it was England's premier export metal. During the period under consideration the Stannaries of South-West England were virtually the only source of tin in Europe and the metal was an important component in the manufacture of bronze, bell metal and pewter.[121] Exports of tin therefore represented a substantial fraction of production which was consequently subject to the fluctuations in overseas demand.[122]

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118 Williams, 'Mining Laws'.
119 Gill, *Lead Mining in the Pennines*, pp. 87-124.
120 Burt, *British Lead Mining*, pp. 1-9
121 Hatcher, *Tin production*, pp. 2-5.
122 *Ibid.*, p. 150-1.

The use of tin dates back to prehistory and, along with copper, formed the basis of metallurgy in Europe from the 3rd millennium BC onwards. Evidence for the working of English tin deposits prior to the Roman occupation is as yet scant.[123] But the proximity of the deposits to the Bronze using civilisations of the Irish Sea area, and the easy with which alluvial tin could be mined, would suggest that they were worked at an early date. This is supported by archaeological evidence from finds, including smelting residues, in prehistoric contexts.[124] Although known to the Romans, tin in Cornwall was not worked extensively until the latter part of the occupation period in the 3rd century AD as an alternative to resources in north-west Spain.[125] For the early medieval period there is again scant evidence but sufficient to indicate that some tin production continued after the departure of the Romans.[126]

It is evident that the English Crown had established an interest in tin production by the middle of the 12th century when the collection of a farm on the duty on tin was recorded in the Pipe Rolls. The 'Stannaries', as distinct tin mining areas in Devon and Cornwall under Crown control, are documented during the second half of that century. An inquisition of 1198 regularised the arrangements for payment of tax (coinage) on tin and confirmed the existence of mining customs within the Stannaries. Those customary laws were codified in a charter of 1201 and allowed the miners (tinners) liberty to search for, and work, tin without interference, to divert water as required and take fuel for smelting. Tinners were to answer only to the Warden and his officers who were granted exclusive jurisdiction over them. The customary laws were subsequently subject to modification,

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123 Tylecote, *Prehistory*, p. 43.
124 See table in Penhallurick, *Tin*, pp. 219-221.
125 Hatcher, *Tin production*, pp. 13-14.
126 Penhallurick, *Tin,* pp. 237-243

notably by the Charter of 1305 which granted tinners an immunity from taxation, and regulated tin mining until incorporated into statute law in the 19th century.[127]

Tin production, estimated from the farm of Crown income from a tax on the first smelting, is believed to have risen rapidly in the second part of the 12th century, reaching at least 600 to 720 thousandweight in 1194.[128] Collection of a new tax on production after 1198 confirmed that it had risen to 900 thousandweight (worth around £2700), falling back briefly before rising to 1200 thousandweight in 1214. Some would be consumed in construction work at home but the majority would have been exported. Unfortunately, thereafter, until 1300-1, total production figures are not available but, judged on the figures attained in early years of the century, tin represented a significant element in England's export trade. Early 14th century production was, however, only half of that in 1214. Cornish output recovered during the first half of the century only to be cut drastically by the effects of the plague and it was not until 1386 that total production again reached the levels of the early 13th century. Hatcher suggests that the disruption in production after the Black Death was largely due to a shift to agricultural as tinners expressed a preference for farming over tin working by taking up vacant holdings.[129]

Tin withstood the depression of the mid 15th century far better than any other export commodity. In terms of quantity, value and the numbers employed in its production it eclipsed the performance of the lead industry.[130] At its lowest point, in 1460, production

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127 Lewis, *Stannaries*, pp. 65-84; Costello, 'Stannary courts'.

128 Hatcher, *Tin Production*, p. 19. The bulk of production at this period came from Devon where the 'thousandweight' was 1200 lbs; in Cornwall it was measured at 1000 lbs.

129 *Ibid.*, p.148; Hatcher, *Rural Economy*, p. 120. For tin prices see Lewis, *Stannaries*, p. 275

130 Hatcher, 'Myths', p. 55.

was 750,254 lbs (over 323 tonnes), compared with lead production of around 80 tonnes per annum, added to which tin was worth, measure for measure, five times that of lead. By the end of the century tin production had virtually doubled.[131] Much of this was exported as block tin, in the form of ingots, but a substantial proportion was as pewter (an alloy of tin and lead used in the manufacture of tableware). The increased use of pewter in the later medieval period contributed significantly to the demand for English tin.[132]

The demand for tin during the late medieval period attracted external finance, largely provided by local men of substance, merchants, gentry and clergy, keen to secure a share of the produce. Working capital was required to finance tin working, a labour intensive activity employing a significant number of full time workers. With producers unable to sell tin before the infrequent coinages, tinners were obliged to take loans, guaranteed against future production, to maintain their activity. Thus from an early date the tinner was *'enmeshed in a web of indebtedness'*.[133] The money advanced to the tinners by local men came in part from London and alien merchants. There was what Hatcher describes as a 'three tier' system financing production and securing the tin presented for coinage. Investments were also made in tin working as merchants and others became partners in ventures, providing the capital with a view to sharing the profit.[134]

During the period under consideration tin was largely worked from secondary placer deposits. These were either stratified alluvial deposits created in the valley bottoms, on and around the granite mass, by erosion of vein deposits, or eluvial deposits of eroded,

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131 Hatcher, *Tin Production*, p. 158; Blanchard, *Lead Production and Trade,* p. 309.
132 Hatcher, *Tin Production*, pp. 89-117.
133 *Ibid.*, p. 49.
134 *Ibid.*, pp. 49-88

detached tin on the steeper slopes close to the veins. Working those deposits was not technologically demanding, nor did it require large amounts of capital. Only when those deposits were depleted did the tinner turn to working the primary vein deposits, and that was not common until the 16th century and later.[135] The method used to work the secondary tin deposits was 'streaming', using water action to separate the waste sands and gravels from the heavier tin ore. These 'streamworks' generally involved the systematic extraction of the tin-bearing deposits by trenches or pits, sometimes several metres deep, starting at the lowest point and working upstream. Waste from the process was dumped on the worked ground as the process advanced. Water, essential for the process of gravity separation, was channelled to the site from an adjacent stream or, particularly in the case of eluvial deposits, from some distance away. Effective drainage of both ground water and water used in the separation process was an essential feature of streaming.[136]

Once recovered from the secondary deposits tin ore might require further preparation before it was smelted. Tin ore still entrapped in waste material had to be broken down, or crushed, before being put through the separation process again, and by the end of the medieval period that crushing had been mechanised using water driven stamp mills. Smelting of tin prior to the middle of the 14th century was carried out in small shaft or

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135 Burt, 'History of Metalliferous Mining', pp. 212-213. One of the earliest sites where there is evidence for the working of primary vein deposits is Furzehill, near Horrabridge in Devon, suggested by Blanchard (*Afro-European Supremacy*, pp. 833-850) as a major source of vein tin in the 12th century. However, whilst 'ancient' workings were discovered here in 1860 (*Mining Journal*, 1860, pp. 312-3, 533, and 633) and 'Fursse Hill als Fursseball' tinwork was actively worked in 1521 and 'a long time before then' (Greeves, pers comm., see also Greeves, 'The Devon tin industry', p. 89), there is no evidence for 12th century working. On the contrary, there is good archaeological evidence for extensive tin working across other parts of Dartmoor at that period (Thorndycraft, et al., 'An Environmental Approach').

136 Gerrard, 'The Early South-Western Tin Industry'.

bowl furnaces.[137] It was a two stage process, a first smelting on or near the workings and a second smelting (refining) at Exeter, Bodmin or another town designated by the Warden of the Stannaries.[138] Both smeltings were initially points at which tax was levied but by 1305 coinage was divorced from smelting. Subsequent improvements in smelting made the second smelting unnecessary. The larger furnaces with water powered bellows, blowing houses, were then capable of producing metallic tin in one process.[139]

4.3 Iron mining and production.

The demand from agriculture, building and the material of warfare gave iron production considerable impetus. A widespread industry, already well established at the Conquest, was developed to supply local and regional demand. Areas specialising in the mining and smelting of iron ores can be identified. These drew on a varied ore resources, each requiring different mining techniques.

Historians of the medieval iron industry have focussed attention on certain localities with substantial and sustained production, for example the Sussex Weald, south-west Yorkshire and the Forest of Dean. But iron was probably the most common mineral and sufficient could be mined to supply a small bloomery in most areas of England. For example, six settlements scattered across the western and southern parts of Somerset are recorded in Domesday as paying, or having paid, dues in iron blooms. Other payments in

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137 Jenkin, *Cornish Miner*, pp. 68-9; Tylecote, *Prehistory*, pp. 44-47.
138 Lewis, *Stannaries,* p. 134
139 Earl, 'Melting tin in the West of England'.

iron or reference to iron working can be found in at least four other counties.[140] It is also becoming evident from archaeological work that there were far more centres of specialisation than had previously been supposed. In south-west England recent work has strengthened the view that Exmoor and its borders hosted a thriving iron industry throughout the medieval period.[141] Similarly it has been demonstrated that mining and smelting of iron was carried out on the Blackdown Hills of east Devon from the Roman period until at least the mid 15th century.[142]

A significant proportion of demand for iron was local, agricultural and building sundries, which makes production difficult to quantify. Schubert has concluded that conflict during the reign of the early Norman kings reduced the agricultural demand for iron. Production recovered in the early 12th century as mines and forges were either acquired or established by monastic orders, principally by the Cistercians. Purchasing of iron by the Crown for military use, either in weapons or in castle building, is well documented, with the Forest of Dean as the largest supplier.[143] Production of iron in England is estimated to have been around 1,000 tons in 1300.[144] This was not enough to fully satisfy demand, and large amounts of iron were imported from Spain and the near continent. The availability of imported iron may have contributed to a decline in home production after 1300 although it is possible that a shortage of wood had a greater impact. Whatever the causes the evidence suggests a general fall in iron making capacity prior to the advent of the

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140 *Domesday Book*, 8 Somerset 1,4. 3,1. 17,3. 19,4; 27; 65. 21,75-76; op cit., 38 Index of Subjects, p. 98. The bloom was the product of one firing of the bloomery furnace, hammered to extrude the slag and resulting in a more or less homogenous mass of malleable iron (the direct process).

141 Juleff, *Earlier Iron-working on Exmoor*; Juleff, pers. comm.

142 Griffith and Weddell, 'Ironworking in the Blackdown Hills'.

143 Schubert, *Iron and Steel*, pp. 81-87 and 94-98.

144 Miller and Hatcher , *Towns, Commerce and Crafts*, p. 62, quoting Pollard and Crossley, The Wealth of England 1085-1966, p. 44.

Black Death. One exception appears to have been the Weald, where the proximity of London may have stimulated production. Here the introduction of water power for bloom processing (hammering) suggests a requirement for increased capacity. Renewed demand for iron in the 15th century was again accompanied by the application of water power to both smelting and processing, allowing for increased production with the limited labour available. By the end of the century further increases in production were made possible by the introduction of the blast furnace (indirect process) into south-east England.[145] There is unfortunately little evidence regarding capital required for iron mining and iron working. Before the 15th century it was probably low and came from the resources of the individual operator. With the introduction of water power to iron working processes, later evidence from the Weald would suggest that landowners were willing to invest in the fixed capital of the ironworks themselves.[146]

The techniques of mining varied from area to area depending on the nature of the iron deposits. In some areas bog iron ores, deposited by iron-rich water as a horizon in the soil, were worked at an early date by simple pitting.[147] Stratified clay ironstone in the coal measures of south-west Yorkshire, comprising a multiplicity of thinly bedded nodular deposits, where well suited to working by means of bell pits once the outcrop deposits were exhausted. These shallow shafts, widened at their base to work as much ground as the roof stability would allow, are generally associated with coal working. However they appear to have been developed in the medieval period when iron was of greater value than coal. Abandoned workings are sometimes found back-filled with unwanted coal from the

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145 Schubert, *Iron and Steel*, pp. 111-115 and 145; Miller and Hatcher, *Towns, Commerce and Crafts*, p.63; Crossley, 'Medieval iron smelting'.

146 Zell, *Industry in the countryside,* pp. 237-8.

147 Tylecote, *Prehistory*, p. 125.

next shaft.[148] Iron deposits in the limestone occur in two forms: either as metasomatic alteration of the limestone to carbonate ironstone, as found in association with lead veins in Upper Weardale, co. Durham, or replacement and karsitic deposits where iron oxides have replaced the limestone or filled existing cavities within the rock, as in the Forest of Dean and the Furness area of southern Cumbria. The former were worked at outcrop or in conjunction with lead/silver rake workings from the 12th century.[149] In the Forest of Dean the irregular masses of oxide ores (haematites and limonites) were worked at outcrop by a combination of trenching and shallow tunnels, leaving a characteristic series of hollows locally referred to as 'scowles'. Similar workings might be expected in Furness. On the Weald in south-east England ironstone nodules, found in Cretaceous clays, were worked by pits at outcrop or by shallow shafts up to 12 metres deep.[150] In east Devon the iron nodules, found in the Cretaceous Upper Greensand which cap the Blackdown Hills, have been worked by multiple shallow pits.[151] Lenticular deposits, as on Exmoor, and fissure deposits (veins) appear to have been exploited at surface as linear openworks, although a positive chronology has yet to be identified.[152]

There is archaeological evidence to suggest that some iron mining areas were exporting their ores for processing elsewhere. A cargo of iron ore was found in a boat, dating from 1240 to between c 1250 and 1280, wrecked at Magor Pill on the Severn estuary. The boat's structure was not suitable for work on the open sea and the probable origin of the ore was at or near Llanharry in Glamorgan, implying a regional trade in iron ores.[153] This

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148 Tylecote, *Iron smelting*, pp. 116-7; Moorhouse, 'Iron Production'.
149 Dunham, *Tyne to Stainmore*, p. 4.
150 Cleere and Crossley, *The Iron Industry of the Weald*, pp. 15-21 and 98-9.
151 Griffith and Weddell, 'Ironworking in the Blackdown Hills'.
152 Juleff, *Exmoor*, p. 13.
153 Nayling, *The Magor Pill medieval wreck*, pp. 105-115.

is reinforced by archaeological evidence for the movement of Forest of Dean ores across the Severn to the Bristol area.[154] Even within an area of specialisation iron ore might be carried some distance before being smelted.[155] Smelting locations were largely determined by the availability of fuel, wood charcoal, and, in the 15th century, by the availability of water as a power source.

4.4 Copper mining

Copper mining had a lengthy pedigree in the British Isles during the Bronze Age but there is little evidence for it being worked beyond the period of Roman occupation. Even after 1066 there are only occasional references to copper mining. Copper ores of some form were being worked at Bere Ferrers, south Devon, in the early 13th century probably for their silver content but their origin is unclear.[156] Tradition has it that copper was worked in north Devon at North Molton 'by the Romans' and during the reign of King John but the earliest documentary reference to the mine there is 1346.[157] There is no evidence of sustained production although the mine was again noted as a copper working in 1524.[158]

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154 Allen, 'A possible medieval trade in iron ores'.

155 Moorhouse, 'Iron Production', p. 755.

156 PRO, *Pipe Rolls*, E372/162. Account of Stephen de Brawode, Michaelmas 9 Edward II - 28 June following.; *Exchequer Accounts*, E101/261/21 (2), Account of Ricardus de Wygorn keeper of the mines from Michaelmas 10 Edward II to 1 July following; E101/261/13, Account of Robert Thorpe clerk, keeper, from Michaelmas 5 Edward II to Michaelmas 6 Edward II.

157 Anon, *New Bampfylde Copper Mine*; *Cal. Fine R.*, vol. 5, p. 454.

158 PRO, *Letters and Papers, Henry VIII,* SP1/236 f1.

Copper was regarded as being subject to royal prerogative and was regularly included in royal grants of mines from the 1260s.[159] In 1319 copper/silver deposits in the Caldbeck Fells of Cumberland were investigated but again there is little evidence of sustained production although the mines there were worked to an unknown depth prior to the arrival German miners in the area in 1568.[160] A mine of copper and silver was also reported in Shropshire on the demesne of the alien priory of Wenlock in 1394, although nothing further is heard of its working.[161] The attraction of these deposits was undoubtedly their silver content with only limited demand for copper metal. Increased military use of copper in the manufacture of cannon during the last years of the medieval period was satisfied by imports from the continent. Although the problems faced by the Crown in securing supplies in time of conflict are well illustrated by events in 1540-41, when an embargo was placed up to 4000 cwt of copper, paid for at Antwerp, intended for Henry VIII's campaign in the Low Country.[162] Despite the obvious strategic advantage of controlling supplies of copper there is no evidence for large scale exploitation until the latter half of the 16th century and then with only limited success.[163] Non argentiferous copper was worked at Ecton, in Staffordshire, in the 1630s. But it was not until the end of that century, and the successful application of reverberatory smelting techniques to copper ores, that English copper mining took off. It then expanded to world dominating proportions by the mid 19th century.[164]

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159 For example *Cal. Pat. R.*, Edw. I, vol. 2, p. 322; *ibid.*, Hen. III, vol. 5, p. 256.; *Cal. Fine R.*, vol. 7, p. 71.

160 *Cal. Fine R.*, vol. 2, p. 389-90. Donald, *Elizabethan Copper*, p. 173.

161 *Cal. Pat. R.*, Ric. II, vol. 5, p. 444; *Cal. Close R.*, vol. 6, p. 128.

162 *Letters and Papers Henry VIII*, Vol. 16 (1540-41), pp. 1058, 1070, 1080, 1126 and 1132.

163 Hammersley, 'Technique or Economy'.

164 Harris, *The Copper King*, pp. 1-17; Burt, 'Metalliferous Mining', pp. 214-5.

4.5 Coal mining

The real expansion of coal mining dates from after 1500 when the scarcity of wood for fuel in the growing urban areas, London in particular, made the burning of coal an attractive proposition despite the problems of transport and noxious emissions. However, coal had been used as fuel from at least the Roman period. In the late medieval period it was the preferred fuel in high quality smithing, as an industrial fuel in such processes as lime burning and only slowly was it adopted for domestic heating.

Coal seams are found in the upper Carboniferous rocks across much of the Midlands, the north-east and parts of north-west England along with parts of north and south Wales. But coal is not a homogenous product and the quality can vary even within a single coalfield. Coal in the south Wales field varies from bituminous, with a high volatile content, in the east to anthracite, with a low volatile but high carbon content (more than 93 percent), in the west.[165] For local purposes coal would be worked at outcrop on all the coalfields as the amount of wood available for fuel contracted. The signs are that this was happening in some parts of England by the middle of the thirteenth century as woodland was cleared for cultivation and an increasing amount of that remaining was required as building timber.[166] Those coalfields with access to navigable water were in a position to develop a coastal or riverborne export trade. Thus it was coals from areas like south-west Wales, Newcastle and the Midland coalfields adjoining the River Trent that were the first to be worked on a commercial scale. Small amounts of coal were being shipped coastwise in the thirteenth century, largely for industrial purposes. Lime burning, for the preparation of mortar and plaster widely used in the castle building programme in Wales and elsewhere,

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165 George, *South Wales*, p. 95.

166 Hatcher, *Towards the Age of Coal*, p. 19.

called for significant amounts of fuel and this was a process well suited to the anthracitic coals of south-west Wales. Smaller amounts of coal for iron smithing were shipped coastwise as far as south Devon.[167] The requirement in that case was for a coal that would run or cake as it burned, capable of withstanding the blast from the bellows. Coal, largely for domestic purposes, was being shipped from north-east England to ports on the east and south-east coasts, including London, and by the late 14th century that trade probably exceeded 20,000 tonnes per annum. In addition to this there are numerous examples of its use close to the Midland coalfields.[168]

The methods of working ranged from simple pits on the outcrop of coal seams, through shallow shafts accessing workings to the rise, i.e. towards the outcrop, and possibly 'bell pits' in some fields, to well drained 'pillar and stall' workings organised on a commercial scale by the middle of the 15th century.[169] Drainage of workings by means of levels, watergates or soughs to allow a free flow of water to surface was used in collieries as widely separated as Newcastle, Nottingham and Swansea from the late 14th century onwards, and in 1486-7 horse driven pumps were erected at Moorhouseclose, co. Durham.[170] Large, capital intensive, collieries were, however, the exception. Most coal was produced from small pits with minimal capital investment.

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167 PRO, *Exchequer Accounts* E101/261/10, Counter roll of the Abbot of Tavystock, comptroller, of the revenues of the king's mine in Devon, 26 Nov. 1 Edward II to 26 Jan. 2 Edward II, and E101/261/15, Indenture made between Robertus de Thorp, clerk, keeper of the king's mine in Devon, and Robertus de Berkhamstede, comptroller of the same mine, of the revenue and cash received, Michaelmas 6 Edward II to the same feast 7 Edward II.

168 Lewis, 'The development of industry', pp. 146-147; Smith, *Nottingham*, pp. 1-7; Hatcher, *Towards the Age of Coal*, pp. 16-30.

169 Hartley, 'Tudor miners'.

170 Hatcher, *Towards the Age of Coal*, p. 212-3; Smith, *Nottingham*, p. 6. *Cal. Pat. R.*, Ric. II, vol. 5, 654.

The financial requirements of the small coal workings could be met by those engaged in mining in combination with agriculture. Capital costs were restricted to relatively primitive tools and timber which could be provided from local resources. Even the demands of the larger commercial collieries, with expenditure on unproductive development work and drainage, was within the capacity of local landowners and entrepreneurs. Both ecclesiastical and lay lords engaged in mining, either as rentiers or entrepreneurs in their own right, but evidence of costs is patchy. Much of the evidence comes from the north-east of England where the coastal trade with London ensured that production expanded even during the 15th century recession and colliery rents varied from a few pounds to over a hundred per annum. In the early 15th century the prospect of good receipts justified expenditure on capital works like the £60 spent on a drainage adit by Finchale Priory.[171]

Coal was not used in large amounts in silver mining operations. It is not known to have been used as a fuel for smelting or refining in the period under consideration. The presence of coal amongst silver-lead smelting residues found in a 16th / 17th context during recent preliminary archaeological investigations at Combe Martin, in north Devon, is as yet unexplained.[172] It does, however, suggest that it may have been tried as a fuel for new smelting technology introduced in the century following 1500.

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171 Hatcher, *Towards the Age of Coal*, p. 72-77.

172 Dunkerley, *Preliminary Report* and Dunkerley, pers. comm.

4.6 Mining for other minerals in summary.

Of all mining activity in late medieval period only tin made a significant contribution to export earnings and it is against its value that we can judge the performance of the silver mining sector. Production had risen rapidly through the 12th century, being worth over £3000 per annum in the early years of the 13th century. Although production then fell back, the rise in tin prices meant that the industry was worth over £7000 per annum in the early 14th century.[173] This was achieved using undemanding techniques to exploit relatively shallow placer deposits.

Iron and coal largely satisfied local demand, whilst lead found a wider domestic market. However, by the end of the period this was changing with both lead and coal production expanding to satisfy new demands. The techniques employed throughout the period were generally simple with little demand on capital. It will be shown below that, prior to the late 13th century, silver mining had much in common with other mining activity. It shared a common ore base with lead mining, it was organised and regulated in much the same way as lead and tin, and made similarly low demands on capital. Only after the centre of silver production moved to the South-West of England did the techniques, organisation and capital requirements of silver mining diverge from those of other mining activity.

Nevertheless, in the late 13th century the English Crown could call on skills developed in both tin working and lead mining. The skills of the 'tinners' in draining their stream workings were utilised in the early development of the Devon mines but silver-bearing

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[173] See page 117 below.

ores required hard rock mining techniques. It was to the lead mining fields that the Crown turned for the skills required to develop deep mining.

5. Summary

From the very start of the period under consideration silver played an important role in the economy of England and Wales. The availability of silver, from local and continental European sources, stimulated an increased use of coin in commercial transactions. Demand was maintained despite the dramatic demographic decline of the late 14th century. At its nadir in the mid 15th century, the scarcity of silver provoked an economic crisis when mint output fell to low levels.

Whilst a large proportion of the silver entering the economy, particularly during the latter part of the period, came from continental Europe, there were important, geologically diverse, resources in England and Wales. The shallow, sometimes rich, silver-bearing ores of the Carboniferous Limestone uplands were the first to be worked, with those in the Northern Pennines making a significant contribution in the 12th century. Working of deeper silver-bearing deposits in north and south Devon did not commence until the late 13th century. By the close of our period those mines were deep and it was not until the 19th century, and the application of steam powered pumps, that the deposits below the medieval workings were fully exploited.

The mining of silver bearing ores was not carried out in isolation from other mining activity. Throughout our period a variety of minerals were mined in all parts of both England and Wales. Those mining fields could influence, and be influenced by, the techniques employed in silver mining and, in the latter part of the period, provided a pool from which the Crown could draw its skilled labour.

Chapter 2.

The Documentation for Silver Mining in England and Wales.

The documentation for silver mining across the period under study, 1066 to 1500, varies considerably in both quality and quantity. As a general rule, the greater the involvement of the English Crown, either through its lordship of the soil or its right of prerogative over the minerals, the better the surviving documentation. The scant early records of royal administration, prior to the 13th century, are supplemented by occasional references in the chronicles of the period and the survival of some material relating to mineral holdings by lords other than the Crown. For the period 1292 to 1350, when directly engaged in silver mining, the records of the Crown are particularly detailed, but thereafter the record is inconsistent. This later documentation is augmented by that of the legal processes, ecclesiastical administration touching on mining, and the records of later mining ventures encountering the works of the medieval miner.

1. The records of the English Crown.

From the Domesday survey through to the detailed accounts of the mines worked directly by the Crown, these records provide the core of the evidence on which to base this examination of silver mining. The Domesday survey of 1086, as an assessment for a 'land tax', provides us with only limited information on mining activity.[1] It is not until the first

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[1] Transcription and translation published by Phillimore (*Domesday Book*, John Morris, gen. ed.).

surviving *Pipe Roll* of 31 Henry I (1130) that we have a firm record of silver mining, in the Northern Pennines.[2] Entries in the *Pipe Rolls*, disrupted by the troubles of Stephen's reign, resume in 1158 and provide us with a continuous, if limited, record of silver mining on Crown lands in the Northern Pennines throughout the rest of the century.[3] Access to the record is greatly assisted by the published transcripts of the early Rolls by the Records Commission, continued by the Pipe Roll Society.[4] Interpretation of the Pipe Roll entries for the 12th century, in Chapter 3 (Production) and Chapter 6 (Organisation), is assisted by reference to late documentation on the border counties, particularly entries in the *Assize Roll*, many of which were transcribed by Bain in the 1880s.[5]

From the early 13th century, with growing Crown interest in securing home sources of silver, there is an increase in the amount of documentation; primarily in the form of grants and mandates to Crown officers, *Patent* and *Close Rolls*, and entries in the *Liberate* and *Fine Rolls*, concerning the financial implications of silver mining. These, supplemented by entries in *Memoranda Rolls*, *Inquisitions ad quod damnum* and *Post Mortem*, continued through and beyond the period under consideration. Access to much of this documentation was aided by reference to the printed Calendars.[6]

In 1292 the English Crown commenced direct working of silver mines in Devon. Thereafter we have available to us, amongst the *Exchequer Accounts*, documentation

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2 *Magnus Rotulus Scaccarii de anno 31 Henrici I*, p. 142.

3 See Chapter 3 for an interpretation of the record.

4 *Magnus Rotulus Scaccarii de anno 31 Henrici I*; *The Great Rolls of the Pipe, 1155-1158*; *Pipe Rolls* (PRS).

5 *Calendar of Documents relating to Scotland*, ed. Joseph Bain.

6 There is no current published list of the various Transcripts, Calendars and Lists published by the Public Record Office and its predecessors. The author used HMSO, Government Publications, *Sectional List 24: British National Archives*, revised 1 January 1984, as an aide memoir.

connected with the organisation and financing of mining in the period to 1349. For the best documented period in the early 14th century, the *Accounts* deal almost exclusively with the Bere Ferrers mines. Any conclusions drawn from their content is therefore heavily weighted towards those mines.[7] The documentation, although extensive, is not complete and must be supplemented where possible with material from other Exchequer records, principally *Foreign Accounts* and *Memoranda Rolls*. We are, however, fortunate that the records for the period 1327 to 1336 were examined and comment on in detail by Salzman in the 1940s.[8] Some material relating to the working of the Devon mines, found amongst the records of the Crown, was also transcribed by the Records Commission in the mid 19th century.[9] Other material relating to smelting activity carried out at Calstock in connection with the south Devon mines, was transcribed and lodged in the Calstock Community Archive as part of a Manpower Services Commission project in the 1980s.[10]

The earliest documents for the Devon mines, at Bere Ferrers and Combe Martin, are the accounts of Vincent de Hulton and his successor William de Wymundeham, as keepers of the mines in the period 1292-97.[11] These and later accounts are concerned primarily with expenditure and the produce of the mines. The methods used for paying workers (see Chapter 6, Section 5.2, *The workforce in the Devon mines*, below), results in greater detail being provided for the smelting and refining of the ores, with weekly payments to workers

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7 For a list of the material within the Exchequer Accounts, see Public Record Office, *List of Various Accounts*, pp. 167-175.

8 Salzman, 'Mines and Stannaries'.

9 British Library, Additional MS 24770-74.

10 For a brief account of the material in the Calstock Community Archive see Mayer, 'Calstock and Bere Alston Silver-Lead Mines in the First Quarter of the 14th Century'.

11 PRO, *Exchequer Accounts*, E101/260/4, Account of Vincent de Hulton keeper of the mines at Birland and Combe Martin, 20-22 Edw. I; 5, Account of mines at Combe Martin, 20-25 Edw. I; and 6, Account of W. de Wymundeham of the mines at Birland and Combe Martin, 20-25 Edw. I. See transcripts at Appendix 7.

being itemised in the surviving wage rolls of the early 14th century. Some miners were, however, listed when pressed into Crown service in the Devon mines.[12] The accounts also provide detailed information on the materials supplied to miners, the candles, picks, ropes and buckets, essential for the extraction of silver-bearing ores. Occasionally the results of enquiries into the state of the mines or, in the case of Combe Martin in 1327, whether the grant of a lease would be prejudicial to the interest of the Crown, provide useful additional information through the eyes of a local jury, sometimes reflecting the view of the miners.[13]

When, after 1350, the Crown moved to let the mines on lease, rather than working them directly, the amount of documentation diminishes. Some lessees made detailed returns, which are to be found amongst the *Exchequer Accounts*, others are basic or non-existent. The account of John Fogge, in 1480/81, itemised expenditure related to the introduction of new techniques. With Falleron, in 1453, the document pleads his case in failing to make a profit whilst others merely recite the terms of the lease.[14] Very occasionally an insight into activity on the periphery of mining, post 1350, is provided by records of legal and ecclesiastical proceedings. The former are found amongst the *Early Chancery Proceedings* in the Public Record Office but the latter were outside the jurisdiction of the

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12 PRO, *Exchequer Accounts* E101/260/17, Documents relating to the sending of miners from Wales to Devonshire, 25 Edw. I.

13 See, for example, PRO, *Exchequer Accounts* E101/262/13, Account of Robert Thorpe, 5-6 Edw. I; PRO, *King's Remembrancer Memoranda Rolls*, E159/91, f.110, Memorandum re. farm of the Devon mines, 11 Edw. II, and 92, f.96, Commission sent to Calstock to sell slag, 11 Edw. II; and PRO, *Chancery: Inquisitions ad quod damnum*, C143/192/10, Inquisition into the Combe Martin mines, 1 Edw. III

14 PRO, *Exchequer Accounts*, E101/266/25, Counter roll of profits and expenses of the mine of Beer Ferrers, 20-21 Edw. IV; 265/18, Particulars of the account of James Falleron, 31-36 Hen.VI; 263/17, Particulars of the account of Thomas Bowland and Conrad Rede, 2-4 Ric. II. See also Appendix 7 (E101/263/12 f2) for a typical example.

Crown and are amongst the small number of references to silver mining found outside the records of the state.

2. Other documents related to silver mining.

There is no significant body of documents for silver mining in the period outside the records of the English Crown. However, as we have seen above, the records of the Crown provide uneven documentation for mining. There is a real need to supplement the basic information, particularly that recorded in the *Pipe Rolls* of the 12th century, and inform ourselves on activity outside of Crown jurisdiction. For this we can refer to a number of sources.

The chronicles of the period are useful prior to the late 13th century. For mining immediately prior to, and during, the reign of Stephen, when the Crown mines were occupied by the Scots, we find references in the accounts of Robert of Torigini, John, prior of Hexham, and occasional references in the records of the Scottish Crown.[15] For record of mining on the estates of the bishop of Durham there are the 'dialogues' of Prior Lawrence of Durham and the survey known as the Boldon Book to supplement the Pipe Roll entries made during vacancies in the see.[16]

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[15] *Chronicles of the Reigns of Stephen, Henry II and Richard I.* Various grants made by the David I of Scotland, found in British Library, MS. Cott. Vesp. E XIX, fo. 110r., are printed in Barrow, *Acts of Malcolm IV.*

[16] *Dialogi Laurentii Dunelmensis monachi ac Prioris. Boldon Buke.*

For the period post 1350 we have surprisingly little documentation outside the Crown records. Analysis of a unique itinerary of the parish of Bere Ferrers provides us with a rare insight into the social aspects of mining.[17] Much of the information on the location of the workings of the Devon mines has to be gleaned from post medieval documents, including the records of 19th century mining companies.[18]

3. The record of silver mining in summary.

The records of the English Crown are by far the major source for this study of silver mining. Entries in the *Pipe Rolls* for the 12th century provide the basic statistical evidence on which to estimate silver production whereas the *Exchequer Accounts* from the late 13th century onwards can give quite detailed analyses of output (Chapter 3). The detail in the *Accounts*, and other Crown documents of the period, provides us with evidence with which to assess the level of technology and organisation in silver mining (Chapters 5 and 6). But the conclusions reached for mining from the late 13th century onwards cannot be used as a model for the earlier part of our period, for that we must use other, less complete, sources within the records of the Crown. We then look to the small number of isolated, often brief, references outside that record to reinforce the earlier model and inform us on aspects of the later period where the records of the Crown are silent.

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17 Exeter: Dean and Chapter, MS3522.

18 See, for example, Cornwall Record Office, Mount Edgecombe MSS, maps and papers re. land at Bere Ferrers, 18th C.; National Library of Wales, G E Owen MSS, reports of the North Devon and Combmartin Mining Co. 1836-48; and West Yorkshire Archive Service, DB178/60, Reports of Beeralstone Mine Company, 1809-23.

Chapter 3.

Silver Production Levels in England and Wales.

The increased use of silver in the English economy and its links with the Crown through the period 1066 to 1500 have provided the historian with some opportunities to derive a range of statistical material. From this it is possible to identify the general profile of medieval silver production, but more precise quantification of output is a difficult proposition. Mint records, available from the mid 13th century, provide little help, being concerned primarily with the recoinage of foreign silver. Only after 1292, during the period when the Devon mines were worked directly by the Crown, is there anything approaching a continuous record of production and that only for the South West. After 1350 the few surviving returns made by Crown lessees can be supplemented by occasional entries in the record of the Exchequer, the 'foreign accounts'. Prior to the 13th century we must rely almost entirely on secondary indicators of production levels. How those indicators are interpreted is the subject of discussion in the early sections of this chapter.

Silver was produced in several parts of the British Isles - see Chapter 1. There are no national production statistics but some general impression of the scale and profile of output can be derived by conducting detailed local studies of the various districts. Qualitative information suggests that the producing districts can be divided into two groups - major producers and minor producers. The major producers were the Northern

Pennines and Devon; the minor producers were found in the upland zone of England and Wales, in **1)** parts of Yorkshire; **2)** the English Midlands, particularly the Derbyshire Peak; **3)** north-east Wales, **4)** the Welsh border, including the western part of the Shropshire field; and **5)** Mendip, in Somerset. We will first review the evidence of output levels in the minor districts.

1. Output levels in the minor silver producing districts.

Prior to the Norman Conquest in 1066 and up to the early part of the 12th century silver production in England and Wales came from shallow lead deposits of the upland zone. By the 11th century that silver was being minted, along with foreign silver generated by continental trade, at a large number of centres. However, indicators which might assist in estimating levels of production, e.g. the portion due to the mineral lord or tithes paid to the church, have not survived in the historical record prior to the 12th century. The great post Conquest survey of land holding in 1086, the Domesday Book, pays scant regard to mineral production.[1] Domesday provides us with some evidence as to location but none as to the level of production. We have, therefore, no evidence on which to base any reliable estimate of silver production prior to the 12th century. However, the situation changes with the start of a series of returns on income from Carlisle and the county of Cumberland - one of the major centres of production in the Northern Pennines - entered in the Pipe Rolls of the Exchequer from 1130.

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[1] As a 'land tax assessment' Domesday was concerned primarily with land holding not the profit gained from the holding; see Chibnall, *Anglo-Norman England*, pp. 105-115.

As will be shown below, output from the Northern Pennines during the 12th century was significant but silver production was not confined to that area. A number of lesser deposits were exploited across England and Wales. However, quantifying production is, with the exception of the mine at Carreghofa, on the Welsh border, hampered by a lack of documentary evidence.

1.1 Production from mines in Yorkshire.

The farm of the 'mine of Yorkshire' was accounted for in the Pipe Roll, along with the returns for Cumberland and the 'mine of Carlisle', for one year only (1163).[2] At £20 the farm possibly represents production in that year of from 2150 to 2360 ounces of silver. These figures are derived from those for the Mine of Carlisle, explored in detail below, where the farm represented the value of the portion of ore due to the Crown, i.e. a tenth part, less the cost of smelting and refining, and a moderate margin of profit for the farmer.[3] As the location of the mine is as yet unknown and there is no other documented return for the mine, this estimate is speculative.[4]

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2 *Pipe Rolls* PRS 6, p. 10.

3 See Section 2.2.1, *The evidence for the Crown lands - the 'mine of Carlisle'*, below. Production here and throughout this chapter is expressed in ounces, the 12th part of a Tower pound (see Appendix 15 for details).

4 The 'mine of Yorkshire' might have been in Swaledale where the king's 'works' are attested in 1219 (*Rotuli litterarum clausarum*, vol. 1, p. 409) and Richard Phitun, constable of Richmond, ordered to cease hindering the king's miners there (*Calendar of Documents relating to Scotland*, vol. 1, p. 125; quoting Fine R., 3 Hen. III, m. 4, dorso.).

1.2 Production from mines in the English Midlands.

The location of silver producers in Derbyshire is indicated in the Domesday survey of 1086. An annual payment in pure silver (*puri argenti*) of £40, replacing £32 and 6½ sesters of honey in 1066, was specified for the five manors of Darley, Matlock, Wirksworth, Ashbourne and Parwich, with their outliers, within which there were four *plumbariae*, lead works or mines.[5] It would be unwise to translate a tax payment into a figure for local production but the specification does suggest the mines there were capable of producing at least that amount of silver.

During the civil conflict associated with Stephen's reign, 1136-1154, coins produced in the mints of the English Midlands, along with those produced by mints on the Scottish border, were on average of a higher weight of issue than those produced elsewhere.[6] Again this is suggestive of a local source of silver but there is insufficient numismatic evidence on which to base any estimate of production levels.

1.3 Production from mines in north-east Wales.

There is a similar problem in quantifying production from the silver mine(s) near Basingwerk, in north-east Wales, noted by Giraldus Cambrensis in 1188. Englefield or Tegeingel, north-east Clwyd, where the workings lay, was in Welsh hands for all but a few years up to 1241 and it is assumed that silver mined there was minted at Rhuddlan.

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5 *Domesday Book*, Derbyshire 1,15.

6 Blackburn, 'Coinage and Currency', pp. 170-1, Table 5.4.

The assumption has yet to be tested and no attempt has been made to relate the numismatic evidence to production values.[7]

1.4 Production from mines on the Welsh border.

Silver had been produced from mines on the border, some of which were in the western part of the Shropshire lead mining field, prior to 1066 and the continued availability of silver is indicated in the Domesday survey.[8] No quantitative information for this early working is available. This district does, however, provide the best documented production figures for any silver mine prior to the late 13th century, an ephemeral affair at Carreghofa, north of Oswestry. Working of the mine was instigated on instruction from Hubert Walter, bishop of Salisbury, in 1194 with a view to providing bullion to pay Richard I's ransom. The castle at Carreghofa was refurbished to provide a base for troops guarding the mine, the mint at Shrewsbury was reopened to coin the silver produced and working of the mine was under the control of Crown officers. Unfortunately the output of the mine was worth only £20 11s. 1d., i.e. less than 250 ounces of silver was produced from the ore mined, and 41s. 1d. of that was paid as tithe to the church. Mining had ceased by Michaelmas 1195.[9]

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7 See page 217 below.

8 See Chapter 6, Section 1 below.

9 *Pipe Rolls* PRS NS5; PRS NS6. See Wells, 'The Shrewsbury Mint' for details of the mine and the operation of the mint, and Brand, 'Some Short Cross Questions', for a reassessment of mint operations.

1.5 Production from mines on Mendip.

Mines on Mendip were a source of silver prior to 1066. Although no documentary evidence survives for silver production from mines in the bishop of Wells' manor on Mendip prior to the 13th century, later activity is documented. No figures for the amount of silver produced are given. Neither is there mention of silver during the short periods during the 13th and 14th centuries when the see was vacant and in the hands of the Crown.[10] From this we must presume that silver production levels on Mendip were low and not sustained.

1.6 The minor silver producing districts in summary.

From the evidence available to us, the suggestion is that production was sporadic and together the minor districts produced little silver. However, that conclusion would be open to reinterpretation should further evidence come to light, particularly for districts like north-east Wales. In addition, on occasions throughout the period, small amounts of silver will have been extracted from lead produced in the essentially 'non-argentiferous' mining fields. Lack of documentary evidence does not allow us to quantify such production but, in those cases, silver was a by-product with base metal the primary objective. We now move on to consider output from the major silver producing districts, where the precious metal was the primary, most valuable, produce and lead the by-product.

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[10] PRO, *Ancient Correspondence*, SC1/48/177, leadreeve(?) to the Bishop of Bath and Wells, no date. Gough, *Mendip*, pp. 51-53.

2. Output levels in the major silver producing districts.

The major districts saw their principal production periods at different times - the Northern Pennines in the 12th century, and Devon in the late 13th / early 14th century. The quantifiable evidence available for these districts, and explored below, does suggest that they accounted for the lions share of total national output during the period under consideration.

Any speculation on past production from the Northern Pennines is, however, made all the more difficult as the ores from that district, like those from the minor districts, have in recent history been regarded as low in silver. In 1949, and in 1990, K. C. Dunham could, on the evidence from 18th-19th century production, state that 'the normal silver content in Northern Pennine deposits varies between 4 and 8 ozs per ton of lead metal'. Although County Durham alone produced over 1.1 million ounces of silver between 1882 and 1913, little of that would have been recovered before the introduction of new enrichment processes developed by Pattinson and Parkes in the 19th century. However, Dunham did accept that higher silver yields were possible for ores found in certain localities, particularly in the valley of the South Tyne near Alston, based on modern assays taken from below the oxidised zone.[11] And, there is strong archival evidence, highlighted by 19th and early 20th century antiquarians, which suggested that silver, rather than lead, was the primary objective of mining in the 12th century.[12]

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[11] Dunham, *Tyne to Stainmore*, (London, 1st edn., 1949), pp. 84-88; and (2nd edn., 1990), pp. 69-72. Burt, et al. *Durham and Northumberland*, p. xvii. See also Chapter 1, Section 3.2 above.

[12] For a summary of the antiquarian evidence, see Walton, 'Alston'.

The best, and only, continuous series of production data relates to Devon in the years following 1292, when new silver bearing deposits were opened up, and worked directly by the Crown. From that date through the first half of the 14th century production levels were enrolled in the Exchequer Accounts. Details are given in Fig. 15 below. As can be seen production peaked in 1297, and again in 1306, at 23,229 and 21,516 ounces of silver per annum respectively, and the reputation of the area as a high level silver producer continued into the 19th century.

2.1 Earlier estimates of production from the Northern Pennines.

Dunham later reconsidered his view on the potential for Northern Pennine silver production in the medieval period prompted, as much as anything. by Blanchard's article, 'Lothian and beyond:', which suggested production peaks of over 16 tonnes of silver per annum in the mid 12th century.[13] Blanchard's estimates, however, were problematic. He offered no new evidence, nor any reinterpretation of the existing evidence, to support such high levels of production. However, in his recent work on *Mining, Metallurgy and Mining in the Middle Ages* he suggests that the 'farm' of the mines in Northern Pennines included the right to operate the mints, through which all the silver produced had to pass, and the level of the farm reflected the profits of the mint. From those profits he comes to a conclusion on the figure for total production of silver.[14] Yet minting records do not survive for that period and, whilst there were moneyers amongst the farmers of the mines,

[13] See Dunham, et al. 'Rich silver-bearing lead ores in the Northern Pennines?', published after Dunham's death. Blanchard, 'Lothian and beyond', fig. 2.1.

[14] Blanchard, *Afro-European Supremacy*, p. 589.

both the 'Mine of Carlisle' and those on the bishop of Durham's estates, there is no consistent linkage between the farmers and the mint. The 'farm' of the 'mine of Carlisle' is considered further at Section 2.2.1 below.

Even with the limited criteria given by Blanchard in his papers we can identify a problem which undermines his postulated production levels: what happened to the lead which was a significant by-product of silver refining? The increasing ecclesiastical and Crown building programme in the 12th century was the major market for lead but it is difficult to see how it would have absorbed the volume accompanying the silver output suggested by Blanchard. Given the silver values suggested by Blanchard, refining one tonne (34,281 ounces) of silver would have generated something like 200 tonnes of sterile lead.[15] Multiply that by the suggested 24 tonnes (16+ tonnes for Durham alone) in 1166 and the release of so much lead would have depressed the market, causing prices to plummet. Yet indications are that the lead prices in the Northern Pennines at that period were buoyant, with prices rising and not falling back for nearly twenty years.[16]

So what is the quantitative evidence for silver mining the Northern Pennines during the 12th century? No production figures as such have survived, if they were ever recorded,

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[15] Based on silver values of around 125 ozs per ton of lead metal (see Appendix 2, Section 2, above, and the figures for 1309 to 1312) - comparable with the 20-100 oz. of silver per ton of ore suggested by Blanchard (*ibid.*, p. 599).

[16] The allowance given against the farm of the mine of Carlisle for lead supplied by Crown writ rose from 9s. per cartload in 1168 to 13s. 4d. per cartload eleven years later. Lead was again accounted for at that price in 1181, the last year that there is evidence for it being sequested from the 'mine of Carlisle'. Lead from sources in Yorkshire, which appears to have been the production leader at that period with a recorded output of over 550 tonnes between 1179 and 1184, was also accounted for at 13s. 4d. until 1183 when the price fell to 12s 6d. per cartload. Six years late Derbyshire lead was priced at 10s. per cartload. However, in 1211 the bishopric of Durham was accounting for lead at over £1 per cartload. (*Pipe Roll*, PRS 12, p. 109; PRS 28, pp. 29-30; PRS NS26, p. 41. See also Raistrick and Jennings, *Lead Mining in the Pennines*, pp. 25-26.)

but there are secondary indicators for possible production levels. I shall suggest how those indicators can be interpreted and used to provide credible production estimates.

2.2 Northern Pennine silver in the 12th century.

In 1130 £40 was due from William and Hildret for the farm of a silver mine, later referred to as the 'mine of Carlisle', and the amount paid was entered in the Pipe Roll of the Exchequer. Also entered in the roll was the 100s. paid by the burgesses of Carlisle for the 'old' farm of the mine (*de Veti firma Mineirie Argi*); where 'old' refers to the farm for the year, or years, prior to 1130.[17] These entries are the first in a series, to be found in the Pipe Rolls amongst the returns for Carlisle, later the county of Cumberland, which from 1158 provide a continuous record for the 'mine'.[18]

The 'mine of Carlisle' was a collective name for all the minerals worked under Crown lands in those parts of Cumberland and Northumberland around Alston in the liberty of Tynedale, in the high Pennines some 35 miles to the east of Carlisle.[19] The discovery and exploitation of silver in that area is confirmed by Robert of Torigini who noted that in

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17 *Magnus Rotulus Scaccarii de anno 31 Henrici I*, p. 142

18 See Appendix 1.

19 *'The king's predecessors have always had in Tindale, belonging to the king's castle of Carlisle, a certain mine, for which the Constable ought to answer'* (*Calendar of Documents relating to Scotland,* vol. 1, p. 125; quoting Fine R., 3 Hen. III, m. 4, dorso.). The identity of the mine is confirmed in later documents as being '*the mine of Aldeneston* (i.e. Alston - that part of Tynedale lying within Cumberland), *currently in the Exchequer by the name of the mine of Carlisle*' (*Cal. Pat. R.*, Hen. V, vol. 2, p. 57); See Chapter 6, Section 2, below for more detail.

1133 (33 Hen. I) the miners paid the Crown £500 per annum to dig the metal from the bowels of the earth.[20]

Unfortunately these early figures suggesting the rapid exploitation of a rich source of silver are interrupted by the disruption of King Stephen's reign, when the Scots moved south to occupy the border counties of Cumberland and Northumberland. Continued exploitation of the silver resources under the Scots is indicated by the significant amount of coin minted during their occupation and the occasional grant by David, King of Scotland, out of his revenue from the mines.[21] It is only after the accession of Henry II and the withdrawal of the Scots that there were further returns to the Exchequer for the farm of the mine of Carlisle. No such returns are available for the mines within the bishop of Durham's estates, in the upper parts of Weardale and its tributaries between the rivers Tees and Tyne. For those mines we must rely on occasional chronicle reference and returns to the Exchequer during vacancies in the see.

2.2.1 The evidence for the Crown lands - the 'mine of Carlisle'.

The figures available for Tynedale, and the mine of Carlisle, are the farm of the mine; the issues or profit of the mine for the two years, 1184 and 1185, when the farm was not let; the quantity of lead occasionally sequested by the Crown, the value of which was allowed

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20 *Chronicles of the Reigns of Stephen, Henry II and Richard I*, vol. IV. p. 123.

21 In about 1141 the priory at Nostell was granted 3 marks per annum by King David, *'from his mine of Carlisle'*, with a similar sum being granted by his son Earl Henry from the same source. (Barrow, *The Acts of Malcolm IV*, pp. 111-12 and nos. 39-40). This was seen as a temporary arrangement replacing and, after the occupation, replaced by grants from rents in the Honour of Huntingdon (*Ibid.*, nos. 37-38 and 203-4).

against the amount due for the farm; and the sum allegedly paid to the Crown by the miners in 1133. The issues of the mine provide the best starting point for calculating production. However, we first need to establish what is meant by issue (*exitu*) in relation to the mine of Carlisle. Issues are effectively the profits of the mine, in this case the profits to the Crown. They can be either the output, as mined, less expenditure, where the mine is worked directly, or that portion of the ore reserved to the Crown where the mine was worked by a second party. There is no evidence that the mine of Carlisle was worked directly by the Crown. In fact the reverse is the case. The evidence indicates that the Crown distanced itself from the operation of the mine, allowing the miners a degree of autonomy and the right to work the mine according to custom.[22] In return for that right the miners paid '*each ninth disc (dish) dug*' to the Crown.[23] With the church having already taken its tithe, that ninth dish represented a tenth part of the produce.[24]

The value of the issues are available for two years only. In 1184 (30 Hen. II) Walter de Carleol along with Richard de Logis and Humfrey his brother rendered account of £61 11s. for the issue of the mine of Carlisle, as keepers (*custodes*).[25] In the following year the amount was £73 9s.[26] These figures represent the profit to the Crown on a tenth part of the produce after deduction of expenses. Neither the expenses nor the means by which the

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22 See pages 209-213 below.

23 *Calendar of Documents relating to Scotland*, quoting Assize Roll (Cumberland), 6 - 20 Edw. I, Jan. 16, 1278-9.

24 In Crown leases of the mid 14th century onwards the right of the church to first take its tithe was presumed when the royalty was set at the ninth part. Only occasionally was the formula recited in full as in 1385 for the mines in Devon, when the lessee was '*to account to Holy church for a tenth part of his profit .. to the king for a ninth*' (*Cal. Pat. R.*, Ric. II, vol. 2, p.572.)

25 *Pipe Roll*, PRS 33, p. 43. For translation see Wilson, J., *Victoria History of the County of Cumberland,* vol. 1, p. 356. As Wilson points out, the term *custodes* is used in 1184 and 1185 in contrast to *firmarii* (farmers) for all other years.

26 *Pipe Roll*, PRS 34, p. 188.

keepers disposed of its portion of the silver bearing ores are accounted for in the Pipe Roll. On the one hand the keepers may have arranged for the ore to be smelted and refined, sold the lead recovered and had the silver coined at the mint in Carlisle. Each stage would incur costs, deductible as expenses. Some estimation of the expenses can be made by comparison with those later incurred in the Devon mines. However, without knowing the proportion of silver to lead in the ores mined in Tynedale it is difficult to estimate the value of the metals recovered, although later assays do suggests values in the range 62 to 421 ounces per ton of metallic lead (1730 to 11747 ppm).[27] In comparison the Devon mines at Bere Ferrers in the period 1303-7 yield was, on average, just under 156 ozs / ton (4341 ppm).[28]

Using a wide spread of silver values, 62 to 421 ounces per ton, allows us to consider the implications for production of both silver and lead. We can address the problems which beset Blanchard's earlier estimates, referred to above at page 91, in accounting for the possibility of excessive production of lead as a by-product of the refining process.

Assuming that **(1)** the keepers smelted and refined that portion of ore due to the Crown, it is possible to estimate the amounts of silver and lead which might have been produced by the mine of Carlisle from ores of 62 and 421 ounces per ton, using figures gleaned from the accounts of the Devon mines in 1307/8.[29] These are tabulated below (Table 1).

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27 *Cal. Pat. R.*, Edw. IV - Hen. VI, p. 464. Unlike the modern assays used by Dunham (page 86 above) these assays would have come from shallow oxidised deposits.

28 See Fig. 14 below.

29 See Appendix 13.

On the other hand **(2)** the issues may result from the sale of that portion of the ore due to the Crown, in which case estimating production is far more difficult. If the sale realised the full value of the ore, its silver and lead content less the cost of smelting and refining, then the profit from the sale represented production levels in line with those calculated above. However if the practice, adopted in Devon during the early 14th century, in respect of tithe ore was used then the amount received would be only a fraction of its true value. In Devon tithe ore due to the church was purchased by the keeper of the mines for 2s. per load, when the miners were paid 5s. for each load they produced and the average silver / lead content, of ore mined in 1307/8, was worth £1 4s 6d. If the portion of the ore due to the Crown from the mine of Carlisle was similarly sold at 2s. per load, the profit to the Crown would represent production levels of 6155 loads of ore in 1184 and 7315 loads in 1185. The amount of silver and lead which might be recovered from that ore would vary

Table 1 Mine of Carlisle; estimated production levels for silver and lead (1).

In **1184**, when the issues (profit) amounted to £61 11s.,

with ores of **62** ozs/ton - **7290 ozs of silver and 104.5 cart-loads of sterile lead.**

with ores of **421** ozs/ton - **7374 ozs of silver and 15.11 cart-loads of sterile lead.**[30]

In **1185**, when the issues (profit) amounted to £73 9s.,

with ores of **62** ozs/ton - **8699 ozs of silver and 124.79 cart-loads of sterile lead**

with ores of **421** ozs/ ton - **8800 ozs of silver and 18.03 cart-loads of sterile lead.**

[30] The carreta or cart-load of lead is later defined as containing 24 feet at 70 lbs, i.e. a total of 1680 lbs of lead (PRO, *Exchequer Accounts*, E101/261/10, Counter roll of the Abbot of Tavystock, 1-2 Edw. II) - see Appendix 15.

depending on the yield. Using figures gained from the Devon mines in 1307/08, the estimates are tabulated below (Table 2).

Table 2 Mine of Carlisle; estimated production levels for silver and lead (2).

In **1184** -	
with ores of **62** ozs/ton -	**41,240 ounces of silver and 592 loads of sterile lead**
with ores of **421** ozs/ton -	**266,183 ounces of silver and 545 loads of sterile lead**
In **1185** -	
with ores of **62** ozs/ton -	**49,009 ounces of silver and 703 loads of sterile lead**
with ores of **421** ozs/ton -	**316,360 ounces of silver and 648 loads of sterile lead**

However, to sell ore for only 2s. per load would represent a considerable loss to the Crown and production levels based on such a sale should be considered as extreme and highly unlikely. The keepers would be expected to get the best price possible for that portion of ore due to the Crown and the profit made should represent a production figure closer to that based on the ores full value less the smelting / refining costs, as given in Table 1 above. Such a presumption is supported by the amount paid for the farm of the mine in 1186 which, at £100, was only 36% above the value of the issues in the previous year.

With a range of possible production figures now available to us for the two years when the Crown profits from the mine were in the hands of the keepers, we move on to estimate possible production for other years based on the farm of the profits. The farm was a lease of Crown income from the mine, that is the profit on that portion of the ore due to the

detailed figures for the Crown profits, the more speculative the linkage is between the farm, the level of the Crown profit and any estimate of production which might be based on the farm. An impression of the overall trend in production levels can be gained from the level of the farm, the increasing debts of the farmer in the period 1167 to 1179, and the amount of lead taken by the Crown and allowed against the sum due for the farm (see Fig. 8 above). The increased amount of lead taken by the Crown in 1176, 1179, and in 1181, when the lead allowed against the farm was over 75% of the amount due, plus the

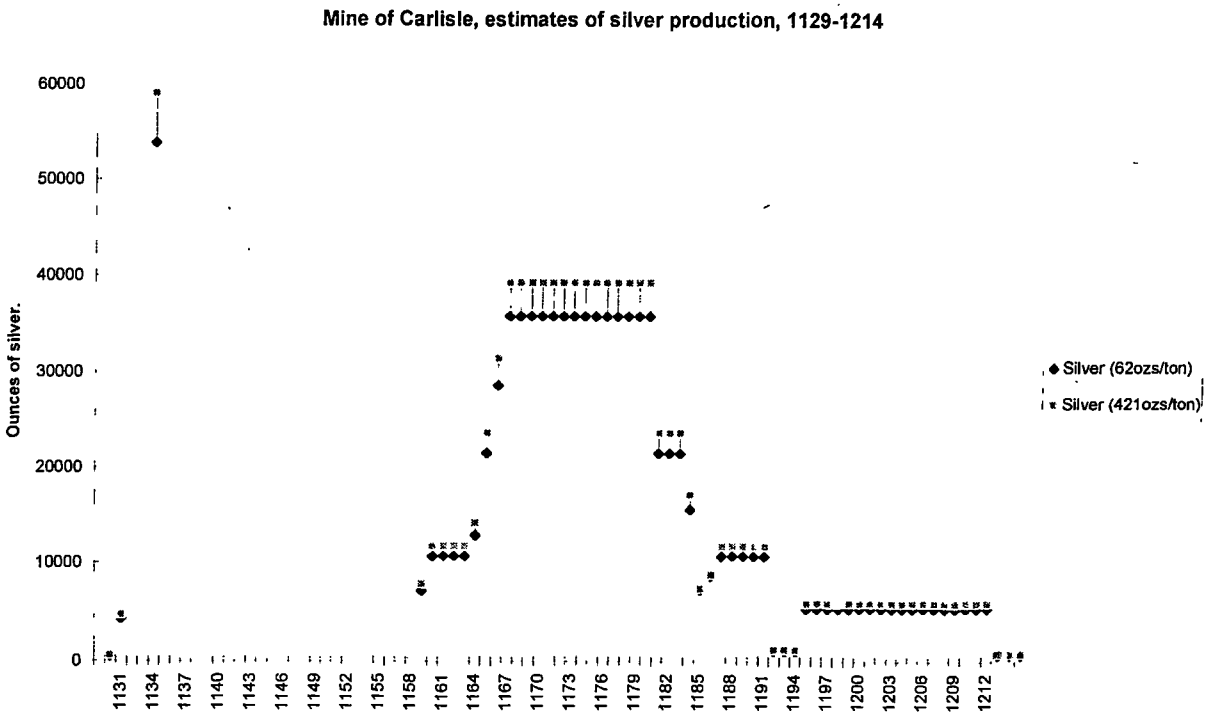

Figure 9 (calculated from data listed in Appendix 1.)

falling value of the farm after 1179, suggests a shift to ores with a lower silver yield. By the 1190s there had been an overall fall to much lower production levels. For the three years 1191 to 1193 the farm was reduced from £50 to £10 after the issues of Northumberland were granted to Hugh de Puiset, bishop of Durham; indicating that the

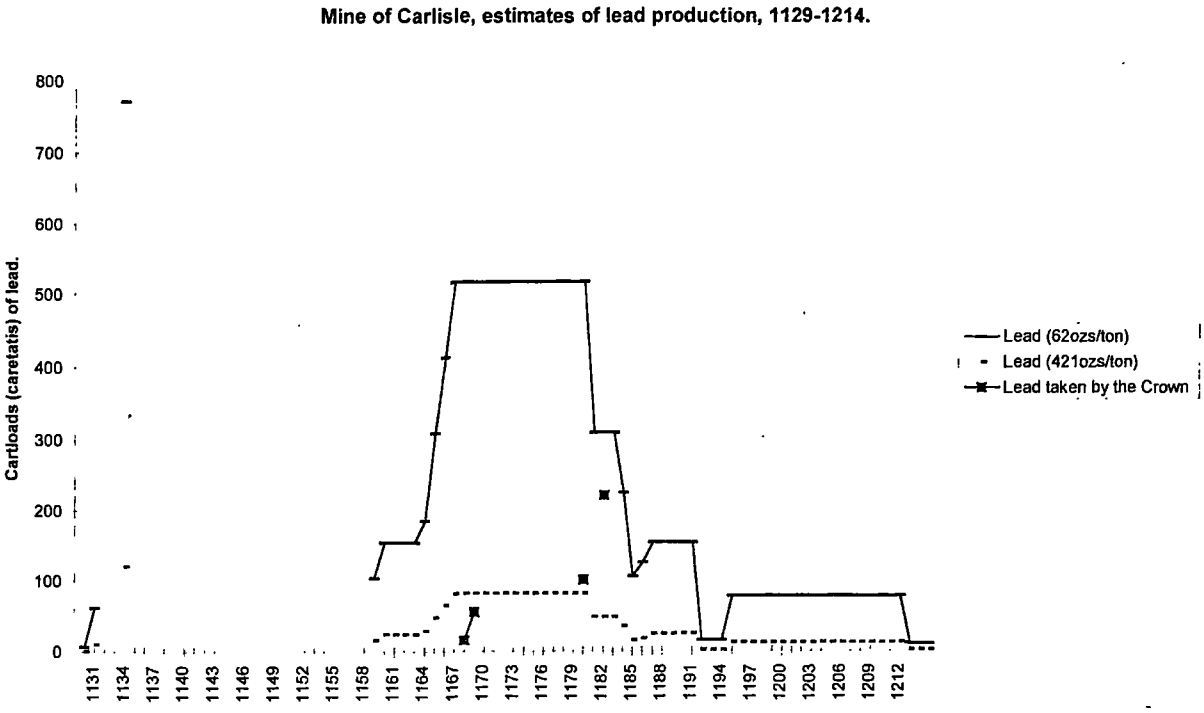

Figure 10 (calculated from data listed in Appendix 1.)

most productive workings at that period were in the part of Tynedale which lay within that county.

It has been suggested by D F Allen that the Carlisle mint existed solely to process the produce of the mines.[31] However it is evident that by 1208 there was, or had been, an exchange at Carlisle and silver other than newly mined was being processed. A sum of 30 marks (£20) was owed in respect of the exchange but it is unclear as to whether that represented a farm of the profits from the exchange.[32] Although heavy minting activity at Carlisle in the last two decades of the 12th century is indicated by the large number of dies used, it is difficult to relate mint output to the production for the Tynedale mines.[33] Most Northern Pennine silver must have entered the economy through other mints.

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31 Allen, *Cross and Crosslets*, p. xci.

32 Allen, 'Carlisle and Durham Mints', p. 50.

33 *Ibid.*, p. 44. Allen identifies at least 21 obverse dies and 29 reverse dies, for coins

By taking the amount paid for the farm as an indication of the value of the portion due to the Crown and expanding it to provide values for total production, as for the two years when the issues from the Crown's portion were in the hands of the keepers, i.e. 1184 and 1185 (above), it is possible to illustrate an estimate of production for the mine of Carlisle from 1130 through to the early 13th century, Fig. 9 above.[34] No indication as to possible production levels is available for the period when the mine of Carlisle was in the hands of the Scots, 1135 - 1157. The value that Robert of Torigini put on the portion due to the Crown in 1133 can however be expanded to provide possible values for total production shortly before the Scottish occupation, and these are included in Fig. 9.

The very much higher value of the silver compared, weight for weight, with the lead extracted from the ore of the 'mine of Carlisle' has a direct impact on an estimate of production levels from the mine. The value of the ore received in the portion due to the Crown and consequently the profit, and the value of the farm, is dominated by the high value of the silver. It is evident from the estimates based on the profit of the mine in 1184 and 1185 (Table 1 above) and the farm of the mine (Fig. 9) that there is consequently little difference in the estimate of the quantity of silver produced from the ores whether they yielded 62 or 421 ounces per ton. If a similar expansion is made, based on the estimates for 1184 and 1185, for the lead produced, it is evident that a much greater variation is possible (Fig. 10). If production in the late 1130s through to the mid 1160s was based on low silver ores, extremely large amounts of lead would have been released onto the

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of the 'Short Cross' type, used in 32 combinations; compared with four pairs of dies for 'Cross and Crosslets' type coins used at Durham (see Section 2.2.2 below); which, on current evidence, is difficult to reconcile with the silver production estimated below.

34 Based on data listed in Appendix 1.

market. There is no evidence for such large amounts of lead and the presumption must be that, at that period, ores with high silver values were being worked. By 1181 we have evidence for the increasing production of lead when the amount of lead taken by the Crown under its right of pre-emption was approaching that which would be produced in working ores yielding the smaller amount of silver. Nevertheless, the mines should still be regarded as 'silver' mines, with the lead recovered from the refining process, worth only around 11.3 percent compared to the silver, as a by-product.[35]

Using the profit of the 'mine of Carlisle' and the value of the farm, along with Torigini's statement, we can identify three production peaks for the mines in Tynedale. The first occurred in the final years of Henry I's reign, possibly peaking at a level of from 54,000 to 59,000 ounces of silver per annum in 1133 with production declining during the period of Scottish occupation. Silver production then rose again during the first decade of Henry II's reign to reach a lower peak, at from 36,000 to 39,000 ounces, in 1166. Thereafter production declined, probably slowly at first but then rapidly after 1179, to reach a low of around 7,300 ounces of silver in 1184 before recovering to a minor peak of about 11,000 ounces in 1186. Decline then set in once again and by 1212 silver production was possibly little more than 700 ounces per annum. On the other hand the proportion of lead in the total produce of the Tynedale mines was increasing. By the mid 1180s the amount of lead produced suggests that the mines were already working ores at the lower end of the range 421 to 62 ounces of silver per ton. From the opening of the 13th century, if not before, Tynedale should be regarded as primarily a lead rather than a silver producer.

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35 See Table 1 above.

2.2.2 Interpretation of the evidence for Durham.

As with Tynedale, no figures for total silver production have survived for the mines in the bishopric of Durham. Unlike Tynedale, the indicators which might be used to estimate production levels do not constitute anything like a continuous record. The Durham mines lay outside the jurisdiction of the Crown, which had no call on their produce except during vacancies in the bishopric of Durham when their profits were entered in the Pipe Roll. Those entries are supplemented by occasional chronicle references. Therefore only isolated figures are available and interpretation of these are dependant on whether the bishops were working the mines themselves or letting them to working miners, and in the latter case whether they took their profits in ore or as a fixed farm.

During the 1140s the profit taken by the bishop amounted to some 360 pounds of silver per annum which has been described as a farm.[36] In which case production levels were approaching those of the mine of Carlisle at that period at around 43,220 ounces of silver. Twenty years later the farm was in the hands of the moneyer Cristien, at Durham. No hard figures are available for Cristien's tenure but Martin Allen provides us with a useful estimation of the output of the Durham mint at that period. Using evidence from coin hoards, the total number of dies used has been determined. The durability of those dies allows for the stamping of a maximum of about 80,000 pennies (that is £333) in a five to ten year period around 1167.[37] It would have been in Cristien's interest to turn as much of

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[36] Three great talents (argentia tria magna), of 120lbs each (*Dialogi Laurentii Dunelmensis monachi ac Prioris*). Allen, 'Durham Mint', p. 394.

[37] *Ibid*, p. 393-4; the exact period of Cristien's tenure is in doubt but he was in post by 1167. The validity of the this type of estimation has been challenged but the possible margin of error in this case is such that any revised total would be well below the output postulated by Blanchard (see Section 2.1 above).

the silver into coin thus maximising his income from the six pence in the pound minting charges. That he only struck a maximum of £333 during his tenure suggests that output from the mines was predominantly lead. Confirmation of that comes when the Durham was in the hands of the Crown after the death of Bishop Hugh de Puiset in 1195.

The best detail then available is for the year ending Michaelmas 1196.[38]

For making at the mint	£130 13s 8d
In smelting the ore	£16 3s 2d
In purchasing lead for the profit of the king	£27 11s 0d
Profit of the lead bought	£40
Bullion - the profit of the ore and the mint	£174 -- 4d

Whilst there is no evidence of a farm at this time, it is not known if the mines were in the hands of the bishop and worked directly, or were worked by the miners under some form of lease.[39] The latter is suggested by the wording of the second line of the Pipe Roll account above which reads *Et in custamento ardendi minam xvj li. et iij s. et ij d. per idem breue*. This has been translated in the past as 'and in the cost of smelting the ore £16 3s. 2d.', where the word *custamento* is translated as 'cost'.[40] The word can however mean a 'customary payment'[41] In which case the line could refer to the expense of

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38 *Pipe Rolls* PRS NS7, p. 261.

39 The former view, expressed in the *Victoria County History, Durham* (vol. II, p. 348), takes no account of the farm of the mines to Cristien in the 1160s.

40 *Victoria County History, Durham*, vol. II, p. 348 ; similarly repeated in Raistrick and Jennings, *Lead Mining in the Pennines*, p. 52.

41 Latham, *Revised Medieval Latin Word-List*, p. 128; Gooder, *Latin for Local History*, p. 110. However, usage would suggest that in this instance the term might be read as 'cost' rather than 'customary payment.' (pers comm. Mrs Linda Drury, Assistant Keeper, Special Collections, University of Durham Library) See also previous lines in the *Pipe Rolls* (PRS NS7, p. 261) referring to payment for the cultivation of land - *Et in custamento excolendi terras Gilonis Hausard....*

smelting the portion of ore reserved to the bishop and due by custom from the miners. Such an arrangement is suggested by the purchase of additional amounts of lead. If the mines were being worked directly then such a purchase would not be necessary.

Given that the mines were being worked by the miners on their own account, we have no idea of the size of the portion reserved to the bishop nor can we state that the £174 - 4d. in bullion represented the silver recovered from that portion. The bullion included silver recovered from the lead purchased, in addition to that from the customary ore, plus the profit from the mint which was not necessarily dealing with mined silver alone. At worst it represents the total production of silver from the Durham mines, at best perhaps one tenth of that production. Whichever is the case the position in 1196 was much better than that in the early part of the 13th century when metallic lead predominated and only meagre profits from the mint were accounted for when the county was again in the hands of the Crown.[42]

The available figures do not allow for much beyond an indication of a peak in the 1140s, a possible lesser peak in the last decade of the century, followed by a decline to low levels of silver production in Durham by the early years of the 13th century. At around 43,200 ounces of silver per annum, the first production peak was significant. It came shortly after that in the Tynedale mines at a time when the latter were in the hands of the Scots. The indications are that silver production during the 1160s was at a low level and that a possible second peak, indicated by figures for 1196, was no greater than 20,904 ounces.

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42 *Pipe Rolls* PRS NS 28, p. 38; PRS NS30, p. 46.

2.3 Northern Pennine production in summary.

Whether they are considered as a group or individually, the mines of Tynedale along with those in the bishops estates in Durham probably were the largest silver producers in England and Wales during the medieval period. At their peak in the 1130s and 40s they contributed up to 59,000 ounces and 43,200 ounces of silver per annum respectively, although a significant portion of the former went north into the Scottish economy.[43] This compares with a maximum annual production of 23,229 ounces from the Devon mines in the last years of the 13th century. The subsequent decline in output with lesser peaks in production at intervals through to the end of the 12th century, is indicative of the early exploitation of shallow rich deposits followed by a shift to, possibly deeper, lower grade ores marked by increased production of lead as a by-product. Estimating total lead production is impossible, given the range of ore values possibly mined,

The closure of the Carlisle mint in the early years of the 13th century marks the end of significant and sustained silver production from Tynedale. Mining there was in abeyance in 1222, although lead production must have resumed soon afterwards and some might have justified refining. Thereafter supporting a distinct but depleted mining community on Alston Moor into the 14th century. Output from the Bishop of Durham's mines probably peaked in the 1140s and possibly again, at a lower level, in the 1190s. However, at the levels suggested above silver production from the mines of the Northern Pennines was of considerable significance, adding weight to the argument that the price rises of the

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[43] Scottish coin did circulate in the English border counties after 1158, and some coin will have been drawn back into the English economy, but finds in hoards across the rest of the country are few (Allen, 'English currency', p. 599).

latter part of the century had monetary rather than demographic origins.[44] With estimates for the amount of English coin in circulation prior to the 12th century varying from £60,000 - £80,000 upwards, if we add in the estimated production from the Northern Pennine mines which, for the Tynedale mines alone in the second half of the 12th century, amounts to from £72,340 to £79,243, the effect of newly mined English silver becomes evident.[45] On the evidence of the recoinage of 1158 and the number of minting dies used subsequently, Allen has already suggested that 'the English silver currency may have doubled between 1158 and 1180'. By 1205 the amount of coin in circulation is estimated to have grown to around £200,000-£250,000 despite heavy losses in funding martial ventures on the continent.[46]

The estimates of silver production made above have to be set against the production figures postulated by Blanchard.[47] His figures, of from 80,000 to 105,000 ounces of silver per annum from the mine of Carlisle in the mid 1130s and a peak of over 450,000 ounces for Durham alone in the mid 1160s, with no production at all for the latter in the 1140s, bear no relation to the evidence used above in estimating Northern Pennine production. Blanchard's figures are also called into question when viewed in light of the market for lead, the by-product of silver refining, which showed no sign of over supply.[48] The available evidence suggests that, while there was a significant output of silver from the Northern Pennines in the 12th century, it did not reach the proportions suggested by Blanchard.

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44 See pages 22-24 above.

45 Grierson, 'Anglo-Saxon Coinage', p. 159. Total of estimated production based on the farm and profits of the 'mine of Carlisle', taken at face value, 1158 to 1214.

46 Allen, 'English currency', p. 606. Mayhew, 'Money and Prices'. Latimer ('English Inflation', p. 21) even suggests an increase of from four to ten fold.

47 Blanchard, 'Lothian and beyond:', particularly Figure 2.1.

48 See page 91 above.

The inflation evident in the late 12th century is now largely accepted by economic historians as resulting from increased monetary supply rather than from demographic pressure.[49] The source of the increased amount of coin in circulation has, however, been traditionally credited to the newly developed mines of central Europe in the 1160s.[50] Such an explanation takes no account of the effect of significant silver production from the Northern Pennines.

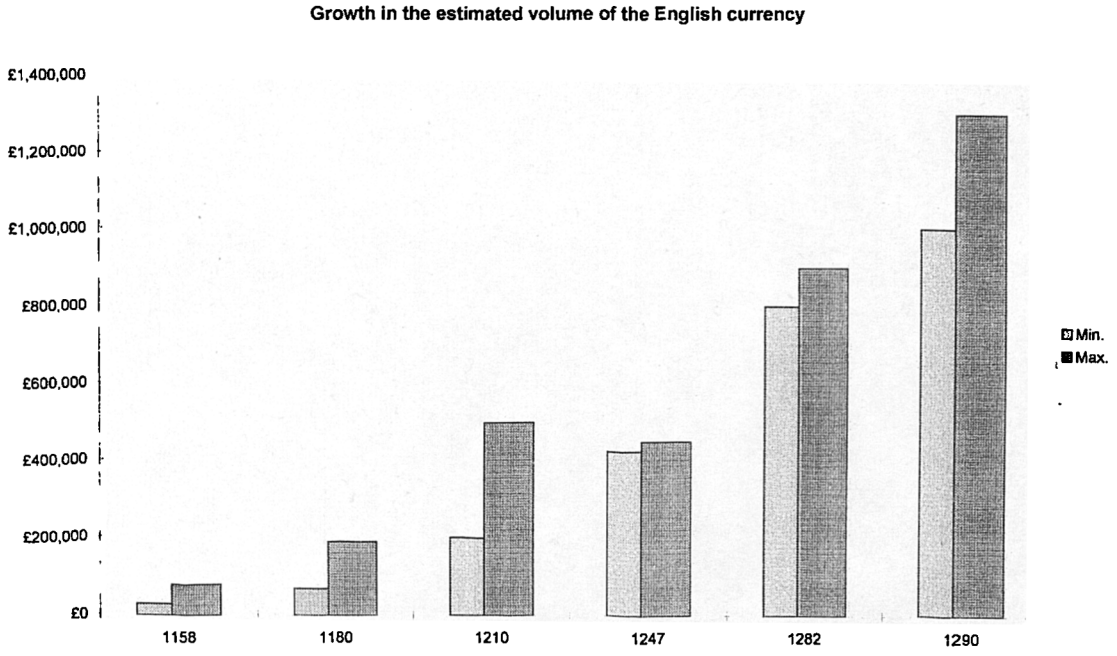

Figure 11 (based on figures from Allen 'English currency', pp. 598-603.

One must also consider the production of significant amounts of silver from the Northern Pennines against the suggested evidence for a strengthening export trade in wool and textiles in the second half of the 12th century. If, as suggested by Harvey, that evidence is

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49 Harvey, 'English Inflation'.

50 See Chapter 1, Section 2.1, above.

based on the increase in money supply in England, then the contribution of the Northern Pennine mines must undermine the perceived strength of exports at that period.[51] Perhaps we should be looking to the 13th rather than the 12th century for the growth in English exports and the consequent increased influx of continental silver. Estimated production from the Northern Pennine mines can account for increases in money supply in the late 12th century. However, the increase in the 13th century, the possibly doubling of coin in circulation between 1210 and 1247 (see Figure 11 above), cannot have been supplied by newly mined silver from English and Welsh mines. It is to this period that we should look for significant growth in exports of wool, cloth and tin.

Any future reassessment of the state of the English economy at the turn of the 12th century will have to take into account the net gains from English silver production in the preceding century and the legacy left by the Northern Pennine mines.

2.4 Silver production from the 13th century onwards.

The opening of the thirteenth century saw few if any silver producers active in England and Wales. Some silver was, no doubt, produced on occasions from lead deposits exploited primarily for the base metal, but the silver rich ores of the Northern Pennines were probably exhausted. Newly mined silver was entering the economy in increasing amounts, but coming largely from the mines of central Europe as payment for exports.

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[51] Harvey, 'English Trade in Wool and Cloth', pp. 370 and 372. In the same paper Harvey drew attention to the disparity between the perceived increase in wool and cloth exports and the evidence (Sawyer, 'The wealth of England in the eleventh century') for a static sheep population from the 11th to the 13th century.

The moribund state of silver mining, which affected England and Wales for most of the century, was not for want of promotion on the part of royal government. The Crown sponsored the activity of 'king's miners', although their role is unclear and they may, at least in part, have been engaged in siege work, undermining castle defences, rather than the search for silver-bearing ores. A determined effort to exploit reputed silver, gold and copper deposits in Devon during the 1260s did not result in production. It was not until the last decade of the century that new lead/silver resources were opened up in the north and south of that county, at Combe Martin and Bere Ferrers respectively. Deposits which were to provided the bulk of newly mined English silver over the next two centuries.

2.4.1 The Devon mines under direct Crown control

From 1292 the documentation associated with direct working of the Devon mines by the English Crown provide the basis for a near continuous record of silver production through to the 1348/9 when activity was curtailed by the advent of the Black Death. Exploitation of deposits at Bere Ferrers (also known as Birland), in south Devon, was responsible for the vast majority of the silver mined in that period. Production from the Combe Martin mines did feature in the last decade of the 13th century and they were tried again, under lease from the Crown, in the 1320s; but in the latter period there is no record of production and a frequent change of lessee is suggestive of poor prospects.

The working of shallow accessible deposits is evident in the rapid rise in production levels at Bere Ferrers in the last decade of the 13th century. However, early production

was not without its problems. The failure of the Crown to appoint a 'troner', the official responsible for weighing the produce, resulted in fertile, silver bearing, lead being held back until the following year before it was refined. An initial inability of the smelting processes to cope with all the ores mined was countered by experimentation with new techniques which continued into the first decade of the 14th century. Nevertheless silver production achieved a peak output in 1297 of 23,228 ozs which was not surpassed in the working of the mines during the medieval period.[52]

This rapid rise in production (Fig. 12 below) proved attractive to the Crown, as a means of clearing its excessive debts, and to the Frescobaldi (or Friscobaldi) of Florence, its principal creditor, as a secure source of cash. With little evident consideration for the cost of working the mines, the Frescobaldi took the Devon mines on lease by an agreement dated 18 April 1299.[53] They then found the working costs so high as to deprive them of any profit, having agreed to pay 13s. 4d. per 'last' for the ore when, in their opinion it was only worth 10s.[54] Kaeuper, who has explored the role of the Frescobaldi as bankers to Edward, notes that even the sum of 13s. 4d. was in dispute, when the Crown's copy of the indenture recorded the amount to be paid as 20s..[55] The mines were back in the hands of the Crown within 12 months of the agreement with the Frescobaldi. Thomas de Swaneseye, controller during their tenure, was appointed keeper and began the task of

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52 See PRO *Exchequer Accounts*, E101/260/5, Account of Master W de Wymundeham of fine silver received issuing from lead, 20-25 Edward I; and E101/260/6, Account of the same Master W. de Wymondham of fine silver received coming from lead from the King's mines of Birland and of Combe Martin from 27 April 20 Edward I to 15 Sept. 25 Edward I, both reproduced at Appendix 7.

53 Kaeuper, *Frescobaldi*, p. 60. William de Wymundham's final account (PRO, *Pipe Rolls*, E372/154 m 42d) does show that output had fallen slightly in the previous year.

54 *Cal. Pat. R.*, Edw. I, vol. 4, p. 513. The term 'last' is an undefined measure, however the later use of the term '*ladam*' suggests that the measure was the 'load', i.e. 9 dishes, of ore *(Cal. Close R.*, Edw. II, vol. 1, p. 95) - see Appendix 15.

55 Kaeuper, *Frescobaldi*, p. 62.

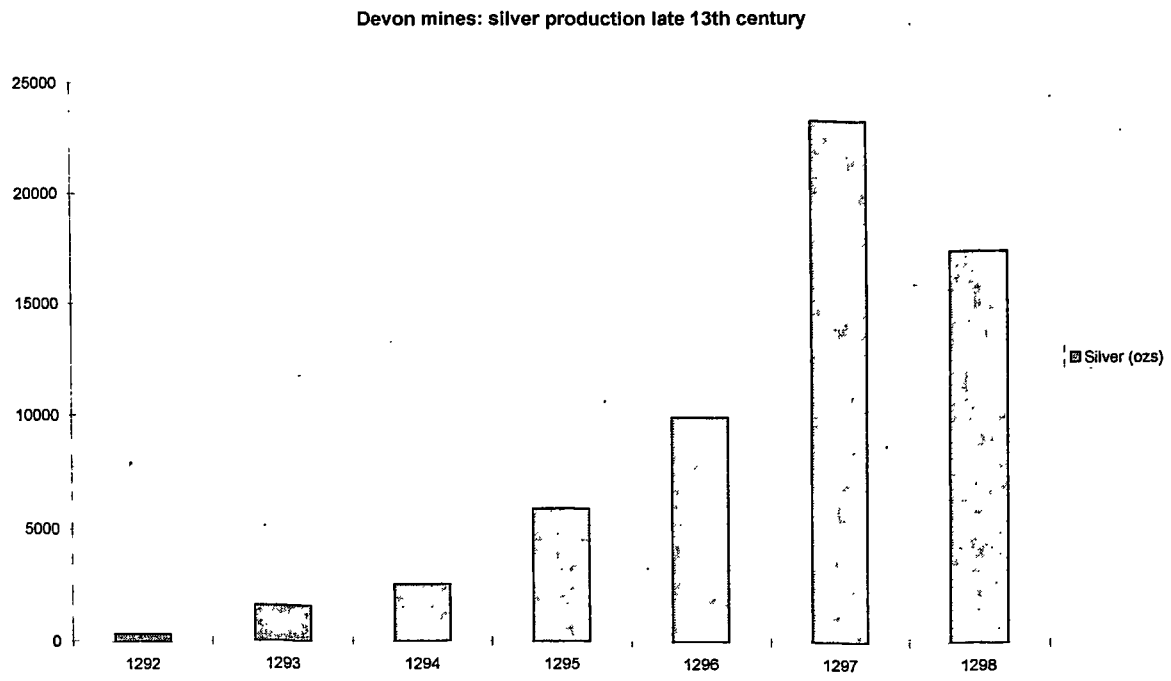

Figure 12 (based on data listed in Appendix 2.)

recovering the productive capacity of the mines. During their tenure the Frescobaldi had evidently worked for short term gain, accounting for some 22,800 ozs of silver, but with little regard for future production.[56] Drainage adits were not maintained and had either collapsed or were in danger of collapsing, and no development work had been done to open up new reserves of ore. It took de Swaneseye four years, and an expenditure of over £1000, before production resumed. Thereafter silver production rose rapidly to peak at 21,516 ozs in 1306 before falling to an average of around 8,000 ozs through to 1314.

The expenditure on unproductive 'deadwork' in the five years to 1305 provided for reduced operating costs during the next decade by improved drainage, using adits to allow free drainage to surface, and a reduction in the requirement for manual water haulage. The number of water bags required fell markedly after 1308 and the number of men

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56 Spufford, *Money*, p. 127, quoting 'mint accounts'.

Figure 13 (based on data listed in Appendix 8.)

specifically employed on haulage was kept to a low level throughout the next decade (see Appendix 8 below). Few full accounts of expenditure and production have survived but the figures available show that by 1306 the value of the produce had covered the expenditure in the first five years plus the working costs thereafter. The mines continued in profit until 1314 before increased deadwork costs in the following three years resulted in small annual losses.[57]

From 1304 changes in the amount of silver recovered are evident as the mines began working below the rich weathered portions of the oxidised zone close to surface. Prior to

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[57] PRO, *Exchequer Accounts*, E101/261/10, Counter roll, 1-2 Edw. II; 12, Account of Robertus de Thorp, clerk, keeper of the mine, Michaelmas 3 Edward II to Michaelmas 4 Edward II; 13, Account of Robert Thorpe, 5-6 Edw. II; and 15, Indenture 6-7 Edw. II; *Pipe Rolls* E372/159 f34, Account of Robert de Thorp of the revenues of the mine, Michaelmas 4 Edward II to Michaelmas 6 Edward II; 161 f52, Account of William Duyn, 21 Dec. 7 Edward II to Michaelmas following; and 162, Account of Stephen de Brawode, keeper, Michaelmas 9 Edward II to 28 June following.

1297 the yield had averaged at just over 207 ozs of silver per ton of lead metal smelted. This had fallen to just over 143 ozs in 1297 and less than 108 ozs when production resumed in 1304. Higher grade ores, up to 180 ozs / ton, were mined in the next two years but over the following decade the yield was little more than 135 ozs at best. By 1317 the yield had fallen well below 100 ozs as the mines were taken deeper (Fig. 14 below).[58]

Expenditure on unproductive 'deadwork' was increasing again after 1313. Silver production was initially maintained at around 5,000 ozs per annum but soon fell to less

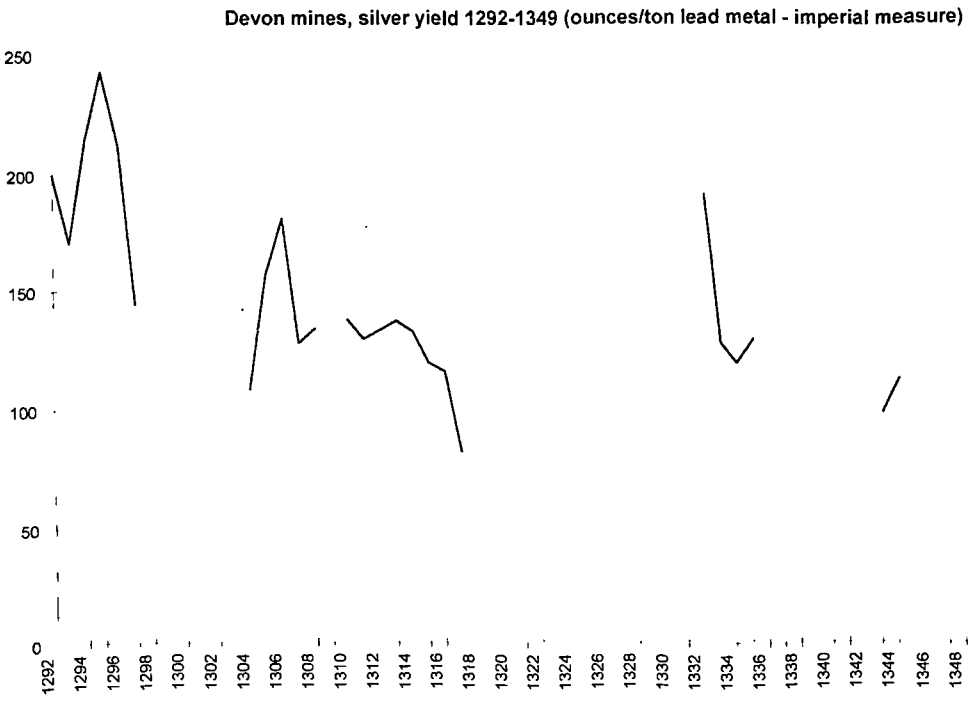

Figure 14 (based on data listed in Appendix 2.)

than 2,500 ozs in 1317. The high levels of the late 13th / early 14th century were not repeated and production through to the 1340s fluctuated between 2,000 and as little as 600 ozs of silver per annum. Some recovery is evident in 1343/44 but by 1348/49, on the advent of the Black Death, mining had ceased and production was confined to the

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58 See breakdown of produce and yield in Appendix 2.

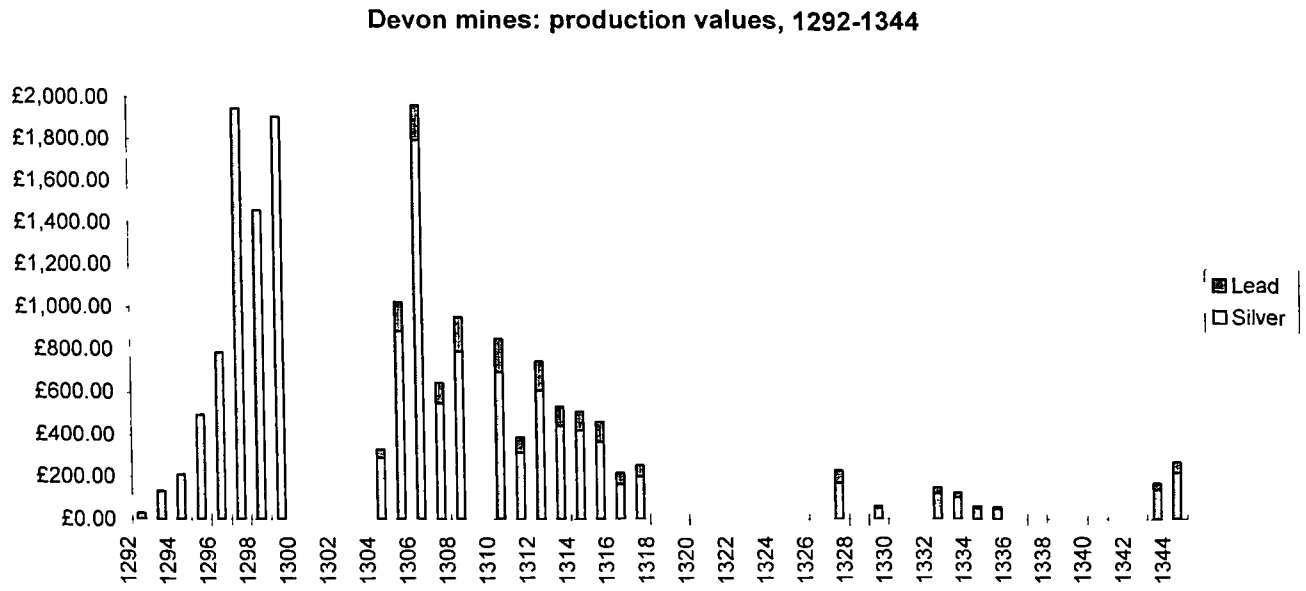

Figure 15 (based on data listed in Appendix 2.)

recovery of silver out of the residues from previous year's activity. The profits on silver mining during the second quarter of the century were low. Salzman has suggested that the Crown and its officers in the Exchequer were disproportionately impressed by the plates of silver deposited at the Tower exchange and that the mines were in reality unprofitable. The Exchequer was however cognisant of the long term value of the mines and had on earlier occasions referred to their fluctuating profitability when considering the form by which they would be worked. In 1318 it referred to the accounts before refusing a farm of the mines to Ricardus de Wygorn on the grounds that '*great expenses had occurred from time to time for diverse years in deadwork ... with no profit had ...; but that in the ensuing time, profit occurred more abundantly*'.[59]

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[59] Salzman, 'Mines and Stannaries', p. 82. PRO, *King's Remembrancer Memoranda Rolls,* E159/91 f 110, Memorandum re. request to farm the mines in Devon, 11 Edward II.

The keeper of the Crown mines was engaged in prospecting a number of other possible sources of silver in the South-West during the first half of the 14th century, see Chapter 4, Section 4.4, Fig. 18, but none were successful producers. The mines at Bere Ferrers, in south Devon, remained the only significant English silver producer in the 57 years to 1349.

Total production in that period, including that from Combe Martin in north Devon, amounted to at least 185,549 ozs, but probably no more than 200,000 ozs, of silver worth nearly £15,462. At a total of no more than 5.41 tonnes of silver, the production of the Devon mines at this period should to be placed in context with that from other mines in Europe. Kutna Hora, in Bohemia, at an estimated 30 to 35 tonnes between 1300 and 1330, dominated European production. Whereas the Devon mines are comparable with those at Iglesias, on Sardinia, where silver production is estimated at around 5.8 tonnes during the first half of the 14th century, and of national rather than international importance.[60]

With the Devon mines producing only a fraction, around a fifth, of the silver mined over a similar period from the Tynedale mines in the 12th century they were not going to have the same impact on the English economy. The impact was, in reality, reduced much further by the amount of silver drawn into the economy from the continent as payment for exports, whereby the amount of coin in circulation had risen perhaps four fold between the end of the 12th century and the period of peak production from the Devon mines.[61] The production peak in the early 14th century, worth £1793 in 1306, must be compared

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[60] Day, *The Medieval Market Economy*, p. 71, Table 2.5 - Kellenbenz ('Production and Trade', p. 318) suggests a much higher output for Kutna Hora in the period 1300-30, over 20 tonnes per annum.

[61] Mayhew, 'Money and Prices', p. 125. Allen, 'English Currency', p. 606.

with the value of tin production, worth around £7285 in 1303, a large proportion of which was exported.[62] With from £500,000 to £1,000,000 in silver circulating in England during the first half of the 14th century, that from Devon mines did little more than compensate for losses through wear and tear.[63] Suggestions that mines in Devon funded the wars of Edward III and, later, those of Henry V are very wide of the mark.[64]

In addition to the silver produced, the Devon mines were significant producers of lead as a by-product of the refining process although its value was only a fraction of that for the silver. For example at least 582 cartloads (428 tonnes) of lead were sold between 1304 and 1317.[65] This lead was sold locally, for use in the immediate area or to individuals and groups of miners who, judged on the quantities purchased, were acting as lead merchants.[66] Some lead from the mines was shipped as far as Pembrokeshire in south-west Wales.[67] However, as Figure 15 above shows, lead contributed only a small fraction to the value of total production.

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62 For silver produced see Appendix 2. For tin production see Hatcher, *Tin Production and Trade*, p. 156. For tin prices see Lewis, *Stannaries*, p. 275.

63 Wear and tear from handling, irretrievable losses through fire. shipwreck and abandoned hoards, are estimated at from 0.2 to 1.0 per cent per annum (Day , *The Medieval Market Economy*, p. 60, quoting Munro, 'Monetary Contraction', p. 99).

64 Hoskins, *Devon*, p. 137; quoting Lysons, *Topographical and Historical Account of Devonshire,* and Westcote, *View of Devonshire*. Within two years of the outbreak of hostilities with France in 1337 Edward III had already borrowed at least £300,000 towards the cost of the war in addition to that raised through parliamentary grants of taxation (Bolton, *Economy*, p.195-6).

65 See Appendix 2. The lead being typically worth 48s. per cartload (PRO, *Exchequer Accounts* E101/260/23)

66 See for example PRO, *Exchequer Accounts* E101/261/2, Memorandum of all barren lead sold from the mine of the lord king in Devon, to Michaelmas 34 Edward I; and Salzman, 'Mines and Stannaries', p. 83.

67 Lead used in roofing and fabrication on the bishop's palace and cathedral at St Davids (Dr Sophie Stos-Gale, Oxford, unpublished report on analysis of lead from St Davids, and pers. comm.)

2.4.2 The Devon mines after 1350

Production from the Devon mines, Bere Ferrers, ceased with the impact of the Black Death, resuming in 1361 at Combe Martin after the mines were leased to Henry de Brislee. Initial results were promising at 1548 ounces of silver and a total of 9075 ounces were produced in the five years to 1365.[68] Thereafter information on silver production is scant. Renewed leases and interest in the Combe Martin mines suggest potential if we do not have record of actual production. The Bere Ferrers mines were productive again by at least 1441. Recorded levels were modest, at 2440 ounces falling to an average of just less than 300 ounces by 1447, but the scarcity of bullion will have concentrated effort and by 1448 production was well over 8000 ounces per annum, and rising to over 9000 ounces in the following three years and 5475 ounces in the half year to 25 March 1452. During the late 1440s the Devon mines were held by the Earl of Suffolk. With his fall from favour, and subsequent murder, silver mining became briefly enmeshed in the web of intrigue which preceded a period of civil conflict in England, the Wars of the Roses. The returns from the Devon mines during Suffolk's tenure were evidently called into question and investigations put in train to establish if silver had left the country illegally.[69]

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[68] PRO, *Exchequer Accounts* E101/263/12, Account of mines at Combe Martin, 33-34 Edward III (partial transcript at Appendix 7 below); and E101/263/14, Counter roll of John Ulf of silver received by Roger Strikil of mines in Devon, 37-39 Edward III.

[69] British Library, Add MS 24513 f95, Account of gold, silver, copper and lead from Crown mines in Devon and Cornwall, 23-29 Hen. VI; and f96, Account of the bishop of Winchester, 11-21 Hen. VI. PRO, *Exchequer Accounts*, E101/265/10 and 11, Particulars of the account of Isabel, late the wife of Richard Curson, 23-29 Hen. VI. *Cal. Pat. R.*, Henry VI, vol. 5, p. 533. In 1449 Suffolk was licensed to export 500 fothers of lead (see Appendix 15), the product of the Devon mines. This suggests a much reduced yield of silver, perhaps 40 ozs per ton of metallic lead compared with circa 125 ozs per ton in the 14th century; either that or some silver production was concealed (*Ibid.*, p. 215).

Continued production into the early 1460s is suggested by the expenditure on drainage and the export of lead from the south coast ports but no figures for silver output survive.[70] Investment in innovative pumping technology in the 1470s led to silver production in 1480/81, however the recorded level, at 1883 ounces, was disappointing.

There was no recorded production of any impact outside the Devon mines. Prospecting in the south-west of England, cited above, brought no new silver resources. In the period 1445-51 a mine at St Tether(?), probably in Cornwall, returned 24 ounces but did not appear elsewhere in the production record.[71] Given the reference to silver recovered from lead mined on the Bishop of Wells estates on Mendip at the end of the 13th century, some production might be expected over the following two centuries but none appear in the record. Mines leased from the Crown in the north of England, in Cumberland and Westmorland, also failed to record any production.

It is evident that the Devon mines were the only silver producers of note in the latter part of our period and they had reached the limit of their productive capacity by the 1480s. In contrast to the Northern Pennine mines, they were not exhausted but the workings were already deep by the 1350s and the relatively high levels of production achieved at Bere Ferrers in the 1450s was at a high cost in drainage. The pattern of mineralisation meant that the innovative technology of the 1470s had little productive potential.[72] It was not until new deposits were discovered at Buttspill, well to the north of the medieval workings, some two centuries later that there was renewed production and not until the

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70 Wiltshire Record Office, 366/1 (see Page 182 below). Blanchard, *International Lead Production*, p. 302.

71 British Library, *Add MS* 24513 f95.

72 See Chapter 4, Section 6.2, below.

advent of steam powered pumps drained the medieval workings that the deeper deposits were worked. The random nature of the Combe Martin deposits provided for greater potential and they did achieve significant success towards the end of the 16th century but outside the period under consideration in this thesis.

3. Conclusions

Newly mined English silver made a substantial contribution to the amount of bullion circulating in the economy of the British Isles in the late medieval period, 1066 to 1500. Total estimated production over the period was in the region of 2,800,229ozs with the vast majority mined before the end of the 12th century - see Table 3 below. Not all the silver will have been coined and entered circulation. Up to ten percent of the silver was in that portion of the ore due to the church as tithe. How the church handled the tithe ore prior to the end of the 13th century is not recorded, but some silver may have been used for church plate. After 1292 the church took its tithe as a cash payment for the ore. However, some silver was disposed of before reaching the Exchange, as in 1296 when a portion of the produce was ordered to be made into chalices for celebrating mass.[73]

At the outset the small mines in the uplands of England and Wales produced undetermined amounts of silver to support the youthful English coinage. Over the 12th century the estimated amount of silver in circulation in England more than trebled to around £200,000-£250,000 (an increase of up to 2,280,000ozs) and the bulk of that

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[73] PRO *Exchequer Accounts*, E101/260/5 f2, Account of Master W de Wymundeham of fine silver received issuing from lead, 20-25 Edward I.

increase probably came from the Northern Pennine mines. Control of some mines, significantly the 'mine of Carlisle', by the Scots between 1135 and 1154 allowed for the establishment of a strong currency north of the border, based on the major portion of an estimated production of 800,000ozs, but the greatest impact was in England. Continued production in the second half of the century possibly supplemented by silver reaching England from new mines on the continent resulted in a substantial increase in money supply; laying the foundation for the inflation which followed. Blanchard's conclusions, that 12th century production was much larger with peaks reach up to 24 tonnes per annum, are arguably not supported by the available evidence.

Table 3	**Best estimates of total silver production, 1066-1500.**	
1066-1129		
	Low level but undefined production.	
1130-1200		
	Minor silver producing districts	
	Low level but largely undefined production.	
	Tynedale (the mine of Carlisle)	
	1130-1158	800,000ozs
	1158-1200	900,000ozs
	Durham	
	c.1130-1200	855,000ozs
1200-1292		
	Negligible production levels.	
1292-1350		
	Devon	185,549ozs (>200,000ozs)
1350-1500		
	Devon	59,680ozs (>108,500ozs)
Total estimated silver production, 1066-1500.		**2,800,229ozs (or c.81.68 tonnes)**

After the demise of the Northern Pennine mines in the late 12th century, a strong English currency continued to be supported by a healthy export trade drawing in continental silver; the growth in which should now, perhaps, be assigned to the 13th rather than the second half of the 12th century. When English production resumed, in Devon, at the very end of the 13th century its impact was much reduced. Unlike 12th century production, when levels have to be determined using secondary indicators, that for the Devon mines is recorded in some detail. Peaks in production in the late 1290s and the early years of the 14th century can be quantified and related to changes in both organisation and mining techniques. Continued, if intermittent, production at low levels is recorded through two centuries to its revival as northern Europe's only credible source of newly mined silver at the height of the 15th century bullion crisis.

Silver was possibly the dominant sector of the mining industry up to the end of the 12th century. Production values for the Northern Pennines, estimated to be worth around £75,000 for the Tynedale mines alone between 1158 and 1200, far exceeded those for tin which in the latter part of the century only reached around £4620 (1156 to 1189).[74] However, after 1200 silver took second place to tin. The continued rise in the value of tin production meant that even after the opening of the Devon mines the value of silver never exceeded that of tin. Thereafter, to 1500 and beyond, the silver received in payment for tin exports surpassed that produced from ores mined in England and Wales.

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[74] Hatcher's estimate of 1540 thousandweight (*Tin production and trade*, p. 153); for price see Lewis, *Stannaries*, p. 275.

Chapter 4:

The Techniques and Technology of Silver Mining.

The perception of non-ferrous mining prior to the 16th century as a backward industry is called into question by the level of technology employed in the working of silver-bearing ores in the late medieval period. Burt has shown that a view of organisational and technological advances, promoted by central European entrepreneurs, in the 16th century was commonplace in our understanding of the development of mining in England and Wales. The continental view is, however, different, and Cipolla could refer to mining as one of the sectors 'in which "bigness" prevailed at an early stage'.[1]

There certainly was a well documented central European participation in certain sectors of English mining in the 16th century but contact with continental mining was not a new phenomena. As will be shown below, 'German' miners were to be found working in English and Welsh mines from at least the mid 13th century.[2] The continental contribution in the 16th century was primarily concerned with the processing of copper ores, something which they were involved with in England as early as 1315, but their success then, as in the earlier period, was limited.[3] As Burt has stated, 'there is no evidence that German experts introduced any new technique, machine, or method that had a significant and sustained economic impact' during the early modern period.[4] Neither is there evidence of any such continental impact in the late medieval period. In Chapter 6 we

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1 Burt, 'International diffusion', p. 250; Cipolla, *Before the Industrial Revolution*, p. 95.

2 See Section 4.6.4 and page 218 below.

3 PRO, *Pipe Roll*, 10 Edw. II, E372/162; Hammersley, 'Technique'.

4 Burt, 'International diffusion', p. 251.

will see evidence for the development of a complex organisational structure, employing a large work force, from the late 13th century onwards and the beginning of an entrepreneurial culture in silver mining from at least the early part of the 15th century. Those advances in organisation were matched by the application of technology to silver mining on an equally large scale. Some of these may have drawn on continental experience but it is evident that, in smelting particularly, techniques were adapted to suit local conditions. Only in the later introduction of labour saving water pumping technology is there indication of rapid diffusion of innovative techniques, possibly through central Europe.

It will be shown that even in the early medieval period the miner had a wide range of advanced techniques available to him. Those techniques are first reviewed and, based on the limited evidence available, their application to the mining and smelting of silver-bearing ores in the two centuries following the Conquest is considered. The application of technology to each stage of mining and smelting from the late 13th century is then considered on an individual basis, as the shift to deeper mining in the South-West of England required the introduction, or we should say initially the 'reintroduction', of techniques to cope with the new conditions. It will also be shown that, during the latter part of the period under study, the choice of technology was influenced by the availability, or not, of labour: leading to the introduction of innovative drainage techniques. The advances were such that by the 16th century there was little the central Europeans could teach the English in the techniques of mining or smelting silver-bearing ores.

Producing metallic silver from silver-bearing ores, primarily those of lead, can be divided into four consecutive processes.

1) **Mining, i.e. extraction,** of the ores from the ground was only the first. It did not end there as the ore as mined was of little use to man. Granted, some selected lead ores were used, after grinding, as Potters Ore in the preparation of pottery glaze but that use was confined to ores low in silver.

2) Once mined the ore required **preparation** or 'benification' to remove waste matter and sort it into uniform size ready for the next stage.

3) Conversion of the ore to metallic form was achieved by **smelting** using heat to initiate and sustain a chemical reaction which released the compounded elements, sulphur or carbon, from the base and precious metals. Even in its metallic form the silver remained alloyed with lead: referred to as fertile lead.[5]

4) **Refining** was then required to separate the silver from the lead. That entailed using heat and air to combine the lead with oxygen to form litharge allowing physical separation of lead and silver. Only at that point was the silver available in pure metallic form. The litharge then had a use as paint pigment but the majority was resmelted to a sterile lead, i.e. lead free of silver, for use in fabrication.

The development of these processes and their application to silver-bearing ores will be examined chronologically.

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[5] The smelting of silver-bearing copper ores was more complex and is considered in detail at Section 4.6.4 below

1. Mining techniques in Europe prior to the medieval period.

The information available to us on the methods and practices used in mining prior to the late medieval period is very limited. There was little documentation and we are to a large extent reliant on archaeological evidence. In recent years the latter has revealed the surprising level of mining skills attained by even the earliest of the metal-using populations.

The depth and complexity of Bronze Age workings is in evidence on a sites like that on the Great Orme at Llandudno, north Wales, where copper ores were worked to at least 35 metres below surface in a 3600 metre^2 area.[6] This was attained using natural drainage in the limestone rocks, with the deposits outcropping on a steep hillside. With the advent of iron based metallurgy, using heat to weaken the rock and attacking it with iron picks, wedges and heavy hammers, it was possible to remove ground much more rapidly than with stone tools.[7] This opened up the way to the improved drainage methods required as mining of certain metals, gold and some copper based ores in particular, progressed from shallow opencast working to underground working of deeper seated deposits.[8]

By the later part of the Iron Age (La Tene Period) dedicated drainage tunnels, or adits, were being driven as crosscuts through unmineralised ground allowing free drainage of

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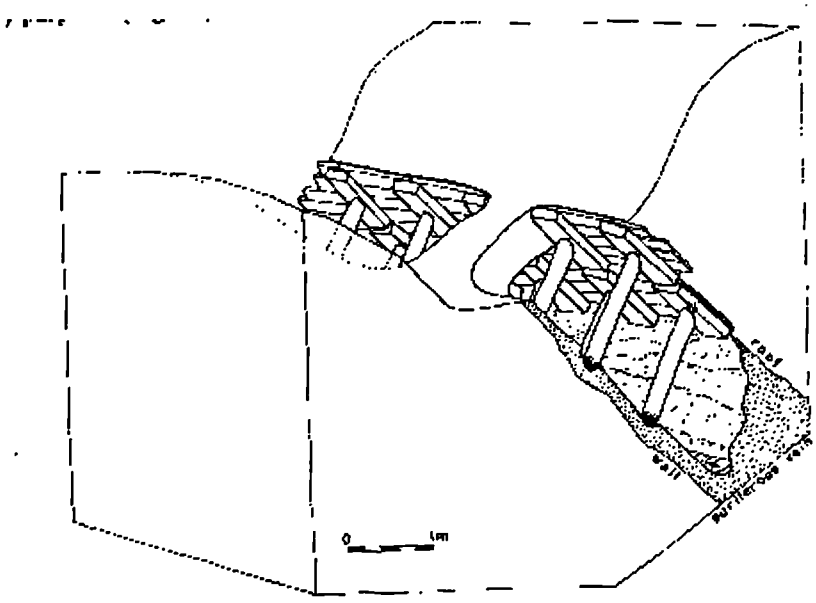
6 Craddock, *Early Metal Mining*, fig. 2.27.

7 This technique of 'firesetting' was known to Bronze Age miners and continued to be used through the Medieval period and beyond the introduction of blasting in the late 17th century (Willies, 'Firesetting Technology').

8 For that progression at Rio Tinto in southern Spain, where the mining of silver-bearing (jarosite) ores in the oxidised zone gave way to exploitation of copper sulphides in the enriched zone immediately below the water table, see Willies, 'Roman mining at Rio Tinto, Huelva, Spain', particularly fig. 10.



A reconstruction of the system of supports at Les Fouilloux (Cauuet 1995, fig. 13.)

Figure 16 (after Cauuet, 'Celtic Gold Mines', fig 13.)

water to surface.[9] Working below the level of free drainage required hand bailing or, later in the Roman period, manually operated wheels to lift water to the level of the adits, as at Rio Tinto in southern Spain and at Dolaucothi in south Wales. By such methods it was possible to lift water up to 30 metres.[10]

Ventilation of deep workings and the long drainage adits, up to a kilometre long, at Rio Tinto in the Roman period required dedicated mining. Stopes were holed through to adjacent adits or to abandoned workings. Where firesetting was employed it would have soon been evident to miners that hot air rose through the workings, drawing in cold air

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9 Cauuet, 'Celtic Gold Mines', p. 231 and fig. 16.

10 Craddock, *Early Metal Mining*, p. 76-81; Boon and Williams, 'The Dolaucothi Drainage Wheel'.

from below, stimulating air circulation. There is little evidence for other methods of artificial ventilation beyond Pliny's suggested use of linen fans.[11]

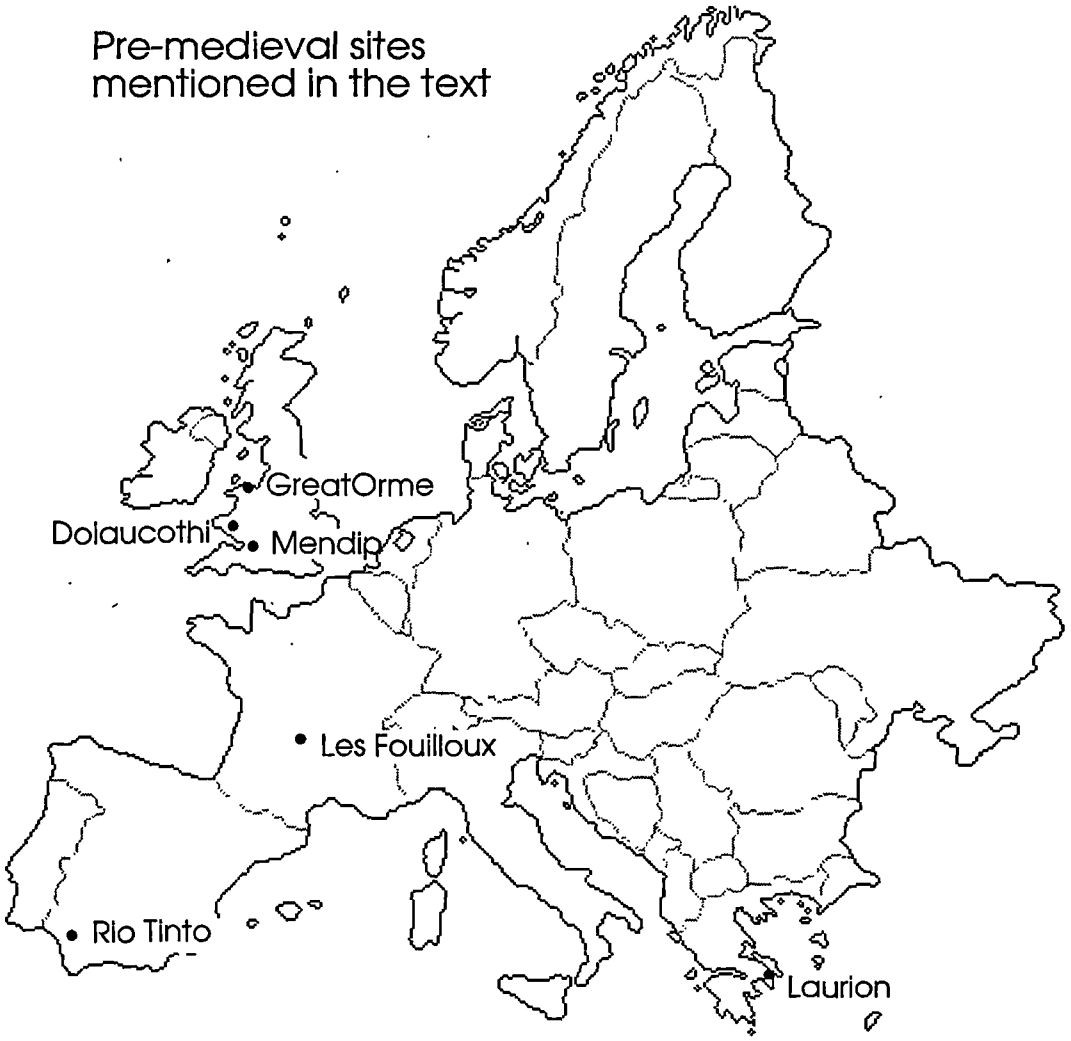

Figure 17 (based on sources cited in the text.)

To ensure the stability of the mined ground pillars of mineralised ground were left to support the hanging wall.[12] These would be supplemented, as in the late Iron Age

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11 Craddock, *Early Metal Mining*, p. 73-5.

12 Where a vein or mineralised deposit was sub vertical the wallrock nearest surface was referred to as the hanging wall, that farthest from surface as the footwall.

workings at Les Fouilloux, near Jumilhac in the Dordogne, by elaborate system of massive timbers.[13]

Exploitation of shallow silver-bearing lead deposits is well attested across Europe during the pre-medieval periods. Perhaps the most productive were the mines at Laurion in Greece during the last two centuries BC. There the archaeological evidence for complex ore preparation, smelting and refining processes is available and has been studied in detail. The Laurion mines do, however, represent the use of contemporary lead/silver mining and metallurgy on a large scale.[14] Most European lead/silver producers operated on a much smaller scale and continued to do so through into the medieval period.

2. Mining in England and Wales during the early part of the medieval period.

After the departure of the Romans in the early fifth century AD metal mining in the British Isles was probably at its lowest ebb since the Bronze Age and that in continental Europe fared little better. With little urban development and a halt to minting the demand for newly mined lead and precious metals was reduced to levels which did not encourage advances in mining techniques. Gold mines at Dolaucothi were already abandoned, with only scant evidence for renewed working there before the 19th century, and their closure marked the end of deep mining in Britain for some eight or nine centuries. The revival of lead/silver mining was probably slow at first but gained in stature with the increased

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13 Cauuet, 'Celtic Gold Mines', pp. 229-231.

14 Craddock, *Early Metal Mining*, pp. 166, 221-223.

commercial use of coin. Even with the proliferation of minting sites in the 10th century, exploitation of resources does not appear to have extended beyond the shallow deposits found in the Carboniferous rocks.

There has been virtually no archaeological investigation of medieval mining techniques. With the expansion of mining from the late 18th century the attention of antiquarians would, from time to time, be drawn to chance discoveries of 'early' workings. Preservation of any finds within the workings was haphazard and, lacking the dating technology available today, only broad assumption as to age were made at the time. Through inadequate recording and the development of modern workings most of those early workings are now lost. We are therefore reliant on surface observation, in areas like Mendip and the Derbyshire Peak District with a history of early working, for indications as to the development of mining techniques.

Rieuwerts has suggested that, in the Peak, the narrow opencast stopes from 20 to 50 feet deep found on most of the rake veins opened up prior to the 17th century were predated by large 'furrow-like' trenches. These were much shallower than the later stopes, 10 to 20 feet in depth and extending along the vein for several hundred feet and are found on sites associated with production in the mid 13th century, if not earlier. Such trenches are not in evidence on Mendip. The open workings on rake veins in the area to the east of Charterhouse (Charterhouse and Ubley Rakes) resemble the Roman workings examined by Todd: only larger, with all the vein material removed to wallrock on either side. However, there is little or no overburden on that part of Mendip in which the 'V' section of a 'furrow-like' trench would be formed.[15]

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[15] Rieuwerts, 'Lead mining', p. 61. Todd, 'Ancient mining on Mendip'.

Very little information has come down to us on the techniques used in the Northern Pennine mines of the 12th century. The best documented discovery of early workings possibly dates from the end of the 11th century, nearly 50 years prior to the peak in production. Iron tools 'of an antiquated form' were found in association with coins of the reign of William II (William Rufus), 1087-1100, in an 'old drift' on Browngill vein. The location of the find was described as being 'about Thortergill Syke', that is on the high ground about two kilometres east of Garrigill where the vein cuts the Firestone Sill.[16] This was probably productive ground for silver and easily drained, in common with other sites, like Fletcheras, on the Firestone Sill around Middle Fell.[17]

At a similar horizon close to surface on the Briglaburn Vein, 1.5 kilometres north-east of Thortergill Syke, evidence of firesetting was noted in the late 19th century. Plaited leather ropes have been found in workings at Blagill and in the Tyne Green mines, and a stone hammer is reported from the latter. A wooden spade and 'rudely constructed tools' were also found at Nether Hearth and Silverband respectively. Whilst these artefacts might date from any period from prehistoric to late medieval, they do suggest areas of early working.[18]

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[16] Wallace, *Alston Moor*, p. 99; at about NGR NY757421. The coins of William Rufus may have been hoarded and then hidden at a much later date but, given restrictions on the circulation of 'old' coin, they are more likely to have been hidden in 1093 when, after William had secured Carlisle and the southern part of Cumbria for England, the Scots again threaten the area. A probable terminal date for the use of coins of William II, based on evidence from coin hoards, is c.1125 or earlier (pers. comm. Martin Allen, Fitzwilliam Museum, Cambridge): that they remained there until the 19th century does suggest that part of the vein was not reworked after the 12th century.

[17] Ore from the Browngill vein, mined in the 1860s by the London Lead Company, yielded 7 ozs of silver per ton of lead. Surface workings on the vein were reported as being 'ancient' and the ore mined in the 19th century came from the Great Limestone, well below the water table. Dunham, *Tyne to Stainmore*, pp. 144-145.

[18] Wallace, *Alston Moor*, pp. 135-8.

A method of prospecting for and working lead/silver veins on the steep valley sides in the Northern Pennines was by 'hushing' - using a torrent of water, released from a temporary dam high on the hillside, to remove the overburden and tear ore from the exposed deposit. When used to work lead veins, the action of hushing performed a natural means of separating the ore from waste rock and vein material. As the water flow reached the gentler slopes near the valley bottom, the heavier ore settled into hollows in the bottom of the hush whilst the lighter waste was carried further down towards the valley floor. Hushing was by no means unique to the Northern Pennines, being used in a few other upland mining areas, but it was most widespread in this area.

Dating the first use of hushing in the Northern Pennines is problematic as the required archaeological fieldwork has yet to be carried out.[19] The technique was certainly used by the Romans in the exploitation of gold deposits in north-west Spain, although those were largely alluvial deposits, but the assumption that the technique was used at Dolaucothi in Wales has now been discounted.[20] The majority of documentary references to hushing in the Northern Pennines are from the 18th century, with the earliest confirmed evidence in the 17th, and it had generally fallen from favour by the early 19th century.[21] That is not to say that it was not used much earlier, in the medieval period, as the detailed documentary evidence which might refer to the technique is absent. It should, however, be noted that

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19 Although further investigation is required, first indications from work currently underway at Cwmystwyth, in mid Wales, do suggest the use of hushing in the early medieval period. See Timberlake, 'The dates of early leats and hushing remains'.

20 Cauuet, in Ancel, et al., *Dolaucothi Gold Mines*, p. 49.

21 A report to the Society of Mines Royal, amongst the Lowther MSS in the Cumbria Record Office, dated circa 1600 recommends the use of hushing as a means of prospecting copper/silver deposits at a mine in the Caldbeck Fells (Donald, *Elizabethan Copper*, p.173).

hushes predominate on the upper strata in areas known to have been worked in the medieval period. Although that may be determined by the topography of those areas, with steep sided valleys and access to sufficient water on the high ground. Given the nature of the silver rich deposits worked in the medieval period, oxidised ores possibly containing native silver, it is unlikely that the separating action of the hush was selective enough to allow its use in working the veins but it would still have been an effective prospecting tool.[22]

3. Smelting and refining techniques prior to the late 13th century.

The choice of the late 13th century as a terminate date for an initial discussion of smelting and refining techniques might seem rather arbitrary. No new techniques were developed at that date nor was there any change in the scale of operations. But, more so than is the case with mining techniques, the vast improvement in documentary evidence occasioned by the opening up of the Devon mines under the direct control of the Crown allows us to speak with much greater authority on the techniques employed after that date. Prior to the late 13th century we must rely to a large extent on supposition as to which techniques might have been carried forward from earlier periods where some archaeological evidence is available.

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[22] Cranstone, 'To hush or not to hush'. The only groups of hushes which have been examined in detail are Greengill and Natgrass Redgroves on Middle Fell, south of Alston, where it is clear that the main hush or, at least, its final deepest phase post-dates shallow shaft working and, in one case, an early (pre 16th century) smelting site. Such evidence, and documentation for both sites, places that final phase of hushing in the 18th / early 19th century but does not preclude earlier activity (Fairbairn, 'Alston Moor Hushes').

No documentary evidence has come down to us for the smelting techniques used in the Northern Pennines. There is field evidence for early smelting in and around Tynedale but it is not as abundant as the supposed output of the mines might suggest. Much of the field evidence is for bole smelting sites to the north-east of the mining field on routes leading to the east flowing rivers, the Tyne and the Derwent, and in the lower part of Weardale around Wolsingham.[23] The latter group are associated with the centralisation of Weardale smelting in the hands of the bishop of Durham in the 15th century. Those in the Tyne and Derwent catchment are probably associated with development of the lead trade shipping out of north-eastern ports like Newcastle from the late 12th century onwards, although this has not been confirmed by dating of the sites. The move to smelting on or close to the routes to the coast was probably prompted by greater availability of wood for fuel in the lower dales and could have begun during the period of peak silver production in the mid 12th century.[24]

Blanchard has suggested that the introduction of the bole was occasioned by the switch to lead as the primary product, with the silver producers of the 12th century and earlier utilising a charcoal burning, bellows blown furnace.[25] However, there is little field evidence to back up that suggestion. Slag scatter from early smelting sites is found

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23 The bole, or bale, is a wind-blown hearth usually sited at an elevated location open to the prevailing winds (see Section 4.6.1 below for a detailed description.)

24 Fairbairn, 'Bales', map on p. 95. One recently discovered site, near Plankey Mill in lower Allendale, was not included on that map. It is probably not a bole smelting site, being located in the valley bottom with poor exposure to the prevailing winds, and is marked by a wide scatter of black vitreous slags more typical of furnace smelting. Such a site, within the liberty of Tynedale and therefore benefiting from a free wood supply, could possibly be associated with silver-lead smelting activity but further investigation is required to confirm its date and purpose (R A Fairbairn pers. comm. 26 Jan 1998.) For smelting activity in Weardale during the 15th century see Drury, 'Leadworks', and Blanchard, 'Seigneurial entrepreneurship'.

25 Blanchard, 'Technical implications'.

adjacent to a number of sites which might be associated with the working of silver bearing ores in the 12th century - particularly around Middle Fell, south of Alston, and on the north-east slopes of Cross Fell, all at the Firestone Sill horizon. They are all elevated locations which would suit smelting using the bole hearth but without detailed archaeological investigation it is difficult to reach any conclusion as to method or date for those sites. In Weardale, in the 15th century, smelting residues were recovered from the bishop's deer park at Stanhope, where the Rookhope valley joins upper Weardale, for resmelting at Wolsingham. Those residues were the slag remaining from smelting prior to the establishment of the park in the 13th century and are probably associated with the working of silver-bearing ores but, again, without extensive archaeological investigation it is hard to come to a firm conclusion as to the methods used.

Similarly, no refining debris has been found either in or around the Tynedale area or in Weardale. There can be little doubt that cupellation was the method used to separate silver from metallic lead, as it was in antiquity and is well documented in the Devon mines from the late 13th century onwards.

The process of cupellation involved heating the silver rich metallic lead to about 1000^{o}C whilst it was exposed to a strong blast of air from bellows. This resulted in the lead being converted to litharge (lead oxide) which was removed leaving the silver behind. This was best carried out in a small bowl shaped hearth with an absorbent lining which could withstand the high temperature and the corrosive nature of litharge. Traditionally bone ash was used, although tanning bark ash was the preferred material in the Devon mines of the late 13th/ early 14th century.

Unfortunately no cupellation hearths, for the refining of newly mined lead, have been found and excavated in a medieval context but recent work on a Romano-British site at Bromford/Pentrehyling, near Church Stoke on the Welsh border, suggests that the hearths there were about 0.5 metres in diameter.[26] As the lead was gradually removed as litharge, taking with it the oxides of other metals which might be contaminating the lead, the silver was concentrated in that remaining. The last of the litharge was absorbed into the lining leaving silver, mixed with any gold that might be present, sitting in a hollow which had been formed when the hearth was prepared. Documentary evidence shows that cupellation hearths of the late 15th to mid 16th centuries were covered by a domed lid, sometimes with chains attached to aid removal, with an opening through which the operator could rake off the litharge. Although there is excavated evidence for such domed covers in antiquity, without further investigation we cannot be sure that the medieval hearths were covered during operation although the practicalities of the process. and the need to contain the blast and the resultant litharge, would suggest that they were.[27]

The supposed lead/silver smelting, and refining, furnace at Ronaldsway on the Isle of Man, used as an example by Blanchard, would date from the second half of the 13th century a period when, as will be seen later, the bole was firmly established in England as the preferred method of smelting lead and, by the last decade of the century, is known to have been used for lead/silver ores. Unfortunately the excavation of the supposed furnace

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[26] Bayley and Eckstein, *Pentrehyling Fort*. Smaller cupellation hearths have been found and excavated on a number of metalworking sites but they were all used to refine metal recovered during recycling. For example see Bayley, 'Coppergate'.

[27] Craddock, *Early Metal Mining*, pp. 223-8; Agricola, G., *De re metallica*, pp. 464-83. Wolfegg, *Venus and Mars*, p. 80.

was not fully recorded at the time and illustrations of its layout are based on photographs and recollections some thirty years after the event.[28]

Blanchard has suggested that the smelting / refining technique used in the Ronaldsway furnace had its origins in the processing of a mixed argentiferous lead / tin ore supposedly found in deep vein deposits at Furzehill, near Horrabridge in Devon during the early 12th century.[29] If correct, this theory would have considerable implications for our understanding of early tin mining techniques as well as the lead/silver smelting and refining process. However, there is no documentary, archaeological or mineralogical evidence in its support.[30] In constructing at metrological hierarchy from the smelting technique Blanchard assumes that the refining process was free of losses, stating that '*the lead when cupelled was totally converted yielding its assayed silver content without any loss of lead*'.[31] This takes no account of the losses, up to 28%, in the recovery of lead from the cupellation process.[32] The release of so much lead into the environment will have laid down a marker for future archaeological investigation.[33]

With the opening up of the Devon mines in 1292 the smelting techniques used initially appear to have been those current in the established lead mining fields. Those techniques,

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28 Megaw, 'Bakenwaldwath and the medieval lead mines'. The connection with lead smelting/ refining is tenuous, with no slag reported from the site, and the presence of clay and pottery fragment might suggest that the structure was some form of kiln.

29 Blanchard, *Afro-European Supremacy*, pp. 597-9.

30 *Ibid*, pp. 596, 833-850. None of Blanchard's source references stand up to close examination; Dines (*South-West England*, p. 699) makes no mention of a mixed lead/tin ore at Furzehill (see also page 64, n. 135, above), and the references to 'white lead' cited, and referred to in an earlier paper ('Weights and measures'), are for tin production where '*plumbum album*' is white tin, the product of the second smelting (Hatcher, *Tin Production*, p.16. See also pages 64-65 above).

31 Blanchard, *Afro-European Supremacy*, p. 835.

32 See Appendix 2, Section 2, below.

33 West, et al., 'Heavy metals in Holocene peats'.

based on the wind-blown bole hearth, had to be adapted and supplemented to deal with the ores mined in Devon which suggests that the techniques appropriate to silver-bearing ores were not immediately familiar to smelters from the lead mining fields.

On the limited evidence available it is difficult to come to any firm conclusions as to the smelting techniques used for silver-bearing ores prior to the late 13th century. Unless further detailed documentary evidence comes to light, the route to a better understanding of those techniques will necessarily be through archaeological investigation. A recent discovery at Cwmystwyth in mid Wales, where a lead smelting site in the valley bottom has been tentatively dated to the 12th century, appears from the initial archaeological investigations to comprise one or more charcoal fired furnaces with a small wind-blown bole hearth. The silver content of the lead smelted has yet to be determined.[34]

4. Mining and smelting in the Devon mines.

The evidence presented in the previous sections has shown that there was a wide range of quite complex methods on which the medieval miner could build but little evidence that they used them, their needs being met by shallow working with few demands on technology. However, development of techniques from the late 13th century onwards provides evidence that silver mining and smelting, confined to a limited resource base, was at the forefront of technology in the medieval and into the early modern period. Even by 1296 the miners in Devon had developed a body of expertise on which the Crown could draw. Such that, at a time when the Irish mines were being reopened, miners were

[34] Pers. comm. Simon Timberlake, and field visit 18 Oct. 2002.

deployed from Devon to Ireland. Again in 1319 they were pressed into service to work the Glamorgan iron mines.[35]

With the advent of direct involvement by the Crown in the working of the Devon mines in the last decade of the 13th century much more information is available on the techniques employed in both the mining and smelting of silver-bearing ores. The choice of those techniques has to be viewed against a background of the restricted nature of silver-bearing deposits and the need to work the new, deeper deposits in the South-West of England. Continued drainage of the deep workings was to be a constant problem. It was a problem which, with falling population levels from the second half of the 14th century through the 15th century and the consequent shortage of labour, stimulated the introduction of mechanisation in the 15th century. After 1292, and the opening of the Devon mines, smelting techniques soon departed from those used in the established lead mining areas. Processes had to be adopted which allowed for the treatment of all the ore mined, leading to an increased reliance on the charcoal fired furnace.

4.1 Ore extraction techniques.

Within a year of opening up the mines, at Bere Ferrers (Birland) and Combe Martin, the accounts were reflecting the techniques employed. Workings were soon more than mere trenches along the back of the lode; they had advanced to a point where artificial lighting was required.[36] Labour was cheap and large numbers of skilled miners were available to

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35 Salzman, *English Industries*, p. 64; *Cal. Close R.* Edw. II, vol. 3, p. 127.

36 PRO, *Exchequer Accounts* E101/260/4, Account of Vincent de Hulton, 20-22 Edw. I. In the early accounts the term used for a mine working was 'grovis' or groove;

volunteer or be pressed into Crown service. These miners brought with them techniques developed in the established lead mining areas. In ore extraction and drainage they were to serve them well in the initial years. However, as the nature of the ore bearing deposits was more fully understood, new developments in drainage, as in smelting, were required.

Technique in the lead mines of the Pennines, Mendip and North Wales was to open up a rich veins along its length at surface in the form of a trench. There is some evidence to support the use of that technique at Bere Ferrers where the wall rock was sound and easily supported.[37] It was unlikely to have been used to any great depth at Combe Martin without massive support. The lenticular deposits there were in the same plane as the bedding of the soft country rock and examination of old workings in the area of Harris's Lode has revealed that the hanging wall in even the smallest stope was inherently unstable.[38]

Where openworking by trench was inappropriate access to the silver bearing deposits was by shallow shaft sunk on the vein. Levels, or galleries, were then opened up along the vein as far as ventilation and primitive ore handling would allow. Once those limits had been reached another shaft was sunk a few metres further along the vein.

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that is similar to the term used in the Pennines for a rake working, commenced as an open trench along the vein.

[37] At Whitsam Down, immediately south of the stream, the vein has been worked as an open trench to a depth of at least 15 metres but this was later arched over to support 18th / 19th century activity at surface. Similarly the vein beneath the road immediately north-east of Gully Town, at Cleave Mine, has been worked as a trench and later arched to support the road. In both cases the wall rock remains sound, with little support, to the present day. Elsewhere at Bere Ferrers little evidence remains at surface for such trench working along the back of the vein, however, much would have been filled with waste from later activity.

[38] Reports of the Combmartin and North Devon Mining Co. for 1839 refer to *'the ground kept abroad with numberless large pieces of timber'* in the early workings on the Old Combmartin Lode. The ore deposits there having been removed from surface to a depth of 54 metres by the end of the 16th century (National Library of Wales, *G E Owen Papers*, Box 54; Kingdon, 'The Silver Mines of Combmartin').

Ore extraction techniques were appropriately simple. Steel tipped iron tools for breaking rock and ore, wedges, hammers and picks, and leather bags and hempen rope for haulage. Steel tipped iron picks with wooden handles accounted for the majority of the £4 13s. 10d. spent on equipment in the first 18 months of mining to September 1293 and the £8 16s. 1d. spent in the following year.[39] As with all items of capital expenditure, these were provided by the Crown.

The ordinances for the working of the Crown mines, laid out in 1298, required the keeper to maintain a smith at each of the three mines then active.[40] By the first years of the 14th century with four separate mines and the Calstock smelting complex at work, smithing costs could amount to £37 2s., nearly 10% of expenditure, in materials and labour.[41] That figure included £6 13s. 4d. in fuel costs. Moor coal (peat), brought down from Dartmoor was the main fuel for general smithing but, where high quality finished work was required, mineral coal (probably anthracite from south-west Wales) was imported by sea; being referred to as 'sea coal' in the accounts.[42] Charcoal had replaced both sea coal and peat by the 1340s, probably on grounds of cost.[43] By the 1340s only one smith was

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39 PRO, *Exchequer Accounts* E101/260/4, Account of Vincent de Hulton, 20-22 Edw. I, f3; *et picofiis utesilibus cunct' ad extrahend mina de mine.*

40 BL Add MSS 24770 f203

41 PRO, *Exchequer Accounts* E101/261/10, Counter roll of the Abbot of Tavystock, 1-2 Edw. II.

42 The properties of mineral coal as a quality fuel for smithing iron tools were well known by the late medieval period. Its advantage lay in the physical properties - its ability to provide a sustained and concentrated heat source capable of withstanding the rigours of the smith's hearth. Particular grades of coal in south-west Wales are noted by 16/17th century writers as being preferred by smiths for their ability to combine and consolidate in the hearth. Hatcher (*Towards the Age of Coal*, pp. 418-25) lists many instances of the preference for coal and also comments on the problem of charcoal being displaced by the blast from the smith's bellows.

43 'For the wages of one woman sieving charcoal at the smithy' in 1343 (PRO, *Exchequer Accounts* E101/263/5, Account of John Moveron keeper of the mine of

employed but productive working was, at that date confined to the adjoining mines at Furshill and Middledale.[44]

Although there are regular references in the *Exchequer Accounts* to men working in shafts and galleries, further details of ore extraction methods are limited due to the practice of setting the work on a very simple form of tribute. The miners were paid for their produce by the load, washed fit for smelting. All that appears in the accounts is the expenditure based on the total produce of the mines. Unproductive work, deadwork, on the other hand was accounted for by the task or by the fathom and is examined in greater detail at Section 4.4 below.

4.2 Drainage

Once the miner worked below the water table he was hampered by the influx of water from the adjacent ground. In the early years it was deemed adequate to rely on teams of water hauliers equipped with leather buckets (*bulgi*), ropes and probably a windlass to drain the lower parts of the workings.[45] At Bere Ferrers in the five weeks to 13th August 1306, 87 new water bags were made, at 1d. each, and 31 old bags were repaired, at ½d. each; a total of 12 cow hides were then purchased at a cost of 42s. 1d. to make and repair

Birland, 16-17 Edw. III). The ability of charcoal to withstand the blast in the hearth could be improved by combining it with clay.

[44] The four mines named in the early 14th century were the Old Mine, Fershull, Middledale and the South Mine. It is not possible to identify the sites of individual mines despite, in the case of Fershull or Furshill, the existence of a mine of similar name in the modern period.

[45] Water 'winding', implying the use of a windlass, is not referred to until 1480 (PRO, *Exchequer Accounts* E101/266/5) although the use of the windlass or winch is attested in north-east Wales in 1303 (see Section 4.3 below).

further bags. This gives some idea of the numbers involved and the capital costs of manual drainage, the labour element of which was, prior to 1309, the responsibility of the miners themselves. In that year the Crown paid wages to 13 of the water hauliers for five months whilst an adit was brought up to drain the active workings and subsequently it appears to have met the bulk of labour costs incurred in manual drainage in addition to the capital costs.

Adits were a major capital cost at Bere Ferrers from their inception in about 1297. Drainage adits were not a new technique having been employed as early as the second (La Tene) Iron Age in gold mines in the Limousin region of France.[46] At Bere Ferrers they allowed free drainage from the upper parts of the workings; reducing the labour of the water hauliers and extending the working season into the winter months.[47] The employment of tinners in the construction of 'avidods', drainage galleries or adits, in the late 1290s suggests that they were initially open trenches as that was a form of drainage familiar to those working in tin streaming. There is, however, in hard rock mining of vein deposits a limit to how far a trench can be extended without incurring the heavy cost of cutting through the country rock. Subsequent use of the term, in the early 14th century, indicates that the avidods or galleries did not necessarily effecting free drainage to surface. They were in some cases used to drain to a underground sump allowing water to be hauled to surface in buckets. What field evidence there is at Bere Ferrers also suggests that, on entering rising ground, the drainage galleries or adits were soon taken underground.[48]

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46 Cauuet, *Les mines d'Or*, p. 22-3; Cauuet, 'Celtic Gold Mines', pp. 231-2.

47 Salzman, *English Industries*, p. 53; PRO, *Ancient Correspondence* SC1/48/81.

48 BL Add MS 24770 f 202; Lewis, *Stannaries*, p. 9; Hatcher, *Tin Production*, p. 44. On Whitsam Down, Bere Ferrers, south of the stream in an area worked from at least the early 14th until the late 15th century, a large open cut has been excavated in barren

In the early period the adits appear to have been driven along the veins in soft ground requiring timbers for support and launders to channel water through active and abandoned workings. Such adits would be liable to collapse quite quickly and appear to have done so judging by the amounts regularly spent on their upkeep. During the Frescobaldi's tenure they were evidently not maintained and in the half year to Michaelmas 29 Ed. I (1301) £56 0s. 9d. was expended in new drivage and repairs, rising to £343 18s. 5½d. and £307 18s. 10d. in following years.[49] By 1308 costs were lower; £4 4s. 0d. in clearing out adits, £10 13s. 4d. on new work. Costs fell to 32s. for repairs in 1309-10, with new work confined to 'the boring of a rock or blockage of rock from the head of the adit of the mine of Furshill lying through the middle vein, in length 60 fathoms to the south (*iacent' per mediam venam in longitudine - 60 teys versus austr'*) .... so that water could have its course to the adit' at a cost of £20.[50] See Chapter 3, fig. 12, above.

It was not until the year 1 Edw. III (1327) that there is any suggestion of crosscuts to increase the depth at which an adit would drain old workings. An adit of 50 fathoms in length was proposed at Furshill to get under old workings in an area where, as stated above, there was already a long adit along the vein. The cost estimates for that new adit were correspondingly higher, £1 per fathom as against 6s 8d per fathom for extensions

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ground east of, and at a shallow angle to, the vein with the clear intention of draining the ground to the south. The cut is now badly eroded and of indeterminate age but clearly predates the deep drainage adit driven from the valley to the west at some time before 1800.

[49] The Frescobaldi accounted for the issues of the mines in Devon from 18 April, 27 Edw. I to 26 February, 29 Edw. I (*Cal. Pat. R.*, Edw. II, vol. 1, p. 234-5)

[50] PRO, *Exchequer Accounts* E101/261/12, Account of Robert Thorpe, 3-4 Edw. II.

along the vein in 1309 and earlier; reflecting a slower drivage rate in hard rock.[51] It would have taken at least one and a half years to complete.[52]

By the 1340s drainage by adit was quite effective. Only four water haulage bags were manufactured in 1343 and two in the following year. The wages for water haulage were no longer itemised separately in the Exchequer accounts and were again the responsibility of the miners producing ore. It is evident that this situation was the result of regular maintenance to existing drainage adits. For example, 21 fathoms (37.80 metres) *'digging and timbering the adit'* at Furshill Mine in 1343 and *'To William Attebirch for timbering and digging 3½ fathoms in the adits of Middeldale'* in 1344.[53] There was also continued extension of adits into areas of productive working, with frequent reference to deadwork letting down the water in the mines.

Despite being labour intensive the expenditure on adit driving can be regarded as a capital cost, adding to the fabric of the mine. However the ore shoots at Bere Ferrers and, particularly, at Combe Martin are of limited lateral extent; controlled by the junctions of mineralised horizons with north-south crosscourses.[54] They had to be followed deeper to maintain production. This entailed further adits at lower levels to effect drainage at a greater cost in labour.

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51 PRO, *Exchequer Accounts* E101/262/13, Account of Robert Thorpe, 5-6 Edw. II.

52 Based on drivage rates in the 16th century, quoted in Buckley, *The significance and role of adits*, p. 27.

53 PRO, *Exchequer Accounts* E101/263/5, Account of John Moveron, 16-17 Edw. III and E101/263/7, Counter roll of John Cory, 16-17 Edw. III ; *Exchequer Accounts*, E101/263/10, Account of John Moveron, 17-18 Edw. II, entry for 20th December.

54 Beer and Scrivener, 'Metalliferous Mineralisation', pp. 122-3 and 141.

4.3 Haulage

The *Exchequer Accounts* provide ample evidence of the materials purchased for use in haulage of ore, rock, and water from the mines, and 'to lower down miners, timber and tools'.[55] Hempen ropes along with leather bags (*bulgi*) feature regularly amongst the expenses of the mine. It is generally assumed that the ropes were used in conjunction with windlasses, although there are no specific references to their construction.[56] The windlass was a common item of machinery employed in the construction industry of the period.[57] Heavy loads to be hauled out of the workings would have required the mechanical advantage of a simple windlass at least: that this did not advance to the use of the treadwheel, as in the construction industry after the mid 15th century, or the horse whim is probably due to the decline of the mines. Neither is there specific reference to any form of head frame, erected above the shafts, but the materials for construction would be drawn from general timber supplies and not necessarily identified as such in the accounts. An illustration of mid to late 15th century mining activity, albeit probably in an Italian context, does show a head frame similar in construction to the 19th century 'poppet head' although without a windlass (See Fig 1).

Rope for haulage at the Bere Ferrers mines was initially brought from Bridport in Dorset. In 1305 a special building was erected alongside the Tamar and a rope maker employed to make rope there, using hemp purchased for the purpose. The hemp was costing the mine

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55 PRO, *Exchequer Accounts* E101/260/19, Account of Thomas de Sweyneseye, 28-35 Edw. I.

56 The construction of a 'winch' is specifically referred to in accounts of an abortive trial for copper at Dyserth, in Flintshire, in 1303. A group of four central European miners, one from Freiberg, were engaged to carry out the trial using bags and ropes for haulage as in south Devon (Jones, *Flintshire Minister's Accounts*, App. A).

57 Matthies, 'Medieval Treadwheels'.

from 8 to 12d per measure and wages for the making were 3d per length.[58] A total of 139.5 stones of hemp were purchased in 1306 and 97 lengths, plus 11 stones, of rope made up for use in the mine.[59] However, there was still the occasional purchase of rope and by 1308 the mine was again buying all its rope ready made.

4.4 Deadwork - clearance and prospecting.[60]

Prospecting for new ore deposits was an essential activity if output was to be maintained. None of the mines worked in the medieval period presented ore bodies of any great lateral extent and, although it is clear from nineteenth century activity that some did continue to considerable depths, the miner was limited by available drainage as to how deep he could work them.[61] The unproductive work involved in prospecting and drainage, paid for as piecework, features regularly in the accounts; as did that for the clearance of old working to allow access to new ground.

The earliest accounts featuring deadwork tasks are for the period in the opening years of the 14th century when the mines were being refurbished following the departure of the Frescobaldi. Initially that involved the clearance of the old workings neglected by the Frescobaldi. It was necessary to employ miners to drain the working manually in advance of the clearance work at a cost of £1 18s. in 1300/1. Clearance and repair work and the

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58 The measure of hemp was a stone but the length is not specified and would vary with the diameter of the rope.

59 Manufacturing costs at the mine are variously given as 3d per length or 1½d. per stone (PRO, *Exchequer Accounts* E101/260/30, Account of wages, 34 Edw. I).

60 *'Ad minam probandum'* - to prospect for ore.

61 That at the Old Combmartin Mine was subsequently worked to a depth of 228.6 metres below surface and at South Tamar Consols to 387 metres below surface.

driving of new adits into the workings to effect adequate drainage took until 1305.[62] The amount of work to be carried out over those five years was planned and negotiated in advance with four groups of miners. An agreement was drawn up between the keeper (Thomas de Swaneseye), the controller and the miner's groups specifying the total cost, £1026, for the work to be carried out. The miners were paid at intervals through the year according to the progress made. Initially the payments were monthly but had become erratic by the Spring of 1302. It is not clear from the surviving wage rolls whether work continued throughout the year or if miners were diverted onto productive work in the summer months.[63]

Even in 1312 some sections of the Old Mine, at Bere Ferrers, were still in poor condition. One area of workings and their associated drainage gallery had been abandoned 12 years earlier as the supporting timberwork was rotten. The gallery was cleared and the supports reinstated at a cost of £20. Similarly a section adjacent to the South Mine, at Walchemannesknot, was cleared and the timberwork reinstated at a cost of 103s. 4d. Only when that work had been carried out was it possible to continue prospecting work in those areas. Four fathoms (7.2 metres) of new ground were cut in that year and a further 16 fathoms (28.8 metres) in the following year, at 5s. and 6s. 4d. per fathom respectively.[64] It is clear from the amounts paid that the clearance of abandoned workings was a time consuming and probably dangerous operation. But it was necessary, to allow access and drainage to new potentially rich ground. At Walchmannesknott the new ground lay to the north of the old workings and drainage by manual methods was not possible until a new

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62 *'Pro factura anidodorum et reparatione minerarum'* (Smirke, 'Supplementary notes relating to the working of silver mines in Devon', p. 316)

63 PRO, *Exchequer Accounts* E101/260/19, Account of Thomas de Sweyneseye, 28-35 Edw. I; and E101/260/22, Wage roll, Calstock and Bere Ferrers, 30-32 Edw. I.

64 PRO, *Exchequer Accounts* E101/261/15, Indenture, 6-7 Edw. II.

gallery was driven, in barren ground, from the south. Of the 12 fathom (21.6 metres) required, half had been completed by the end of the 1313 financial year.[65]

Three years later deadwork still continued at the South Mine in the area of Walchmannesknot. Further north the drainage adit at Middledale (the Middle Mine) was being extended into the Old Mine to lower the water levels. There was already an adit draining the Old Mine but workings were clearly already well below that level and reaching the limit of manual drainage. Meanwhile prospecting did still continue at the level of the Old Mine adit. Amounts spent on deadwork gradually rose after 1308, reaching £65 per annum in 1315. The opening up of new ore ground was, however, needed to sustain output which was showing signs of decline.[66]

The mines at Furshill and Middledale were still being expanded through prospecting work in the 1340s but new locations at Bere Ferrers were also being explored. Speculative deadwork, boring through barren ground, was carried out next to 'la Redegrove' in 1343.[67] In the following year similar work was carried out at 'la Hillegrove', 'Brodebirch', 'Blakegrove' and 'Kyrkestey'. Further afield prospecting was once again undertaken at the mine at Haghelond (1, in Fig. 18 below.), in Lobbecombe, near Plympton, tried unsuccessfully in 1332.[68] In Cornwall, a mine 'next St Michaels Mount' (4) was investigated; as were other prospects in Cornwall, at Cubert (2) in 1344 and much earlier,

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65 *Ibid.*, f3.

66 PRO, *Exchequer Accounts*, E101/261/21, 1 & 2, Particulars of the account of Richard de Wigornia, 9-10 Edw. II.

67 PRO, *Exchequer Accounts* E101/263/7, Counter roll of John Cory, 16-17 Edw. III. The 'grove' element in the placename being the northern Pennine term for a mine working.

68 PRO, *Exchequer Accounts* E101/263/8, Counter roll of John Cory, 17-18 Edw. III and E101/263/10, Account of John Moveron, 17-18 Edw. III. For details of the earlier trial see Salzman, 'Mines', pp. 84-5.

in 1301, at Altarnun (3).[69] A 'silver mine' at South Tawton and Sticklepath (5), in Devon to the north-east of Dartmoor, was investigated in 1312 along with the mine at Brushford and Dulverton in Somerset (7).[70] Although some of these prospects were worked in the post medieval period, they all proved unproductive in the 14th century.

The tools employed in rock cutting, either for prospecting or adit driving, were the same as those used in ore extraction - wooden handled iron picks tipped with steel, wedges and hammers. The techniques used varied with the type of rock encountered. In harder rocks

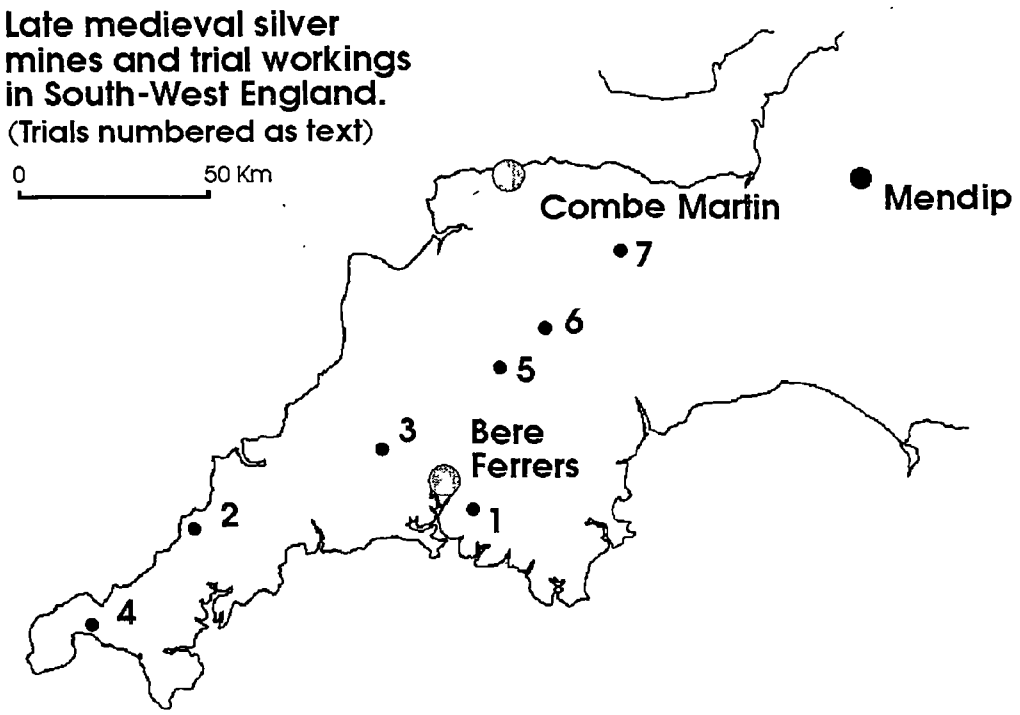

Figure 18 (based on the various references cited in the text above).

advantage was taken of lines of weakness, e.g. fault lines, in the rock. There is a lack of direct documentary evidence for firesetting, where the rock was heated with a wood

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69 PRO, *Exchequer Accounts* E101/263/8, Counter roll of John Cory, 17-18 Edw. III. *Cal. Pat. R.*, Edw. I, vol. 3, p. 577. *Cal. Close R.*, Edw. III, vol. 7, p. 406. In 1498 there was also a futile trial for silver at Brushford, in Devon, (6, in Fig. 18 above) in an area evidently devoid of mineralisation (*Cal. Pat. R.*, Hen. VII, vol. 2, p.135).

70 *Cal. Fine R.*, vol. 2, p.126. *Cal. Close R.*, Edw. II, vol. 2, p. 52

fuelled fire causing it to shatter as entrapped water expanded, although there is limited field evidence for its use in associated surface works in the late 15th century.[71] An essential element to the use of firesetting underground was good ventilation and there is occasional reference to work carried out to effect ventilation in the Bere Ferrers mines, but no linkage to firesetting activity.[72] In a partially completed adit recently examined at Combe Martin, in soft Lester slates and sandstones, the face has the appearance of being advanced uniformly by clean sweeps of the pick. Such a technique would have limited application in the harder rocks of the Bere Ferrers mines: there miners would resort to undercutting or working outwards from a central 'slot', a method used in Derbyshire and parts of Cornwall.[73] Using such methods, from 23 to 26 fathoms of new ground in the Bere Ferrers mines would be cut per year during the second decade of the 14th century.[74]

The deadwork element of ore extraction in the Devon silver mines illustrates more than any other the scale of operations. Development work of this nature in other sectors of the mining industry in the 14th century was virtually unheard of. With more accessible resources, like alluvial tin and non-argentiferous lead ores, it was easier to search out new deposits close to surface than to employ men on the deadwork required to access and drain known deeper deposits. It was not until the mid 17th century that development work on this scale was initiated in the lead mining field of Derbyshire.[75]

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71 See Appendix 11, p. 322, below.

72 See, for example, Salzman, 'Mines', p. 73.

73 Buckley, *The significance and role of adits*, p. 17.

74 PRO, *Exchequer Accounts* E101/261/15 f1 and f2, Indenture, 6-7 Edw. II; and E101/261/21, Account of Ricardus de Wygorn, 10 Edw. II.

75 Wood, *Social Conflict*, pp. 228-229.

4.5 Ore preparation techniques.

As miners in the Devon mines, at Bere Ferrers, in the 13th/14th centuries were paid by the load for ore prepared ready for smelting little detail of the techniques employed appears in the accounts. '*And in payment made to various miners for their labour and expenses, expended by them about the extraction and washing (lotura) of the said .... ore, receiving 5s. per load*'.[76] Thus they had to find the labour and the cost of erecting any equipment they required from the 5s. per load. Such tools as they required were provided by the Crown.

Washing of the ore to remove the waste was a significant part of the process of ore preparation but before that could be carried out the ore had to be physically broken down to manageable size and a certain amount of manual separation was required. Bucking hammers, sometimes referred to as 'broad buckers', for the manual breaking of ore feature in all the surviving inventories of equipment from the mines.[77] No examples or illustrations of the hammers in use on English mines have survived but those in use on the continent were similar in construction to the bucking hammers used in the 19th century - see Fig. 1.[78]

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[76] PRO, *Exchequer Accounts*, E101/261/10, Account of John Moveron, 17-18 Edw. III. A dish for measuring the ore appears in accounts of deadstock on the mine (PRO, *Exchequer Accounts* E101/263/8, Account of John Cory, 17-18 Edw. III and E101/263/11. Account of John Moveron, 22-23 Edw. III).

[77] See, for example, the list of deadstock on the Bere Ferrers mine at Michaelmas 1344 - Appendix 9.

[78] Detail from an illuminated manuscript copy of Pliny's *Historia Naturalis* (National Art Library, MSL/1896/1504), probably Italian and dating from the late 15th century, depicts two miners breaking ore with hammers (Whalley, *Pliny the Elder, Historia Naturalis*, pp. 8-9, and p. 42).

Figure 1, at Page 3 above, well illustrates the technique of manual ore breaking. It was hard physical work, best carried out by the miners themselves, whereas for the manual separation and washing processes they may have employed members of their families. Female labour was regularly used for similar processes in preparing the blackwork, residues from initial smelting, for resmelting.[79] Mechanised crushing, using horse-drawn edge-running(?) millstones, was used in the preparation of blackwork but there is no evidence that it was used in ore preparation. In fact, crushing of ores destined for bole smelting would have been counterproductive as anything smaller than walnut size failed to react fully in the wind-blown hearth. With the smaller ores to be smelted in the furnace, particularly those ores which were heavily contaminated with waste material, there will have been a benefit from crushing prior to washing. But if mechanised means were used the hire of horses to provide power would have been down to the miners, although the crushing stones themselves would probably have been deemed capital expenditure and paid for by the Crown.[80] The only stones featuring in the mine accounts are designated for blackwork crushing.

Once broken up to detach the waste the ores would be picked over to remove the uncontaminated larger pieces of ore. The remainder was washed in a stream of water to separate the mud and lighter waste from the heavier metal bearing ore. The equipment required for the washing process could be constructed using timber from general supplies to the mine so it never appeared in the accounts as a discrete entry. Without the documentary or archaeological evidence to assist us, it is difficult to determine how much

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[79] See Section 4.6.3 below.

[80] Similar methods to those for mechanised blackwork crushing were in use in Derbyshire for ore crushing in the 19th to early 20th centuries but by that time smelting techniques had changed allowing fine ore to be treated with ease.

classification of ores was carried out as part of the washing process. Some must have been carried out to separate the larger sulphide ore (galena), capable of smelting in the bole, from the small ore destined for the furnace. Separation of carbonate ores (cerussite) from galena would best be carried out by eye, after initial washing, as they were easily differentiated by colour, whereas in a primitive form of gravity classification the lower specific gravity of the carbonates made them difficult to separate from the waste.

Using planks or stone paving to make a shallow trough with gently sloping floor, over which a stream of water passed, would form a primitive buddle. A mixture of ore and waste would be introduced at the head of the trough. The heaviest pure ore remained near the top of the trough whilst the waste was carried off by the water. Towards the lower end of the trough the ores still combined with waste matter were deposited and when recovered these could be returned for further breaking before reclassification. By altering the angle of the slope and the velocity of the water entering the trough, the values of ore mixed with waste recovered could be controlled. The steeper the slope and the greater the velocity of water the more likely that smaller pieces of ore would be carried away and lost.

The pieces of ore mixed with waste returned for further manual breaking were probably dealt with using smaller 'hand buckers', one of which appears in an indenture of tools dated 1325. That work was lighter and perhaps allocated to female labour as it was in the 18th/19th century.[81] Once the material subject to further breaking had been reclassified in the trough it could be sorted by size, the larger pieces going to the bole for smelting and the smaller to the furnace. To achieve this the ore could be sieved or passed over a grating

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[81] Burt, *Ore Preparation Techniques*, p. 15, fig. 2.

with a mesh allowing anything smaller than about one half inch to pass through. Whilst the purchase of sieves does occasionally appear in the mine accounts the majority are fine sieves intended for sorting refinery ash. A sieve for washing purposes was purchased in 1343 and appears on the account of deadstock in 1344, and again in 1349.[82] The sieving of smelting residues is specifically referred to in 1342/3: '*To Richard Hipper and his associates for breaking, washing and sieving 29½ feet and ½ quarter from the said resmeltings - £4 8s. 10½d., per foot 3s.*'[83] A number of tubs also appear in those accounts and, although their purpose is not specified, they were probably used in conjunction with the sieve to concentrate ore by gravity separation, commonly referred to as jigging. The technique was known in central Europe in the 14th century, contrary to Agricola's claim that it was new to Germany in the 16th century.[84] Ore was sieved in a vat of water, the pure ore settling to the bottom with mixed ore/waste in the layer above and waste at the top. The fine material fell through the sieve and was later recovered for reclassification in the buddle. The material in the sieve was removed a layer at a time. Waste was discarded, mixed ore and waste was returned for further breaking, and ore went forward for smelting. Other sieves or gratings used in ore preparation were probably made from wood found for the mine and, again, would not appear as a discrete item in the accounts. The finest ore and mixed ore / waste were initially discarded but from time to time the waste heaps would be reworked to extract more smeltable ore. By the mid 15th century the finer ore, referred to as the 'afterwash', was specifically reserved to the lessee as an issue not subject to Crown royalties.

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82 PRO, *Exchequer Accounts* E101/263/7, Counter roll of John Cory, 16-17 Edw. III, entry for 19th April; *Exchequer Accounts* E101/263/8, Account of John Cory, 17-18 Edw. III, and E101/263/11, Account of John Moveron, 22-23 Edw. III.

83 PRO, *Exchequer Accounts* E101/263/5, Account of John Moveron, 16-17 Edw. III.

84 Craddock, *Early Metal Mining*, p. 165; Agricola, *De re metallica*, p. 310.

The accounts mention no specific sites for ore preparation at the Bere Ferrers mines although one is named as being used for blackwork washing.[85] Entries in the accounts, for payment due on the transport of ore, suggest that ore was taken directly from the workings to the designated smelting site. Each of the mines would have had an area set aside for the process with ready access to water. Such sites have yet to be identified but, in all probability, they will have been lost beneath modern workings.

4.6 Smelting techniques

Within a few years of commencing operations in the Devon mines, in 1292, smelting methods were diverse. Initially the simple wind-blown hearth, the bole (*bolem*), was the only smelting technique employed but its capabilities were limited and it was soon necessary to supplement the bole with a number of charcoal burning, induced draught, furnaces as illustrated in the accounts for the six year period 1292 - 1297 (Table 4 below). Experimentation with furnace design continued into the early years of the 14th century, establishing a complex of smelting operations suited to the treatment of all the ore mined. There were variations in the ratio of bole to furnace smelting, reflecting changes in the quality of the ore mined, and changes in the timing of campaigns but the bole/furnace complex (Fig. 20 below) was to hold sway in the smelting of silver-bearing lead ores until supplanted by the 'fynyngmyll' in the second half of the 15th century.

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[85] Referred to as 'La Ponne' and possibly south of the Tavy, near Pound - see Fig. 19 below.

Table 4 Fertile Lead Production; Devon mines 1292-7 [86]

Year	Method	Sub Totals (feet)[87]		Annual Total
20 Edw. I	Bole (galena)	Birland	42.4	
		Combe Martin	19.5	61.9 feet
21 Edw. I	Bole (galena)	Birland	230.5	
		Combe Martin	90.5	321.0 feet
22 Edw. I	Bole (galena)	Birland[88]	405.0	405.0 feet
23 Edw. I	Bole (galena)		713.0	
	Hutt (galena)	(included with above)		
	Furnace (cerussite plus blackwork from previous years smelting)		120.5	1014.0 feet[89]
24 Edw. I	Bole (galena)	2 Feb - 25 Mar	32.5	
		25 Mar - 21 May	191.0	
		21 May - 12 Jul	91.75	
	Furnace (blackwork from the bole)		63.5	
	Hutt (galena)	2 Feb - 25 Mar	93.25	
		25 Mar - 21 May	140.5	
		21 May - 12 Jul	258.25	
	Furnace (blackwork from the hutt)		125.25	
	Furnace (cerussite)	2 Feb - 25 Mar	103.75	
		25 Mar - 21 May	168.75	
		21 May - 12 Jul	108.5	
	Furnace (galena)		245.0	1622.0 feet
25 Edw. I	Bole (galena)	6 Jan - 22 Mar	272.0	
		22 Mar - 26 Apr	111.5	
		26 Apr - 24 Jun	331.5	
		24 Jun - 15 Sep	143.0	
	Furnace (blackwork from the bole)		616.75	
	Furnace (cerussite)	6 Jan- 22 Mar	204.75	
		22 Mar - 26 Apr	143.5	
		26 Apr - 24 Jun	190.75	
		24 Jun - 15 Sep	99.25	
	Furnace (blackwork from furnace above)		124.25	
	Furnace (galena)	6 Jan - 22 Mar	84.25	
		22 Mar- 26 Apr	139.5	
		26 Apr - 24 Jun	62.5	
		24 Jun - 15 Sep	159.0	2682.5 feet

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[86] Based on PRO, *Exchequer Accounts* E101/260/5, Account of mines at Combe Martin, 20-25 Edw. I; and E101/260/6, Account of W. de Wymundeham, 20-25 Edw. I.

[87] One foot = 70 lb.

[88] All figures thereafter refer to Birland, i.e. Bere Ferrers, alone.

[89] Includes 180.5 feet of pure lead (*plumbi pur*) returned to the hutt, *'for which they are not answerable for the silver.'* (*Ibid.*, see Appendix 7, p. 309 below)

4.6.1 The Bole

Bole smelting was a simple process. It relied on the wind for its draught, so an exposed elevated site was chosen and an open topped, roughly rectangular, structure was erected with the windward side left open; either totally or partially, to allow air flow to the fire. Within this structure was laid a foundation of logs on which was spread a layer of slags from an earlier smelting and above this layers of brushwood and ore. Once ignited in a strong wind the ore near the top of the pile was roasted to form an oxide which then reacted with the unroasted ore giving off sulphur dioxide. The lead thus released fell through the fire to collect in specially formed hollows or channels below the foundation of logs. The process can be expressed in chemical terms as

$$2PbO + PbS = 3Pb + SO_2$$

Once the process was complete the metallic lead was removed and some of the residues or slag retained for use at the next burning, the rest being discarded. The log foundation was relatively unaffected being retained for the next burning.[90]

The form of the bole structure used in Devon is unclear as no examples have been excavated and we must rely on comparisons with hearths investigated in the Pennine lead mining fields.[91] The amount of ore smelted at one firing of the bole is not clearly defined

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90 Gill, 'Chemistry of lead smelting'.

91 These are predominately from the late 15th / early 16th century and are substantially larger than those used in the Devon mines of the late 13th / early 14th century, smelting up to 16 fothers (c. 16 tonnes) at one firing. (see Kiernan, *Derbyshire Lead Industry*, p. 41 et seq.; Kiernan and Van de Noort, 'Bole Smelting in Derbyshire', p. 20, fig. 1.)

in the accounts but the amounts supplied to the bolers in the 1340s suggest the structures were much smaller than those used in Derbyshire in the early 16th century.[92] They were, however, substantial in their construction. Ground was cleared to form the base (*basas*) and walls erected using masonry and, on occasions, *tegula* (bricks or tiles). There is also one instance of a simple earth structure being used: *bolas terreas*.[93] Siting of the bole depended to some extent on the availability of wood for fuel but, as they relied on natural draught from the wind, an elevated location was essential. At the Bere Ferrers mines, even after the majority of smelting and refining activity was removed to Calstock, bole smelting continued at sites on the high ground on both sides of the Tamar.

Initially, from the 1290s until the second quarter of the 14th century, the bole in Devon was worked throughout a large part of the year. Increasing from a six month period in 1296 to nine months in the following year, perhaps reflecting the increased output of the mines. By 1307-8 the boler and his two helpers were paid for the full period of the account, 26th November to 29th September, providing a steady supply of fertile lead to the refinery. With limitations to the performance of the bole, detailed below, there was a move to smelting in short campaigns by the 1320s and 40s (see n. 96 below). However, by that period the output of the mines had fallen and there was less ore suitable for bole smelting. These campaigns of a week at a time in the 1340s, generally in autumn, early spring and, on one occasion, in July, allows an insight into the costs involved, Table 5 below.

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92 See Table 5 below.

93 PRO, *Exchequer Accounts* E101/260/22, Wage roll Calstock and Bere Ferrers, 30-32 Edw. I, entries for 2 Feb., 20 Jul. and 3 Aug. 30 Edw. I.

The ability of the bole to reduce silver-bearing lead ores was restricted to the larger pieces of galena, referred to as 'bing' ore in the lead fields of the Pennines, free from entrapped waste. Added to which the residues, blackwork (*opus nigram*), from bole smelting still contained appreciable amounts of lead and silver. Bole smelting was introduced to the mines at Bere Ferrers and Combe Martin by workers used to treating the lead ores found in the limestone uplands of England and north-east Wales where an abundance of shallow deposits allowed the miner to move on to new sources of suitable ore.[94] It was well suited to that application - relatively efficient on fuel and its ability to reduce the ores to metal [95] - but had probably never before been applied to silver-bearing ores. The restricted nature of the resources available in Devon - effectively confined to the one mineralised cross-course at Bere Ferrers and unpredictable deposits at Combe Martin - meant that all the ores mined, and their residues, had to be treated by methods other than the bole to extract the available silver.

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94 Blanchard, 'Lead mining and smelting', p.74

95 See p. 169 below.

Table 5 Bole smelting costs [96]

1342	December 21st	Payment for 18 loads 3 dishes of black ore	£4 11s 8d
		Carriage of same to bole	23d
		Cutting of wood for one bole plus carriage	14s
		To William Hacche for firing bole	15d
		To his helpers	16d
1343	March 1st	Payment for 8 loads of black ore	40s
		Carriage to the bole	10d
		Cutting down and carrying wood to the bole	6s 4d
		To Jordan Kannel and 2 helpers for smelting the bole for 2 days and 2 nights	18d
	September 20th	For cutting and carrying one bole load of wood	11s
		For 17 loads of black ore	£4 5s
		Carriage of same to bole	21¼d
		To William Hache for the bole for a week	15d
		To his 2 helpers	16d
1343	November 29th	Felling and carrying all the wood for one bole	7s 4½d
		Payment for 13 loads black ore	65s
		Carriage of ore to bole	16¼d
		To Jordan Kannel for firing the bole	15d
		To his two helpers	16d
1344	February 21st	For the repair of the bole house (and roofing the smithy)	3s 1d
	March 20th	To Phillip Purour, repairing the bole for 1 day	2d
		For cutting wood of 1 bole load and carrying	8s
		For 15 loads 2 dishes of black ore	76s 1d
		Carriage of the same to the bole	19d
		To Jordan Kanel for firing the bole	15d
		To his 2 helpers for a week	16d
	July 17th	Felling and carrying all the wood of one bole load	8s 6d
		Payment for 18 loads 6 dishes of black ore	£4 13s 4d
		Carriage of the same to the furnace and bole	23¼d
		Jordan Kanel, for firing the bole for a week	15d
		To his 2 helpers	16d
	September 18th	For breaking and washing the blackwork of one bole load[97]	4s
	September 25th	For 11 loads of black ore	55s
		Carriage of the same to the bole	13¾d
		For felling and carrying the wood of one bole	7s 6d
		Jordan Kanel for firing the bole of a week	15d
		To his 2 helpers for the same time	16d
		For breaking and washing the blackwork of one bole	4s

[96] PRO, *Exchequer Accounts* E101/263/8 and 10. The change to campaign smelting had occurred by at least the late 1320s (Salzman, 'Mines', p. 76.)

[97] If compared with the rate for breaking and washing other blackwork and smelting refuse containing silver, usually 3s per foot of lead recovered, then only about one and one third feet were recoverable from the refuse of the previous firing (PRO, *Exchequer Accounts* E101/263/5, Account of John Moveron, 16-17 Edw. III)

4.6.2 The turnbole (*bolas turnellas* or *bolas vesatilis*)

One adaptation of the bole appears to have been unique to the Devon silver mines.[98] The need to provided a steady flow of fertile lead to the refinery left the bolers to cope with shifts in wind direction, employing multiple bole sites without the advantages of prominent high ground sites available to their contemporaries in the Pennines. By at least 1296 a bole structure had been mounted on a moveable platform capable of being rotated about a central vertical axle to face the wind.[99] These became a permanent feature in smelting on the Devon mines. As smelting activities were moved around the Birland area, and across to Calstock, in response to the availability of wood for fuel, the substantial timber base of the turnbole was uprooted for transfer to the new site. At Buckland Monachorum in 1303 it took seven men a whole day in *'removing the post and timber of the said bole from the ground'*. For which they were paid 4d. each, twice the normal rate for labour at that date - heavy work indeed.[100] We have no details on the construction of the turnbole but the development in Europe of the post mill provided an ideal model on which it may have been based. Confirmation of this must await the identification and archaeological investigation of specific sites.

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98 Blanchard ('Lead mining and smelting', p. 77) has suggested that the turnbole was adopted in Durham in the 15th century but this is not supported by Drury ('Leadworks') in her examination of the Bishop's accounts.

99 PRO, *Pipe Roll* E372/145

100 PRO, *Exchequer Accounts* E101/260/22, Wage roll Calstock and Bere Ferrers, 30-32 Edw. I, entry for 31 August 31 Edw. I

4.6.3 Furnace smelting, and its development to 1500.

Limitations in the ability of the bole were countered by the introduction, in 1295, of the charcoal fired furnace using a bellows induced draught, along with a smelting method described as the '*hutt*' which is considered in detail below.[101] The furnace was initially used to smelt the carbonate ore (cerussite) along with *blackwork*, the residues from the previous three years bole smelting, but other ores unsuitable for the bole and residues from other processes were smelted in following years (See Table 4 above). High temperature reducing conditions in the charcoal fired furnace meant that lead in the ores tended to volatilise before it oxidised, preventing the initiation of the reaction which released the lead in metallic form. Blackwork did not present the same problems as it had already been oxidised in the bole smelting process. Smelting a mix of ore and blackwork together overcame the problem which attended the smelting of ore alone, and could account for the delay in the introduction of furnace smelting.

The furnace structures were of stone, brick and clay. In some cases specific materials were used, as in 1305 when granite was brought from Hingston Down to the smelting site at Calstock.[102] Bricks were commonly used, as in 1323/4 when they were shipped by river from Cornwall into the smelting site at Martinstowe on the Tavy, and a mason was regularly employed in building and repairing furnaces.[103] Manually operated bellows were used to create a forced draught, two per furnace with a team of three blowers to ensure a

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101 These introductions were effected at the Bere Ferrers mines only. Production from Combe Martin ceased in the previous year.

102 PRO, *Exchequer Accounts* E101/260/30, Account of wages, 34 Edw. I, entry for 27 August.

103 PRO, *Exchequer Accounts* E101/261/22, Account of John Suge, keeper of the king's mine in Devonshire, 15-16 Edw. II. For furnace construction see, for example, frequent references in E101/260/30 the wage roll for 34 Edw. I

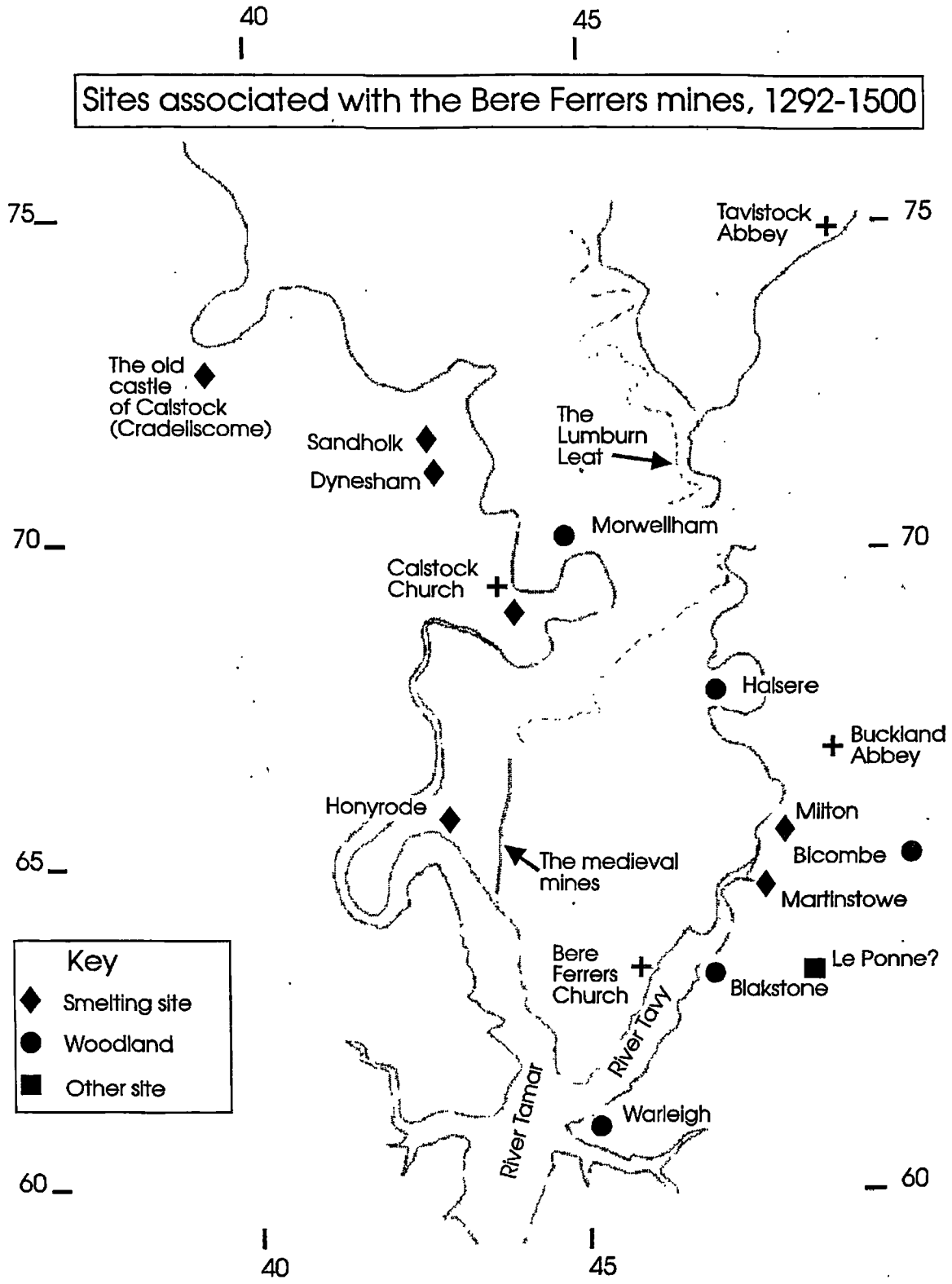

Figure 19 (based on the various *Exchequer Accounts* cited in the text).

continuous draught.[104] In at least one case the bellows blowers were female.[105] The whole process was supervised by furnacemen, some of whom, in the early part of the 14th century, were drawn from the established lead mining fields.[106] No detail of bellows construction is evident in the record, apart from the purchase of materials: leather and the hemp cord used as part of their mechanism.[107] The cord probably returned the bellows to rest in much the same manner as the saplings illustrated in the 16th century. [108]

Before resmelting the blackwork had to be broken up, crushed and then washed to remove the lighter waste material containing little or no lead. Breaking was done by hand, using bucking hammers. Crushing was a mechanical process, using a horse powered turning device or engine, *'ingenia turnabil frangendo nigrum opus'*, possibly a millstone running on edge.[109] That used at Milton was removed in October 1302 and re-erected near the furnaces at Calstock in the December.[110] Two devices were in use in 1307-8, with four horses and up to three men employed in what was predominantly a winter activity; only one man was retained after the end of January.[111] Some manual crushing of blackwork may have been carried out using stone mortars and hammers. Such devices would be

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104 See for example frequent references in *Exchequer Accounts*, E101/260/30, to the number of bellows blowers employed.

105 PRO, *Exchequer Accounts*, E101/260/22, Wage roll 30-32 Edw. I, entry for 14 September, 31 Edw. I.

106 See, for example, Phillip de Yal whose surname suggests he came from north-east Wales. For a full list see Appendix 4.

107 PRO, *Exchequer Accounts* E101/260/22, Wage roll, 30-32 Edw. I, entry for 26 Oct. 31 Edw. I.

108 PRO, *State Papers Domestic, Eliz. I*, SP12/122/63 (see Kiernan, *Derbyshire Lead Industry*, p.122 for a clear illustration.)

109 PRO, *Exchequer Accounts* E101/261/10, Counter roll of the Abbot of Tavystock 12 Edw. II.

110 PRO, *Exchequer Accounts* E101/260/22, Wage roll, 30-32 Edw. I.

111 PRO, *Exchequer Accounts* E101/261/10, Counter roll of the Abbot of Tavystock 12 Edw. II.. For an example of a similar device still used in Derbyshire in the late 19th century, see Kirkham, *Derbyshire*, p. 54.

made from locally available material and do not appear in the accounts, but have been found in a medieval context elsewhere, for example at Nantymwyn, in Carmarthenshire, and at Brandes en Oisans, in France.[112]

Washing the crushed blackwork was by gravity separation, a process similar to that for ore preparation, using some female labour.[113] At Calstock, 1302 to circa 1316, water for the purpose was brought by leat to a site adjacent to the furnaces.[114] The benefits of resmelting the residues (blackwork), in the amount of lead and silver recovered, are well illustrated in Table 6 below. Treatment of blackwork remained an integral part of the lead/silver smelting process throughout the medieval period, although there is no firm evidence for its adoption in the non-argentiferous lead fields until the first quarter of the 15th century.[115]

By 1296 furnace smelting, of cerussite, galena (small galena not suitable for the bole), and blackwork, already accounted for 50% of the fertile lead produced. Much of the remainder came from experimentation with a process called the '*hutt*', continued from the previous year. Only 20% was the produce of the bole.[116] The '*hutt*' only appeared in the accounts for the two years (1295 and 1296), and they provide little information on its operation. It was apparently a form of liquation, involving the return of sterile lead into

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112 Timberlake and Craddock, 'Pen Cerrig-mwyn'. Bailly-Maitre and Bruno Dupraz, *Brandes en Oisans*, pp. 89-91.

113 See Section 4.5 above.

114 PRO, *Exchequer Accounts*, E101/260/22, Wage roll Calstock and Bere Ferrers, 30-32 Edw. I, entry for 14 September, 31 Edw. I.

115 Drury,'Leadworks'; Blanchard, ' Seigneurial entrepreneurship'. It is evident that the resmelting of residues was an established practice on the continent, and in use at Melle by the 10th century (Téreygeol, 'Les mines d'argent', fig 7).

116 See Table 4 above.

the process, where the silver in difficult ores was drawn into the lead.[117] Exactly which ores were being treated in the '*hutt*' is unclear. The accounts say 'black ore' (*mina nigra*) which in every other respect refers to the sulphide ore, galena, but this may have been an attempt to work silver bearing copper ores.[118] Despite making a sizeable contribution to fertile lead production, no further mention is made of the '*hutt*' after 1296.

Further experimentation in smelting continued into the first decade of the 14th century. In 1304 a furnace was erected on a turning device '*ingenium versatilis*' mounted in a pit at Calstock, the whole being roofed over.[119] Its purpose is unclear although it may have been intended to reduce discomfort to the operators during variable wind conditions. In the following year a further new smelting device was erected using stones (granite?) brought from Hingston Down. The cost of making 'faggots' for the new device is entered in the wage roll but little else that would indicate its method of operation.[120] At the same period reference was made in the accounts to the cost of erecting a '*T'engle*' for smelting the ore.[121] This and the new device above were probably one and the same.

Lead losses, through volatilisation, would be much greater in the furnace than in the lower temperatures of the bole. It is difficult to give an accurate extraction rate, ore to metallic lead and silver: the ores were mixed, various processes were employed and it is unclear if

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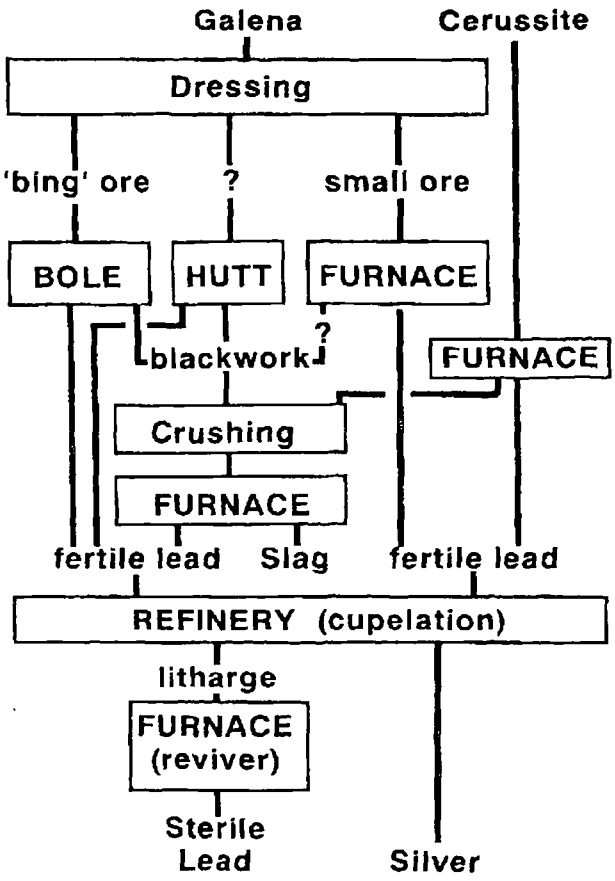
117 '*Plumbi pur apportati ad Hutt'* (PRO, *Exchequer Accounts* E101/260/6, Account of W. de Wymundeham, 20-25 Edw. I, f12)

118 See page Section 4.6.4 below, for further comment on silver-bearing copper ores.

119 PRO, *Exchequer Accounts* E101/260/22, Wage roll Calstock and Bere Ferrers, 30-32 Edw. I, entries for 11 January, 32 Edw. I, et seq. PRO, *Exchequer Accounts* E101/260/26, Account of wages, 32 Edw. I, entry for 1 August.

120 PRO, *Exchequer Accounts* E101/260/30, Account of wages, 34 Edw. I, entries for 27 August and 3 September.

121 PRO, *Exchequer Accounts* E101/260/19, Account of Thomas de Sweyneseye, 28-35 Edw. I, necessary expenses 33-34 Edw. I - '*in quodam novo igenio faciende T'engle pro mina comburenda'*.



The smelting and refining complex of the late 13th century

Note - feed lines marked thus -? - are implied but not specifically referred to in the accounts. Source - *Exchequer Accounts*

Figure 20 (based on the various *Exchequer Accounts* cited in the text.)

blackwork from initial smelting was all treated immediately. It is evident that the keeper monitored the expected yield of the ores as regular assays were carried out, although the details do not appear in the accounts.[122] However, an overall idea can be gained from the accounts for 1307-8 (Table 6 below). Unfortunately the accounts do not provide us with

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[122] PRO, *Exchequer Accounts* E101/260/22, Wage roll Calstock and Bere Ferrers, 30-32 Edw. I, entries for 14 September, 31 Edw. I, et seq.

figures on which to calculate the increased lead losses in the furnace, but using figures given elsewhere it is possible to calculate a rate for the extraction of fertile lead from the ores at 45% for the bole and 38% for the furnace.[123] An overall figure for 1307-8, at 40%, reflects the predominance of the furnace in the smelting process and there is further evidence for this in the number of skilled workers employed at Calstock, with three furnacemen to one boler.[124]

Table 6 Production Bere Ferrers, November 1307 to September 1308.[125]

Ores[126]	Fertile Lead[127]	Sterile Lead	Silver
681 loads, 1¼ dishes	88½ carts, 1¾ feet	59 carts, 11½ feet	8296 ozs
Blackwork			
(quantity not specified)	13 carts, 7¾ feet	9½ carts, 1¾ feet	1206 ozs

In the following four decades, to 1349, there were occasional references, in the accounts of the Devon mines, to a 'mill' in connection with smelting activity and the siting of the furnaces but no real evidence for the application of water power to the furnace bellows.

123 PRO, *Pipe Rolls* E372/145. See also Salzman, *English Industries*, p. 58.

124 A trend reflected in the employment of smelters throughout the first decade (see Appendix 4).

125 Based on PRO, *Exchequer Accounts* E101/261/10, Counter roll of the Abbot of Tavystock, 1-2 Edw. I.

126 1 load = 9 dishes; where the dish was an unspecified volume measure - see Appendix 15.

127 The account specifies that a cart contained 24 feet of lead, each foot weighing 70 lbs. - see Appendix 15.

The wage rolls continued to list the furnaceman and his bellows blowers.[128] For over fifty years an interlinked smelting complex utilising the bole and the furnace, to treat all the ores mined, held sway in the Devon mines. It is well into the 15th century before firm evidence for changes in smelting technique appears in the record of English silver mining.

The use of the 'fynyngmyll' at Bere Ferrers in 1480/81, for the smelting of all the ores mined and the refining process, signalled a significant change from the techniques developed in the late 13th and 14th centuries. Bole smelting was abandoned and all ores were treated in the furnace. To achieve this it was necessary to roast the ore prior to smelting. The product of the 'rost' was described as 'metall' in the accounts but is unlikely to have been metallic lead unless the 'rost' was another term for the bole. There is, however, no reference to the carriage of blackwork, slags or residues or the employment of men in the processing and resmelting of such residues. Rather the 'rost' was a preliminary treatment to remove sulphur and initiate the reduction of the ores, a process to be completed in furnaces at the 'fynyngmyll', and the material referred to as 'metall' was in a semi-metallic form or matte.[129]

The process in 1480/81 was approaching that illustrated for central Europe by Agricola in the latter half of the 16th century.[130] No mention is made in the accounts of manual blowing of bellows. A bellows was provided for the 'fynyngmyll', as was fuel in the form

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128 PRO, *Exchequer Accounts,* E101/263/7, Counter roll of John Cory, 16-17 Edw. III, and E101/263/10, Account of John Moveron, 17-18 Edw. III. Salzman, 'Mines', p. 76. The 'slaggemill' identified by Salzman would be the crushing device for blackwork (p. 165 above).

129 PRO, *Exchequer Accounts,* E101/266/25, Counter roll of profit and expenses of the mine of Beer Ferrers, 20-21 Edw. IV. For later examples of the roasting process see Agricola, *De re metallica*, pp. 273-6.

130 Agricola, *De re metallica*, pp. 276 and 395.

of charcoal, and the name is suggestive of the use of waterpower for the bellows. No account is made of the cost of constructing the 'myll', nor is its location given, but the frequent reference to carriage by water does suggest the use of an existing structure close to the river.[131] Later, a water-powered furnace is known to have been erected at Combe Martin by Joachim Hochstetter in 1528.[132] That furnace would have had its origins in central Europe and probably followed the same lines as the 'Almain' furnace used by Burchard Cranich in Derbyshire in the 1550s.[133]

The 'fynyngmyll' came at the beginning of a process of change in lead/silver smelting techniques which extended well beyond 1500. Even after the introduction of the ore hearth for smelting lead ores in the second half of the 16th century some furnace techniques continued to be used in silver-lead smelting.[134] There were claims, and counter claims, as to the best smelting methods. Those were mainly connected with attempts to use mineral coal (sea coal) as fuel, a technique not perfected until the late 17th century.[135]

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131 Probably at Martinstowe, on the Tavy.

132 *Cal. L & P. Hen. VIII*, vol. 4, pt. 2, no. 5110; *ibid*, addenda, vol. 1, pt. 1, no. 603. *Cal. Pat. R.*, Edw. VI, vol. 3, p. 5. For details of Hochstetter's activity at Combe Martin, see Claughton, *The Combe Martin Mines*, pp. 9-10.

133 Kiernan, *Derbyshire*, p. 121. The water-powered furnace, probably located in Italy, illustrated in Figure 1 has the appearance of an Almain lead furnace. With the produce now tarnished black but originally silver in colour, it is clearly depicting fertile lead being tapped as silver was not drawn from the furnace in this manner (Whalley, *Pliny the Elder*, pp. 8, 42).

134 See Kiernan, *Derbyshire*, for the development of the ore hearth. An Almond or Almain furnace was still used for smelting slags at the Ynyshir smelter, Cardiganshire, in 1662. Although the five smelting 'furnaces' there were clearly ore hearths, employing a workstone, accounts of the fuel used vary. It was stated to be either white coal (dried chop wood) alone or a mixture of that and charcoal (Ray, *Collection of English Words*, pp. 113-118; Pettus, *Fodinae Regales*, p. 35.)

135 *Cal. S. P. D.*, 1616-1623, p. 594; *Acts of the Privy Council*, vol. 39, p. 514.

4.6.4 Copper ores

On at least three occasions in the first half of the 14th century copper based ores or residues were smelted by the Crown at the Devon mines. The source of the ores is not specified. In 1311-12 one and a half cart loads of fertile lead was recovered from what was described as copper blackwork, residues from the previous years smelting.[136] This may have been the produce of a liquation process like the 'hutt'. No copper appears to have been produced as, in the following year, 15 pounds of copper was actually purchased to 'purify' the silver.[137] By 1315/16 copper was being produced 'from certain old work at Calstock' and sold for £1 8s. A German, Hermannus de Almannia, was employed to carry out the smelting at Martinstowe.[138] In the year following more blackwork was resmelted yielding 12 feet of copper which sold for 18s.[139] A decade later there is a further reference to copper production, again from blackwork, when one of the smelters at the Bere Ferrers mines, William le Wower, erected a furnace for the task. He and three bellows blowers were then paid for one days labour smelting and two days refining. In that year, 1328, 126 pounds (57.27 kg) of copper were produced selling at 2½ to 3d per pound. The copper was evidently not suitable for use in alloying with silver as two pounds were bought in specifically for that purpose.[140] The source of the ores smelted to produce 'copper blackwork' is not known. They may have been copper rich tetrahedrites from the Bere

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136 PRO, *Exchequer Accounts* E101/261/13, Account of Robert Thorpe, 3-4 Edw. II.

137 PRO, *Exchequer Accounts* E101/261/15. Indenture, 6-7 Edw. II; by 'purifying' the silver it could mean that copper was added to achieve sterling standard.

138 This could be the same H(erman) de Alemannia who was prospecting a silver mine at Dulverton in 5 - 7 Edw. II (1311-14.) (*Cal. Close R.*, Edw. II, vol. 2, p. 52.)

139 PRO, *Pipe Rolls* E372/162; *Exchequer Accounts* E101/261/21 (2), Account of Ricardus de Wygorn, 10 Edw. II.

140 Salzman, 'Mines', p. 85; 'for 2 pounds of copper for mixing with the blanched silver in the refining, because it annihilates and destroys the lead and makes the silver pure in itself.' Which, as Salzman points out, is metallurgically doubtful.

Ferrers mines, silver-bearing copper ores from the Tavy valley mines, or more complex silver-bearing ores from the mines in the western part of Calstock manor, worked around Wheal Brothers in the 19th century. Whatever their origin, it is evident, by the recovery of fertile lead, that they were worked primarily for their silver content, probably using a liquation process similar to that used earlier in the 'hutt'.

4.7 Refining technique

The cupellation hearth used in the Devon mines, at the smelting/refining sites associated with the Bere Ferrers workings, in the first half of the 14th century typically processed 18 feet of fertile lead at each firing (at 70 pounds to the foot), producing from 65 to 72 ounces of silver.[141] Tanning bark ash was used to form the lining of the cupel which, if compared with the hearths illustrated by Agricola in the latter half of the 16th century, would have been about 0.45 metres in diameter.[142] No mention is made in the accounts as to the form of the cupel itself, only its ash lining. There are, however, listed in the inventory of 1325 two '*cradles*' in which to put the ash. These may be formers for the ash lining.[143]

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[141] In some years the produce would be considerably less when refining poor quality fertile lead. As in 1342/3 when the average produce of silver over 311 days was only 32.3 ozs per hearth. (PRO, *Exchequer Accounts* E101/263/5, Account of John Moveron. 16-17 Edw. III)

[142] Agricola. *De re metallica*, pp. 467-72. The cupels illustrated by Agricola were approximately 0.75 metres in diameter and were usually charged with 50-60 *centumpondia*, each of 70.6 lbs, per firing.

[143] PRO. *Exchequer Accounts* E101/262/4. Indenture of the tools of the mine. Bere Ferrers. 18 Edw. II.

Each firing took a day to complete and, in addition to the refiner, two men were employed to operate the bellows. Prior to 1302, when smelting operations were moved to Calstock on the Cornish bank of the Tamar, the refining of lead from the Bere Ferrers and Combe Martin mines was carried out in a building erected for the purpose in 1292 at Martinstowe, on the east bank of the river Tavy upstream from Bere Ferrers village.[144] There the bellows used at the hearths was operated by a waterwheel. The wheel was subsequently moved to Calstock but not used. With a poor surface water supply at the principal smelting/refining site immediately south of the church and an abundant supply of labour, mechanisation was probably deemed an unnecessary expense.

Even after 1316, when smelting and refining activity returned to Martinstowe, the refinery bellows continued to be manually operated. In the 1340s two blowers were assigned to each refinery hearth. It was not until the latter half of the 15th century that we have evidence that the practice had been discontinued and water power was again being used.[145]

The ash required to line the cupellation test was produced by burning the waste oak bark from the tanning process. Once there was a regular demand the tanners sold it as a prepared ash at a price which included transport to the mines at Bere Ferrers. In the early years, before it was realised that the market existed, the mines had to search out and procured the waste bark themselves ('*tan turves*' in the accounts of the 1290s) for reduction to ash at the refining site.[146]

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144 *Ibid.*

145 PRO, *Exchequer Accounts* E101/263/5, Account of John Moveron, 16-17 Edw. III, plus regular references to bellows blowers in the wage rolls for 16-18 Edw. II (E101/263/7 and 10). See page 170 above for the 'fynyngmyll' and introduction of waterpower.

146 PRO, *Exchequer Accounts* E101/260/4, Account of Vincent de Hulton, 20-22 Edw. I; and E101/260/27, Account of wages, 32-33 Edw. I, entry for 22 Aug.

4.8 Transport

Of the productive Devon mines only Bere Ferrers benefited from proximity to navigable rivers. Tidal waters of the Tamar and the lower reaches of the Tavy provided an essential artery for the produce of the mines. The ease with which ore, packed in hemp bags, and wood could be moved allowed for a dispersal of smelting activity throughout the medieval period.[147] Even during the early years of the 14th century, when many aspects of the smelting process were concentrated at Calstock, some processes continued on the Bere Ferrers peninsula and smelting residues (blackwork) were routinely moved up the Tamar by boat. A boat was also maintained specifically to ferry personnel and materials across the Tamar.[148]

Combe Martin was not so fortunate: no navigable streams dissected the north coast close to the mines. Combe Martin itself relied on an exposed beach for the transfer of goods. The nearest river port was Barnstaple, on the Taw, 15 kilometres to the south. In the 1290s, when the mines were first opened up, fertile lead had to be moved to Maristow (Martinstowe) in the south of the county to be refined. How this was achieved is not recorded in the accounts. Road links north and south across the county were not well developed. Difficult as it was the coastal route around Land's End was probably the easier option.

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147 Hemp bags to transport the ore were made on site (see PRO, *Exchequer Accounts*, E101/260/30, Account of wages, 34 Edw. I, entry for 4 June, for a typical payment for the labour).

148 See regular entries in the wages rolls for maintenance of the boat (*Ibid.*, 5 May).

Movement of materials around the mines, between the mines and the river at Bere Ferrers, and between the smelting sites and the river at Calstock, relied on horses and a few wheeled carts. Most of the horses were hired locally, although the Crown did maintain a small number of horses itself and there are regular entries in the accounts for their feed. Carts, but more often just their wheels, feature in inventories of the mine.[149] There were regular entries in the wage rolls for the cost of maintaining the carts, with the materials coming from the timber allocated to the mine.

The movement of silver was not by means of local river boat or by sea. In the early part of the 14th century silver from the Bere Ferrers mines was transported to London overland. A journey taking six days each way. On occasions an archer would be employed to accompany the shipment. Typical of such journeys was that made in 1306. In May three men and horses were employed to take just over £502.25 of silver to London. The silver was packed in canvas bags and loaded in purses, two to a horse. They were joined at Sherborne by another man who accompanied them for the three days to Putney where they took passage on the Thames for London. When a smaller amount of silver was sent there in July it was accompanied by a total of eight men included one who was tasked with guarding the shipment.[150]

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[149] See, for example, PRO, *Exchequer Accounts* E101/262/4, Indenture of tools at the mines, Bere Ferrers, 18 Edw. II. The wheels were no doubt the most valuable component of the cart. No wheelwrights were employed by the Crown and the wheels had to be bought in.

[150] PRO, *Exchequer Accounts* E101/260/30, Account of wages, 34 Edw. I, entries for 4 June and 23 July.

4.9 Timber supplies and woodland management

Servicing the needs of the mines and smelting operations required large amounts of timber. It was the primary construction material for everything from buildings and underground support to pick handles and shovels. All the machinery, the engines, waterwheels and, later, the pumps were fabricated from wood with minimal ironwork. The accounts regularly differentiate between mine timber and that used for fuel. The latter was burnt in large quantities in smelting and refining, much of it having been converted to charcoal. Furnace smelting and the refining of 2076.5 feet of fertile lead in 1309/10 required 98 dozen 1.5 quarters of charcoal, costing 14d per dozen.[151] These supplies of fuel had to be obtained as near the locality as possible to reduce transport costs.

Initially the Devon mines were well provided with timber. Neither Bere Ferrers nor Combe Martin were in areas where woodland had been exploited for industrial or urban heating purposes. But, unlike the Carlisle mines, there was no right to free timber supplies incorporated into the ordinance governing the operation of the mines.[152] Timber supplies were guaranteed but had to be purchased from landowners and if required, to avoid dispute over price, assessed by local juries. On occasion free access would be granted to Crown woodlands, as had happened during the abortive working at la Hole in the 1260s, and was to help sustain operations at Bere Ferrers in the first quarter of the 14th century.

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151 PRO, *Exchequer Accounts* E101/261/12, Account of Robert Thorpe, 3-4 Edw. I; a dozen in this case was 12 quarters or 48 bushels (OED 2nd edn., vol. IV, p. 1004; *ibid*, vol. XII, p. 989).

152 The miners working the silver deposits of the Carlisle mines had, by customary right, free access to timber for smelting, structural work within the mines, and the construction of buildings. Exercise of this right did on occasion bring them into conflict with landowners (pages 210-211 below).

The woodland available to the South Devon mines on the Devon bank of the Tamar would appear extensive but was soon supplemented by resources within the Crown manor of Calstock, on the Cornish bank. On 26 February 1301, the sheriff of Cornwall was ordered '*to permit Thomas de Swaneseye, king's clerk, keeper of the kings mine in that county ... to take from the king's wood of Calistok, in that county, as much wood and as often as shall be necessary for the works of the mines, as the king has assigned the wood for the works of the mines*'.[153] Most smelting and all refining activity was then transferred to Calstock to take full advantage of the resources but, even whilst the keeper had the use of those woods, timber still had to be brought into the mines from Warleigh on the southern side of the Tavy estuary.[154]

During the 1290s the woodland at Bicombe (Bickham) in the Abbot of Buckland's manor of Bickleigh, close to the refining mill at Maristow, had provided the bulk of the timber required. 300 acres had been consumed by 1301.[155] With a 16 to 20 year regeneration cycle for coppice woodland, Bicombe was again ready for harvesting when smelting operations were returned to the Devon bank by 1318. There was evidently a desire on the part of the keeper to return to Buckland's woods as that at Calstock was depleted, although the Crown felt that Calstock should suffice. In 1315 the keeper was ordered not to touch that at Buckland.[156] In 1320/21, if the woodland at Calstock was shown to be spent, the keeper of the Devon mines again had the use of the abbot of Buckland's woods

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153 *Cal Close R.*, Edw. I, vol. 4, p. 433

154 Plus the unidentified wood at Hergene (PRO, *Exchequer Accounts* E101/260/22, Wage roll, 30-32 Edw. I. entry for 23 Nov 32 Edw. I)

155 A half being used in a little over one year during the Friscobaldi's tenancy (Kaeuper, 'The Frescobaldi of Florence and the English Crown', p. 61, quoting from E368/73 mm. 17d, 18.)

156 *Ibid*, p. 61, n. 64, quoting from E368/85 m. 204.

at Bicombe and Blakstone (Blaxton) along with those of William de Ferrers in Birland (Bere Ferrers).[157]

In 1339 John de Ferrers' woodland at Halsere and that belonging to the Abbot of Tavistock at Morewellham was assessed for use in the Bere Ferrers mines with 60 acres of the former astride the road to Denham Bridge and 30 acres of the latter adjoining the road to the quay being allocated to the Crown for that purpose.[158] All such wood, outside the crown manor of Calstock, had to be paid and accounted for by the keeper, with an enquiry before a local jury to ensure that the assessment was fair.

One by-product of timber production for the mines was oak bark, stripped from the wood before use. This was sold to tanneries in the area for use in preserving leather, for example 100 seams of bark were sold in the year to Michaelmas 1310 generating an income of 25s.[159] Another was the small wood - unsuitable for smelting purposes - sold for domestic use.

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157 BL Add 24770, f 267

158 *Cal. Inq. Misc.*, vol. II, item 1650.

159 *Exchequer Accounts* E101/261/12; Oak bark is high in tannic acid a key element in the preserving process. The bark was subsequently returned to the mines as refinery ash.

5. The labour crisis; its effect on techniques

Manual labour was a major component in the technology chosen in the early part of the 14th century; influenced by the availability of ample, cheap, manpower. Activities which were initially mechanised, for example the refinery bellows at Martinstowe, were replaced by manual power when moved to a new location and it was evidently cheaper to employ men to relocate equipment and structures than incur the capital cost of new materials.[160] However there is some evidence for a slow decline in population around that time, with poor harvests in the second decade of the century; although the South West, and Cornwall in particular, fared better than the rest of the country. [161]

The dramatic fall in population came in 1348-50 with the outbreak of plague; the Black Death. Its effects across the country were variable but some mining areas evidently suffered badly. In Derbyshire, for example, in the Earl of Kent's manor of Ashford there was 'a lead mine formerly worth £20 yearly but now stopped for want of workers'. That was in 1354; eight years later it had still not recovered its former profitability being worth only 100s.[162] Bromfield and Yal, in North Wales, was also badly affected; the mines there being moribund for over thirty years.[163] But it has been suggested that, at first, the overall effect was to bring the population down to a sustainable level. Agricultural rents remained high and, after an initial reaction and countering legislation, general wage rates give the appearance of continuing at pre-plague levels. The rapidity with which the Duchy of Cornwall's south-eastern manors recovered from the initial outbreak suggests that there

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160 See page 162 above.
161 Hatcher, *Rural Economy*, p. 85.
162 *Cal. Inq. Post Mortem* Vol. 8, items 46 and 657.
163 Pratt, 'Minera: Township'.

was a significant non-agricultural population, based in silver mining and tin working, available to fill vacant tenancies.[164] It was not until the 1360s and 70s that repeated outbreaks of disease on both a national and local level, becoming endemic in many areas, had weakened the population such that a labour shortage became apparent as wage rates began to rise.[165]

Although the available evidence is patchy, the situation in the Devon mines appears to have followed the national trend. Activity at Bere Ferrers, confined to reworking of blackwork and earlier residues, ceased at Michaelmas 1349 and although a new keeper was quickly appointed there is no evidence that he made any returns to the Exchequer.[166] The lessees of the Combe Martin mines in 1360-64 and 1370-71 could not expect to draw on a large body of skilled workers in the established lead mining areas as in the past; requesting only a handful of miners and smelters from Derbyshire and Yorkshire, and some of those impressed openly resisted the move.[167]

That mining continued at all reflects the perpetual demand in precious metals for coinage. In a situation where the lead producers of Derbyshire would be content to migrate to new relatively shallow deposits, the restricted nature of the known silver-bearing deposits

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164 Hatcher, *Duchy*, pp. 104-107.

165 Hatcher, *Plague*; Hatcher, 'Black Death'. In the latter Hatcher points out that, although the statistical evidence shows that wages in the immediate post-plague period remained at their old levels, that evidence is at variance with contemporary narrative. Looking beyond those figures which could be quantified in the estate accounts it is evident that workers often received substantial allowances, often in food, to supplement their wages. For comment on this apparent failure to comply with the statutes (pp. 28-29 above) see Munro, *Wage-Stickiness*, pp. 18-19.

166 PRO, *Exchequer Accounts* E101/263/11, Account of John Moveron , 22-23 Edw. III; *Cal Fine R.*, Vol. 6, p. 177.

167 *Cal. Pat. R.* Edw. III, vol. 14, p. 476; *Cal. Close R.* Edw. III, vol. 11, p. 37

meant their continued exploitation at deeper and deeper levels.[168] Drainage by adit now had the double burden of increased length and increased drivage costs. The attraction of Combe Martin in the 1360s was probably the relatively undeveloped state of the workings. Abandoned in the late '20s due to flooding; they justified the application of improved drainage techniques in the form of relatively shallow crosscut adits. The time / cost penalties of ever deeper adits at Bere Ferrers, where few deep valleys cut the mineral deposits, would be excessive leading to increased dependency on manual water winding; and by the mid 15th century wage rates in the mines had in some cases more than doubled.[169] But cash wage figures do not provide a complete picture of the problem.

Blanchard has shown how variations in the cost of living influenced the labour intensity of the miner on Mendip in the 15th century.[170] There not only the price of food but that of the lead ore he produced entered into the equation. However, the Crown silver-lead miner engaged in drainage received a daily wage rate which was not tied to metal prices, but he still controlled the number of days he worked.[171] A miner or skilled worker at Bere Ferrers in the mid 15th century could earn over £4 per annum, over twice the income from mining

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168 These 'new' deposits in Derbyshire had often been exploited at an earlier period but were reopened in the late 14th century once the problems of shallow drainage were overcome. (Blanchard, 'Lead mining and smelting', p. 74).

169 A miner, employed on wages for deadwork, was receiving 9d. per week in the first quarter of the 14th century. By 1480/81 this had risen to 4d. per day. The wages for water haulage had similarly risen from 10d. per week to 4d. per day. (PRO, *Exchequer Accounts*, E101/261/12, Account of Robert Thorpe 3-4 Edw. II; and E101/266/25, Counter roll, Bere Ferrers, 20-21 Edw. IV) See also Appendix 14 below.

170 Blanchard, 'Labour productivity'.

171 The inclination of workers to adjust the number of days they worked in relation to wages and the cost of living was noted by commentators, Gower and Langland amongst them, on social / economic conditions after the Black Death. They took the view, coloured by their position amongst the elite of medieval society, that workers had become lazy and excessive in the leisure habits. (Hatcher, 'Black Death'. p. 14) However. Munro (*Wage-Stickiness*, p. 21) has found no convincing evidence that this was a significant feature in the economy of continental Europe.

of a 'professional' miner on Mendip, but the potential for saving any excess was limited. As the quantity of consumables he could buy with his 4d per day, his 'real wages', rose and remained high through the century the number of days he needed to work to maintain his required standard of living fell.[172]

Silver mining was competing for labour with the demands of increased tin production on nearby Dartmoor and the established textile industry. Both drew on human resources and were industries which lent themselves to greater flexibility in working practices and the opportunity for dual occupation, although there are indications of a move towards full-time working in the former area.[173] Thus, with far fewer potential miners available in a competitive labour market, there ensued a crisis in such labour intensive activities as drainage.

All of which begs the question was to why the Crown did not ensure that sufficient manpower was available to work the silver mines by labour intensive methods. For the answer as to why that did not happen the value of the output, or potential output, of the mines has to be compared with the bullion available to the Crown from other sources. Even at their peak in the late 13th / early 14th century the Devon mines were only providing a small fraction of Crown income, with time that had reduced even further. From the mid 14th century the Crown had divorced itself from the day to day operations of the mines, preferring to lease them out in return for a portion of their produce. During

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[172] PRO, *Exchequer Accounts* E101/266/25, Counter roll, Bere Ferrers, 20-21 Edw. IV; Hatcher, 'The great slump', p. 243, table 2.1.

[173] On Dartmoor amalgamation of farms in the 15th century meant that there were a greater number of full-time tinners. This is marked by a shift to increased tin production in the summer months, shifting from the earlier pattern where production in summer fell as farmer/tinners were busy with harvest (Fox, 'Medieval Dartmoor', p. 168.)

that time the means of raising Crown income, primarily through levying of customs duty, had evolved to take account of changes in export patterns and was realising around £34,000 per annum by the third quarter of the 15th century.[174] The disruption in impressing men to work in the mines, taking them away from export led industries which could ill afford to loose manpower, could not be justified against such a small potential return.[175]

6. The introduction of labour saving technology

There had been a low level of production at Bere Ferrers through the early part of the 15th century to 1448, followed by a steep rise apparently associated with the working of a small group of six shafts on the north side of Lockridge Hill. This was maintained after the impeachment and death of the sub-lessee, William duke of Suffolk, by reopening old workings along the veins to the north and south; which were for the first time leased individually to small adventurers.[176] For at least one of those involved this proved a disastrous investment. John Falron was allowed, and appears to have spent, £250 in drainage costs at Lockridge Hill and Whitsam Down over a four and a half year period without producing one ounce of silver; although his sett was bisected by the deepest valley in the area.[177]

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174 Lander, *Government and Community*, p. 84.

175 Whilst wool and textiles provided the bulk of English exports the value of tin exports, plus revenue from coinage, were not inconsiderable and would suffer most through the impress of miners. (Hatcher, *Tin Production*, p. 89 et seq. and Appendix A)

176 See Chapter 6, Section 9, Fig. 24, below.

177 PRO, *Exchequer Accounts* E101/265/18, Particulars of the account of James Falleron, 31-36 Hen. VI.

This division of the Bere Ferrers mines lasted at the most nine years and appears have been of only short term benefit to the Crown. It was not repeated and the mines were returned to the control of an overall lessee or lessees. This provided no immediate remedy for the costs of deep drainage. By 1460 the cost of water haulage in one section of the mines, over an 18 week period, appears to have reached £120.[178] Costs which would have left very little margin for profit. It was under these conditions that the various factors, scarcity of silver bearing ores, increased working depths, scarcity and increased cost of labour, combined to stimulate the mechanisation of drainage. While primitive pumps had been known in antiquity, the introduction of piston pumps powered by water wheel in 1480 would appear to have been a truly innovative move.

6.1 The suction lift pump

Although forcing pumps were known to antiquity, suction lift pumps were an innovation of the 15th century. Their construction was simple. On its upward stroke a piston, pierced by a flap valve, reciprocating in the pump barrel drew in water by suction through a second flap valve at the base of the barrel. The second flap valve closed on the down stroke and the water below the piston passed through its flap valve into the pump barrel above the piston. On the next upward stroke the piston drew in more water whilst at the same time lifting the water above the piston. This sequence could continue indefinitely with the water above the piston rising until it reached the top of the pump barrel and

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[178] Wiltshire Record Office 366/1, Declaracion of James Ley; see also Skinner, 'The 'Declaracion' of Ley: his pedigree', p. 61. This payment for winding water at Bere Ferrers should be treated with caution. The original indenture has not survived and we are relying on a transcript dated 1608.

poured out of a suitably fixed outlet pipe. The suction lift pump was essentially the bucket pump used as the sinking lift in most 18th / 19th century mines.

Whilst bucket lifts of up to 48 metres were common in the 19th century, the 20 fathoms (36 metres) of pumps employed at Bere Ferrers in 1480 were unlikely to have been used as one lift. The height of each lift would have been limited by the ability of the materials used, primarily timber, to lift and support the weight of water above the piston. Those at Bere Ferrers were divided into at least nine sections but it is not clear if they were used singly or combined to form longer lifts. Available documents unfortunately provide no clues but, based on late 16th / early 17th century evidence, Hollister-Short suggest lifts in the order of 9 to 10 metres.[179]

6.2 Diffusion of technology

Fogge's use of mechanised pumping is the first recorded application of the technology in England, 55 years after the first evidence for the concept of the suction lift pump and only a few years after its application to mining in central Europe.[180] The diffusion path by which that technology arrived in England is still unclear. Sir John Fogge, the keeper of the Devon mines from 1471 to circa 1481, had contacts with continental Europe. He was treasurer to Edward IV's household from circa March 1461 (he was already in post at that date) until at least 30 Sept. 1467 (still in post at that date); being succeeded by Sir John Howard. Whilst in that office, 17 March 1466, he was granted all issues and profits from

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179 Hollister-Short, 'The first half century of the Rod-Engine', p. 84

180 An illustration in Taccola's 'Delngeneis' has been dated to about 1425 (Hollister Short, 'On the origins of the suction lift pump'. p. 58)

the king's mines in Cornwall and Devon and was thus aware of the productive potential of the mines.[181]

The letters patent for the grant of the mines themselves has not survived, but was dated 10 July, 11 Edward IV (1471), immediately after the king's exile in Burgundy. In referring to the original patent, a later document stated that '*it was agreed that the said John should bring water to the mines at his own expense*'[182] In 1474 he was active at the mines when he and John Fogge esq. (his son?) were granted the right to impress workers.[183] By 1480 the work had been completed and water brought into the mine at Bere Ferrers.

Prior to taking the Devon mines he had some contact with possible sources of expertise on mining technology. In 1467 he visited Burgundy although prior to that he was probably fully committed to his office.

'Treasurers of this reign seem, on the whole, to have given rather more personal attention to their household duties than did either chamberlain or stewards. During his tenure of office Sir John Fogge seems to have held no offices which need have taken him away from household for long, except for a visit to Burgundy in the last year of his treasurership.. '[184]

However his duties may have brought him into contact with others with knowledge of the technology. As in 1466 when the brother of the Queen of Bohemia visited England.

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181 *Cal. Pat. R.*, Edw. IV, p. 519
182 *Cal. Pat. R.*, Edw. IV-Edw. V-Ric. III, p. 213
183 *Cal. Pat. R.*, Edw. IV- Hen. VI, p. 420
184 Myers , *The Household of Edward IV*, p. 282

Later in the 1470s there was some activity at Fletcheras and other mines in the Northern Pennines where the adventurers had central European connections. Fogge may have had knowledge of, if not direct contact with, those activities although there is no evidence for the use of new technology in the Northern Pennines nor did the mines realise the potential indicated by high assay values for silver. His successor as treasurer to the royal household, Sir John Howard, had earlier been a member of a group who were granted the king's mines 'north of the Trent' which would have included the Northern Pennine workings.[185]

Sir John Fogge's grant of the Devon mines was possibly in lieu of all or part of his salary. Edward's indebtedness being considerable with debts of £168,000 in 1433, rising to £372,000 in 1449, and resorting to loans at interest rates of 25 to 33.3%.[186] He was appointed keeper (lessee) of the Devon and Cornish mines in 1471.[187] However it took nine years to bring the mine at Bere Ferrers into production. The reason given is the time and effort required to bring water to the mine.[188] Water that was required to power pumps at the workings north of Lockridge Hill.

At a time when the mechanical transmission of power over anything but the shortest of distances had yet to be developed, the power source had to be installed close to the objective.[189] For this it was necessary to bring a leat to a water wheel installed over a specially prepared shaft. There it was used to power pumps (*plumpas*) comprised of 20

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185 *Cal. Pat. R.*, Edw. IV - Henry VI, pp. 132, 464, 505-6, 513.

186 Myers, *The Household of Edward IV,* p. 6

187 Letters patent indented dated 10 July, 11 Edward IV are not listed in *Cal. Pat. R.* and evidently have not survived.

188 *Cal. Pat. R.*, Edw. IV-Edw. V-Ric. III, p. 213.

189 Hollister Short, 'The first half century of the Rod-Engine'.

fathoms of bored tree trunks in nine lengths, brought up from Plympton Wood. Leather hides providing the packing and valves for *'les sowkers'* attached to the piston rods.[190]

Providing an adequate supply of water to the leat was a problem. The medieval mines at Bere Ferrers are situated on a ridge of high ground between the rivers Tamar and Tavy. No streams with an adequate flow were available close to the workings and to take water from the Tamar was impractical. A leat was therefore cut to take water from a tributary of the River Lumburn near Millhill, west of Tavistock: see Fig. 25, in Appendix 11 below, for the route of the Lumburn Leat. The tortuous route, of over 16 kilometres, involved the cutting of channels and tunnels through rocks along the steep hillside high above the west bank of the Tavy. Accuracy was of the utmost importance as the water had to be carried across a shallow saddle in the ridge to the Tamar side, then west and south to the mines north of Lockridge Hill.[191]

Such large scale engineering to provide an adequate power supply was not unique in medieval industry. Technology on a similar scale was used in the iron industry on a number of sites prior to the mid 15th century.[192] What is perhaps unique is the length of leat employed to provide an adequate flow. For sustained use of such a leat good water management would have been essential to the maintenance of the flow as it did not benefit from a large local catchment area. Abstraction was from a number of streams of

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[190] PRO, *Exchequer Accounts* E101/266/25, Counter roll, Bere Ferrers, 20-21 Edw. IV; *Oxford English Dictionary*, Sowk - obsolete form of suck; Sucker - embolus, piston or rising valve of a pump (1611).

[191] See Appendix 11.

[192] For example those in Nidderdale and Bishopsdale, North Yorkshire - Moorhouse, 'A late medieval water-powered ironworking complex at the head of Bishopsdale, North Yorkshire'.

limited flow. There is, as yet, little evidence for the ponds and reservoirs so required. Given the apparently limited working life of the leat, they were probably never built.

No total figure for the cost of the pumps and wheel (*les ordenance*) or the leat is available. Only those costs incurred in the year 10th July 20 Edward IV to 10th July 21 Edward IV (1480/81) are listed in the surviving accounts. These include the making of a shaft under the wheel, 13s 4d (probably only a part of the agreement - the small sum quoted cannot be reconciled with the amount of work required to sink, or even clear out, a pumping shaft); squaring and boring of the pumps at 12d per fathom; and leather hides for '*lez sowkers*'. However, work must have been carried out and accounted for in previous years; covering the cutting of the leat, erection of the wheel and associated pump rods. The whole of which was in operation for at least six months of the year accounted for above.

Fogge was, however, defeated by the pattern of mineralisation at Bere Ferrers which ordained that the deposits haded to the south in the lode and were later worked at considerable depth to the south under the river Tamar itself. The lode north of Lockridge Hill is noted as being 'lost' on a later map.[193] It was not worked successfully north of that point until the mine at Buttspill, some distance to the north, was opened up in the 17th century.

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[193] Cornwall Record Office, *Mount Edgecombe MSS*, 2424, Estate map, Bere Ferrers, dated 1737.

7. Conclusions

At the beginning of the late medieval period silver mining had a wide range of techniques on which it could draw, most of which had been in use during or prior to the period of Roman occupation. Unfortunately it is not until the end of the 13th century that we have much in detail on the technology being used in the extraction and processing of silver bearing ores when it is evident that techniques were being adapted to deal with new deeper seated deposits in the Devon mines. Drainage techniques were augmented by the use of adits, initially reliant on skills introduced from tin mining, whereas the adaptation of smelting processes to cope with all the ore mined was carried out through experimentation. During the most productive period in the Devon mines, from 1292 and through the first decade of the 14th century, a smelting - refining complex was developed using a combination of the bole and the furnace to extract the maximum return from a restricted resource.

The benefits of advance planning, in the clearance of old workings and initiating the deadwork required to drain the deeper silver-bearing deposits, is particularly evident in the early years of the 14th century. Using drainage adits reduced the reliance on manual water haulage. The limitations of adit drainage are evident as the mines were worked ever deeper below the water table. Underpinning the techniques in deep mining during the first fifty years of operations in the Devon was the ready availability of manual labour. With no detailed accounts available for the mines during latter half of the 14th and the early part of the 15th centuries it is impossible to map the early stages of mechanisation. Once the population decline had accelerated in the latter half of the 14th century alternative,

labour saving, methods were required. The reintroduction of water as a motive power for the bellows for the refining, and smelting, processes had taken place at some time prior to 1480. By the latter part of the 15th century the high cost of water haulage in draining the deep workings is evident, leading to the use of innovative pumping technology. The introduction of water-powered suction lift pumps at Bere Ferrers reduced the reliance on manual labour but poor returns appear to have curtailed operations.

The technology of silver mining in the first part of the period had been characterised by the reintroduction and adaptation of earlier techniques. This continued into the 14th century. Smelters at the Devon mines in particular showed themselves well capable of adapting techniques to the best advantage of the industry. Where new technology makes an appearance it does so in parallel with developments on the continent. Although the presence of central European miners in England was largely connected with processing of copper ores, they will have influenced developments in silver mining. The movement of potential entrepreneurs to and from the continent after 1350 would have similar effect, although the precise diffusion path cannot be determined.

The level of technical competence displayed in silver mining from the late 13th century onwards is comparable with that in continental Europe. English miners showed themselves capable of mining and processing deep seated deposits, employing prospecting and drainage to identify and access new, and deeper, deposits. Their competence, along with the scale of organisation identified in Chapter 6 of this thesis, reinforce the view that there was no great advance in techniques attending the involvement of central Europeans in English mining in the 16th century.

Chapter 5:

The ownership of minerals; rights to silver-bearing ores.

In general the current position on the ownership of minerals, excluding coal, in England and Wales is that the rights are held by the owner of the soil. The current position is at variance with that in continental Europe where, as a general rule the ownership of minerals lies with the state.

There are variations from those rules. In England and Wales it is possible for mineral rights to be alienated from ownership of the soil but a general rule still holds fast - that mineral rights are the prerogative of the individual not the state.[1]

This has been the position since the late 17th century and, whilst it is now at variance with that on the continent, it developed from a position where the English Crown, as head of state, held substantial rights to certain minerals, including silver-bearing ores. Those regalian rights were developed through practice during the medieval period.

1. Regalian rights in Europe during the medieval period.

Economic historians have had little to say on mining organisation and the wider concept of the ownership of minerals in Europe during the medieval period. Ownership of minerals was born out of lordship of the land under which those minerals were found,

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[1] With the notable exception of precious metals in their free state, i.e.. not combined with ores of other metals, and coal which remain the property of the Crown.

allowing for the establishment of rights to work them in common, and Nef alluded to this in his contribution to the Cambridge Economic History of Europe.[2] That status, for minerals in the western parts of the British Isles during the early medieval period has recently been clarified with the translation of an eighth century Irish law tract. Silver, gold and base metal ores were then regarded as personal property with fines imposed for working another man's mine.[3] How this was interpreted and how it was to evolve in practice varied from state to state across Europe. The ownership of minerals in England was divorced from lordship of the land under which they were found, but not until the 13th century and then only in respect of the ores of precious metals.[4] In continental Europe that situation had generally been reached much earlier. With imperial control over much of Europe at its strongest in the mid to late 12th century the right to precious metals was claimed as of imperial sovereignty: a concept rooted in the revival of Roman law.[5]

As imperial authority waned in the following centuries regalian rights were delegated to individual state rulers who did not shrink from exercising control over the mining of silver-bearing ores - a move reinforced in central Europe by territorial expansion east from the Elbe, where mines were opened up in sparsely populated mountainous areas. On the whole base metal ores continued to be worked outside the regale. But where individual state rulers were the major landowner they were in a position to increase that control to cover base metals. In many cases through the 14th and 15th centuries they usurped the rights of individual miners. A move which was thwarted in 16th century England due to the strength of customary law.

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2 *Bracton on the Laws and Customs of England*, 3, p. 167; see also Costello, *Profits à prendre to mineral rights*, pp. 1-4. Nef, 'Mining and metallurgy', pp. 441-51.

3 Kelly, *Early Irish Farming*, p. 435

4 See Section 2 below.

5 Nef, 'Mining and metallurgy', p. 442-3.

New discoveries of silver-bearing ores and improved access to known deposits through developments in pumping technology created boom conditions in many central European states in the last years of the medieval period. In Saxony many new 'cities' sprang up in the mining area of the Erzgebirge between 1479 and 1521. Populated by miners who had been drawn from older mining centres such as Freiberg they were to have considerable influence on the organisation of mining. The hierarchical structure of the cities coupled with the religious changes of the Reformation, encouraged by state rulers, were to bring increased control to the activity of ordinary miners. Within a century of the discovery on the Schneeberg, in 1460, the freedom of the miner to work at will had been curtailed and his activity was controlled by what was effectively a city based craft guild.[6] Whilst the states of central Europe controlled mines through their ownership of the minerals and, in some cases provided financial backing, mining operations remained a shared activity, largely in private hands, until the 17th century. Thereafter, under the 'Direktionssystem', the state increased its control of operations with minimal influence from private shareholders.[7]

At the same time that central European princes were establishing regalian rights over their lordships France was moving in the other direction. There strong central government by the Crown could assert its authority over individual feudal lords, controlling all mining and taking a royalty even outside its demesne. The English Crown's position lay somewhere between the two extremes - maintaining its hold on the ores of precious

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6 Karant - Nunn, 'Between two worlds'; in which the social and economic pressures on the miners and their apparent involvement in the Peasant's Revolt of 1525 are investigated.

7 Dr Christoph Bartels, Deutsches Bergbau-Museum, Bochum, pers. comm. See page 219 below for an example of direct state intervention.

metals and curbing the power of individual lordships but unable to extend that right to base metals.

2. Regalian rights and ownership in England and Wales.

Economically viable silver-bearing ores are restricted in their occurence and only a few were known to the medieval miner. This had considerable influence on the organisation of silver mining in England and Wales during our period, particularly in respect of that carried out in South-West England. As the established sources of silver, shallow deposits in the Carboniferous rocks largely within the demesne of the English Crown, were worked out, the Crown sought to control any new discoveries. This culminated in the introduction of a prerogative right and direct involvement in the working of new deep seated silver-bearing deposits in Devon.

Rights to minerals was not just a function of ownership, consideration has to be given the customs which governed working. It is evident that the English Crown did not enforce any right over minerals, including silver-bearing ores, to the exclusion of the customs or liberties of the miners. Prior to the 13th century, with a few exceptions, the known silver-bearing deposits were the property of the Crown by its lordship of the land on which they were found. In these areas the Crown confined itself to a portion of the produce as royalty and a right of pre-emption on production, allowing the minerals to be worked by the miners as a right in common according to custom.[8]

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[8] See Chapter 6, Section 2, below for details on custom and the regulation of working.

In considering the possible sources of new mined silver in the Anglo-Saxon and Anglo-Norman periods it becomes apparent that most, if not all, was refined from lead produced in the mining fields where customary law was acknowledged in the 13th century or later. The majority of those lead mining fields had been within the royal demesne during the 9th/10th century and some were still in the hands of the Crown in the 12th century.[9] Given that the Normans respected English customs relating to land holding, where they had been in place before the Conquest, and did not impose French concepts of tenure, they similarly respected those customs relating to mining rights (that is the right to mine, i.e. work the minerals, rather than ownership rights over the minerals).[10] It could therefore be suggested that it was in those areas where mining was established before, and sustained after, the Conquest that customs survived and were subsequently acknowledged as customary law.

Thus the development of mining in North Wales (Flintshire and Denbighshire), Derbyshire (Wirksworth and High Peak), the Northern Pennines (Tynedale), Mendip (Chewton and Cheddar) and possibly other minor fields (e.g.. parts of Swaledale in Yorkshire), along with the stannaries of Devon and Cornwall and iron mining in the Forest of Dean which retained similar customs, was pre Norman; with the system of custom having evolved under Saxon influences. The outward movement of population from northern Germany during that period would account for similarities in mining law between such diverse places as Bohemia and England.[11] In the case of Tynedale the

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[9] Maddicott, 'Trade, industry and the wealth of King Alfred', p. 45; Sawyer, 'The wealth of England in the eleventh century', p. 159.

[10] Britnell, *Commercialisation*, p. 60; Chibnall, *Anglo-Norman England*, p. 161 et seq.

[11] The study of customary mining law is as yet fragmentary and no overall study has yet been published. See Pennington, *Stannary Law*; Costello, 'The jurisdiction and

Normans had taken over a largely Celtic structure of land tenure and that is reflected in the organisation of mining in that area.[12]

Ownership in such mining fields therefore rested with the lord of the soil but the right to work the minerals rested with the miners, exercised through local courts governed by customary law. Of these, the rights to tin ores in the South-West of England provide a good example. Confined to Cornwall and the western parts of Devon and intensively worked through the late medieval period, tin ores remained the property of the owner of the soil under which they were found; but their extraction was the prerogative of free miners (the tinners) within a framework of regulations evolved through practice and codified by royal grant as the Stannaries. The Crown did, from time to time, claim the ownership of tin ore but, as Lewis pointed out, few of the tin mines in the stannaries were on royal demesne lands and the claims were not upheld.[13] Nevertheless the Crown held a significant element of control over mining which predates the earliest charters.[14] Tin was subject to intervention at the point of smelting when coinage, or tax, was levied and the Crown retained a right of pre-emption on the produce.

However, the Crown was increasingly granting land to its subjects without restrictions on the working of minerals. By the 13th century the established lead mining areas were of decreasing importance as sources of silver. Only with the mines within the manor of Alston, in the liberty of Tynedale, did the Crown reserve the mineral rights in a grant of

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procedure of the stannary courts'; and the various authors in Ford, *The First International Law Conference*.

12 See later - Chapter 6, Section 2.

13 Lewis, *Stannaries*, p. 83 n. 2.

14 *Ibid.*, pp. 83-4.

lordship.[15] Fresh sources of silver, when found, were outside of Crown lands and a new formula was required to establish a regalian right. Thus in 1260, when silver, gold and copper were reputed to have been found in a mine at 'la Hole' in Devon, the Crown exercised rights over the mine as 'of our royal liberty' (*ad dignitatem regalium nostrorum.*)[16] In this the English Crown appears to have followed the path taken by continental rulers in interpreting Roman Law as vesting the right to precious minerals in the state.[17]

Once established, the Crown maintained its prerogative on all ores of precious metals and certain of the base metals throughout the later medieval and early modern periods but chose or was obliged, through political constraints, to exercise that prerogative in a variety of ways. Of the base metals only tin and copper were subject to direct Crown intervention. The position regarding tin has been considered at page 198 above. Copper was, however, of limited value and only occasionally did it attract the direct interest of the Crown although it was frequently cited in grants of mines royal after 1350.[18] Despite various trials through the medieval period, apparently with a view to extracting silver, it was not until the late 16th century that a concerted effort was made to exploit copper and then with only limited success.[19] In Wales prior to the 16th century the right of the Crown was not as clear cut; the ancient laws of the principality are vague as to rights over

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15 The liberty of Tynedale comprised land within the catchment of the upper South Tyne including the manor of Alston. The latter lay within the jurisdiction of Carlisle and formed a part of the county of Cumberland. However mining was not confined to Alston and all workings in Tynedale, including those in co. Northumberland, were administered from Carlisle.

16 *Cal. Close R.*, Hen. III, vol. 12, p. 187.

17 Nef , 'Mining and metallurgy', pp. 442-443.

18 See *Cal. Fine R.*, vol. VII, p. 71 for an example of the inclusion of copper in a grant of mines royal.

19 Hammersley, 'Technique or Economy'.

minerals, referring only to the lord's treasure, and the situation was only brought into line with England in 1536 by the 'Act for Laws and Justice to be Ministered in Wales', one of the so called 'Acts of Union'.[20] Early treatises on English law make no mention of the Crown's prerogative on minerals. The earliest of these, Granvill in the 12th century, based on writs brought before the courts of common law writes only of the 'Fraudulent concealment of treasure trove', however it is unlikely that the Crown rights to ores bearing precious metals as of lordship would be tested in the courts at that period.[21] The Crown's right to those ores was not challenged until the 16th century, and the Case of Mines (The Queen v. Thomas Percy, 7th Earl of Northumberland) of 1568. By which time the Crown's right was well established in practice and a number of grants of mines from the 14th and 15th centuries could be used as supporting evidence in a successful prosecution.[22]

The rights to lead, where free from silver, and iron were the property of the landowner. This was exemplified in orders made by the Crown in support of individual landowners, as in 1282 when Peter de la Mare, constable of Bristol castle was ordered *'not to impede Thomas de Berkeleye and not to permit him to be impeded by the king's ministers from seeking and digging lead mines in his own land, provided that the land be not within the king's forest'*.[23]

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20 Jones, *Early Modern Wales*, p. 79.

21 Hall, *Glanvill*, p. 173-4.

22 Plowden, *The commentaries,* 1, pp. 310-340; A report on the judgement given by the Court of Exchequer, in Hilary Term, 10 Eliz. I, in a Case ... between the Queen and the Earl of Northumberland, ... touching a Mine of Copper containing Gold or Silver, claimed by the Queen, in the lands of the said Earl. Donald, *Elizabethan Copper*, pp. 124-145.

23 *Cal. Close R.*, Ed. I, vol. II, p. 199.

Only with ores bearing gold, silver and copper did the Crown maintain control over the occasion and method of working, and then only in respect of mining outside those mining fields governed by customary law or those where a grant of lordship had included regalian rights, for example, the bishopric of Durham.[24] In the former, where precious metals were found in combination with base metal ores, as in the manor of Alston, the miners had a right to the issue of that ore, after payment of dues, although the Crown as mineral lord might hold a right of pre-emption. In practice, once the accessible richer silver-bearing ores were exhausted and production centred on lead rather than silver, Crown control over renewed searches for silver was not disputed.[25] Until devolved to private monopoly companies in the late 16th century this control was the responsibility of that arm of the royal administration, the Exchequer, to which all issues and profits had to be accounted. The level of control varied from decade to decade, from reign to reign, through direct working of the mines to the lease of mines within whole counties, or groups of counties, and even on rare occasions the lease of groups of shafts within an individual mine. When, in the late 13th and early 14th centuries, the search for silver was at its height the Crown did not discourage prospecting but was always ready to bring any productive working under its direct control. No body of customary law was allowed to become established as it had for lead/silver mining within the Crown lordships, and miners were denied the freedoms they had in central Europe at that period.

Control was at its strongest in the period of direct working from the 1290s through to the middle of the 14th century. During that period the Crown took the organisation of mining into its own hands and appointed officers to control the day to day operation of the mines.

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24 For grants of lordship including regalian rights see Chapter 6, Section 3, below.

25 *Cal. Pat. R.*, Edw. IV - Henry VI, pp. 505-6, 513.

Thereafter the level of regal control over silver bearing ores was, on the whole, reduced with time as readily accessible deposits were worked out and the Crown withdrew from direct working.

Parallels with the continental trend towards increased regalian power over mineral extraction are hard to find and only in the Tudor period, with the extension of English law to Wales, did the Crown augment its position. Conversely the increased restrictions placed on the free miners of Central Europe in the early 16th century brought them closer to their fellows in the English silver mines whilst their contemporaries in the English lead and tin industries continued to enjoy their freedom protected by customary law.[26] Attempts by the Crown during the Tudor period to encroach on the customary rights of lead miners was to result in reiteration of those rights. Interference on Mendip in 1528 met with an angry response from the lead miners there and could have contributed to the establishment of the minery courts by the 1550s.[27] A document reciting the mining laws on Mendip is believed to be of similar date.[28] The right of free search for lead in Derbyshire was similarly repeated in an Act of Phillip and Mary in 1554.[29]

There were however remarkably few challenges over the Crown's right to assign mines of silver-bearing ores to lessees once it had withdrawn from direct working. Until the Case of Mines in 1568, cited above, there were only minor infringements such as that at Bere Ferrers in 1457/8. Roger Champernoun, lord of the manor, was called to account in the Exchequer when *'John Bottwright, Governour of the Mines of Berryferrers in Devon,*

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26 Karant-Nunn, 'Between two worlds'.
27 *Cal. L. and P. Hen. VIII*, vol. 4, pt. 2, 4695; Gough, *Mendip*, p. 74.
28 *Cal. S. P. D.*, Edw. VI to Jas. I, vol. 6, Addenda, p. 440.
29 Kirkham, *Derbyshire Lead*, p. 34.

complains to this Court, that Robert Glover at the command of Roger Champernown took away 144 Bouls of Glance oar, valued at 15l. 6s. 8d. and made profit of the same without anything allowed to the King, to the Kings damage 100l'.[30] Whilst Glance, or Potters, ore is a lead ore usually low in silver content its provenance at Bere Ferrers was believed sufficient to bring it within the scope of the prerogative.[31] Unfortunately record of the outcome to the complaint does not appear to have survived.

The presence of small amounts silver in base metals was a potential avenue for increased regalian power, particularly in respect of lead. But those areas of production where the silver content was insignificant under prevailing technology were well established and had long been subject to customary law. The Case of Mines of 1568, although decided in favour of regalian rights to ores containing even small amounts of precious metals, did not result in any fresh intervention in base metal mining by the Crown. In practice the position was interpreted as *'where the Oar digged from any Mine doth yield according to the Rules of Art so much Gold or Silver, as that the value thereof exceed the charges of Refining, and loss of the baser Metal in which it is contained, and from whence it is extracted, then it is called rich Oar or a Mine Royal'.*[32] Its interest was thereafter confined to ores containing significant quantities of precious metals along with copper ores until removed by the Mines Royal Acts of 1689 and 1693.[33]

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30 Pettus, *Fodinae Regales*, p. 17, quoting *Remembrances of the Exchequer*, 36 Hen. VI., Easter Term Rot. 20. The value of the ore and the loss to Crown in this case would appear excessive. Lead ore in Derbyshire at that date was fetching 6s. 8d. per load (of 9 dishes.) (Blanchard, 'Derbyshire lead production', p. 133, Table 2.) With the 'bowl' being equal to the dish, a more realistic value for the ore would be 5l. 6s. 8d. and the royalty due to the Crown 10s.

31 Hooson, *The Miner's Dictionary*, p. 103.

32 Pettus, *Fodinae Regales*, p. 9

33 The Acts of 1689 and 1693 (1 William & Mary, c. 30, and 5 William & Mary, c. 6) removed the Crown's right to base ores containing precious metals. but retained a right of pre-emption over any precious metals that might be extracted from those ores. Precious

3. The ownership and rights to silver-bearing ores: a summary.

In the period under study the ownership of silver-bearing ores was removed from the lord of the soil to the Crown. Although the Crown exercised a prerogative over silver-bearing ores from the mid 13th century it continued to honour earlier grants of lordship, where the right to the minerals was included, and did not seek to usurp the established rights of miners to work the minerals according to custom. However, no customary rights were allowed for miners working in silver mines, for example those in Devon, opened up after the exercise of prerogative.

State, i.e. Crown, control of minerals came later in England than on the continent and was never extended to base metal ores, other than copper. When challenged in 1568 the Crown's right to silver-bearing ores was upheld and remained in place until the late 17th century.

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metals found in their native form, e.g. free gold, continued to be owned by the Crown.

Chapter 6:

The Organisation of Silver Mining.

The way in which silver mining in England and Wales during the late medieval period was organised changed as the centres of production moved away from the old established mining fields and the level of Crown involvement changed. Distinct regional variations are evident.

After starting with the pre-1066 background, this chapter first examines the older mining areas. Those were essentially the silver/lead deposits in the Carboniferous rocks, largely worked by independent miners regulated by custom, remote from the control of the state (the English Crown). It then moves on to look at the mining areas in the South-West of England that were opened up in the late 13th century. There working came under direct Crown control until the middle of the 14th century and developed as a centralised activity requiring capital investment in its infrastructure. The withdrawal of the Crown from direct working opened up silver mining to outside investment. Mercantile interests, however, showed little inclination to invest in silver production and the new lessees were drawn largely from the royal household, with the occasional mining specialist, using their personal assets to finance mining. It was not until the mid 15th century, at the height of the European bullion famine, that merchant investment was drawn into English silver mining and the chapter ends by examining the response of the industry to that crisis.

Whilst we can to some extent determine the form of its regulation, the workforce prior to the late 13th century is largely anonymous. It is only with direct Crown involvement after 1292 that the documentation allows us to examine in detail the structure of mining organisation and the relations between the workforce and new levels of management. That is the case until circa 1350; thereafter, with the advent of private enterprise, we lack the detailed accounts of royal government which tell us so much about late 13th and early 14th century activity.

1. Mining regulation prior to 1066

Under the Romans gold, silver and lead, along with all other minerals, were regarded as state property, worked either directly or on lease to private individuals. Both these arrangements were employed on Mendip.[1] Laws were drawn up to govern not only the working of mines but also life in the settlements which developed to service the mines. The survival of two bronze tablets dating from the period AD 122 - 138 found at Aljustrel, in Portugal, detailing the laws applicable to the mines in that area show how tightly they were controlled. Facilities within the mining settlement, including the baths, were provided on a monopoly basis but with strict guidelines as to the level of service. Mines had to be kept in work, if not they were re-let; unlimited partnerships were allowed with no restriction on share dealing; and mine safety covering roof support and water drainage was strictly enforceable. All of this was under the supervision of the local Procurator.[2] It is likely that Roman mining throughout Britain was subject to similar

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1 Elkington, 'The Mendip Lead Industry', pp. 183-7.
2 Elkington, 'Roman Mining Law'.

regulation. State control of mining is indicated by the proximity of forts to the workings, as at Charterhouse on Mendip and at Dolaucothi, and the imperial stamp alongside the inscribed names of the lessees on pigs of lead originating from a number of mining areas.[3]

After the departure of the Romans there is little direct evidence for the mining of silver-bearing ores or its regulation, beyond the suggestion that custom predated the Conquest - see pages 196-8 above. Bede listed silver amongst the mineral wealth of the country, suggesting silver was being mined in England in the 8th century.[4] Both Mendip and the Derbyshire Peak District were probably significant sources of silver at that period.[5] By the time of Domesday there is the suggestion of silver extraction from lead in Derbyshire, with at least seven plumbariae (lead mines or works) in operation and the requirement to pay certain rents in 'pure silver.' It has even been suggested that the colonisation of the Peak District in the 7th century was stimulated by the demand for silver.[6] Although lead mining in those areas developed to satisfy the demand for lead in the construction boom of the late medieval period, it is not unreasonable to suggest that mining was initiated for silver in preference to lead given the limited demand for lead as a construction material, compared with the attraction of silver for ornamentation and later for coin, in the Anglo-Saxon period.

Domesday also provides evidence of silver mining along the Welsh border with England recording that the moneyers at Hereford made periodic journeys into Wales, presumably

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3 Tylecote, *Prehistory*, pp. 61-70.

4 Bede, *Historia ecclesiastica*, i, p. 10

5 Blanchard, 'International Bullion Crisis', p. 80; Maddicott, 'Trade, industry and the wealth of King Alfred', p. 45.

6 *Domesday Book*, 27 Derbyshire, 1.12, 13, 15, 27, 28; 10.11. Ozanne, 'The Peak dwellers'.

returning with silver for the mint.[7] That silver was being extracted from lead deposits in Monmouthshire and Glamorgan is quite plausible given the occasional reference to silver mining in those areas in the later medieval period.

2. Regulation of silver mining on Crown lands - the Northern Pennines.

Early in the 12th century there is firm evidence for the mining of silver bearing ores in the Northern Pennines. The 'mine of Carlisle' can be identified with the minerals worked on Crown land in parts of Cumberland and Northumberland, primarily at Alston in the liberty or lordship of Tynedale. Although the majority of Tynedale lay within Northumberland it included the manor of Alston which formed part of the county of Cumberland and lay within the jurisdiction of Carlisle.[8] Mining was not confined to Alston and all workings in the liberty, plus the minerals under other Crown lands in co. Northumberland, were administered from Carlisle. The evidence suggests that this was the major silver producing centre during the Middle Ages, however, the amount of silver produced is unclear, as already discussed in Chapter 3 above.

The Crown lands in the Northern Pennines were unique in England and Wales during the late medieval period as a primary silver producer whose operations are recorded as being governed by customary law. Writing around 1220, the king's chief justice Bracton tells us that gold and silver mines could be worked as a right of common in the same manner as

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7 *Domesday Book*, 17 Herefordshire, 179a. C 9-10.

8 Graham, 'Alston'.

other minerals.[9] This was the case in the liberty of Tynedale where mining of silver-bearing ores was controlled by rules regulating the operations of the miners which had become established in custom; a system well suited to such activity, for none of the workings associated with the 'mine' were close to the city of Carlisle.[10] There were few parts of the kingdom more removed from the seat of the English Crown than the Northern Pennines in the 12th century and the workings were on the remote uplands, 35 miles east of the city. It was a frontier in the widest sense of the word: with the Scots and with the limits of a habitable environment. It is therefore not surprising that the miners there had the greatest degree of autonomy allowed to any of the English mining fields. Their remote location justified an element of self government: a point emphasised at the enquiry which suggested that the right to autonomy might be withdrawn in the 14th century.[11]

Much of the information on production from the 'mine of Carlisle', considered in Chapter 3, is drawn from the amounts paid for the 'farm' of the mine. The farmers of the mine did not control production, they only had a lease of Crown income from the mine which gave them the right to collect, smelt and refine the lot or duty ore. Control of production was in the hands of the miners.[12] Their activity was governed by customary law first documented in the 13th century and described as being the 'ancient' liberties or privileges of the miners there.[13] Drawing on parallels in other mining fields organised according to custom, as in Derbyshire and north-east Wales, it would be expected that miners worked in small

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9 *Bracton on the Laws and Customs of England*, 3, p. 167.

10 They were not, as Blanchard suggests, the mines of Silverbeck and Minerdale (*Afro-European Supremacy*, p. 583), they were probably in the Caldbeck Fells (see Section 8 below).

11 *Calendar of Documents relating to Scotland*, 3, p. 295, transcript of Patent Roll, 30 Edw. III, p. 3, m. 23.

12 Contrary to the suggestion made by Blanchard *(Lead Production and Trade,* pp. 236-7) that the farmers of the mines had custody of the workings.

13 *Cal. Pat. R.*, Hen. III, vol. 3, p. 174.

groups, or partnerships, taking set portions of the deposit and working them in common.[14] They would be responsible for all stages of production, providing their own tools and processing the ore themselves. Only when it came to the recovery of silver from the lead did they have outside assistance. By the 13th century, at least, the Crown was expected by custom to provide the services of a 'drivere' or refiner.[15]

The laws were evidently never codified although they were referred to in the protection granted to the miners by letters patent of 21 Henry III (1237) and earlier. An exemplification of these was requested, and given, after they were lost during border wars in 1334.[16] A number of the privileges established by custom can be deduced from actions and events involving miners and the Crown. Although the examples date from after the period of peak silver production in the 12th century, they reflect the system of regulation in place at that period.

A right to freely take wood for use in the mines and in smelting the ore was acknowledged in 1290, and was evidently exercised in the 1150s when the area was occupied by the Scots.[17] There is no evidence to suggest that the rights of the miners were restricted during the occupation.[18] The archbishop of York, whilst visiting his lordship of Hexhamshire, had cause to complain to King David at Carlisle about excessive damage to

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[14] For the organisation of mining within the Crown demesne of the High Peak in Derbyshire see Gordon, 'Quo Waranto'; Wood, *Politics of Social Change*, p. 137; for north-east Wales see Pratt, 'The lead mining community at Minera in the 14th century' and 'Minera: Township'.

[15] *Calendar of Documents relating to Scotland*, 2, p. 41, quoting *Assize Roll (Cumberland)*, 6-20 Edw. I.

[16] *Cal. Pat. R.*, Edw. III, vol. 3, p. 31.

[17] Coke, *The Second Part of the Institutes of the Laws of England*, p. 578; Nicolson and Burn, *Westmorland and Cumberland*, ii, p. 440.

[18] In grants King David referred to the mines as *'his mine of Carlisle'* in the same manner as Henry I and, later, Henry II of England (see Chapter 3, p. 93, n. 21, above).

his woodland by the miners working silver. The archbishop's lands, including the mines in East Allendale, lay outside the liberty of Tynedale. Miners evidently exercising their customary rights there, as they would on other lordships with rich silver bearing deposits, like Bolbeck further east in the valley of the Derwent.[19]

An element of self government was allowed to the miners. They elected from amongst their number a coroner, commonly referred to as the 'king's sergeant', and he acted on behalf of the Crown in respect of civil and criminal actions involving miners and all living within the bounds of the mine. Whilst the coroner evidently had the power to deal with all cases brought before him, in practice the serious cases were reserved to be heard before itinerant justices of the county (Cumberland) sitting at Alston with a jury drawn from amongst the miners. The frequency with which the justices visited Alston is not clear. In the mid 13th century there was a period of over 30 years during which the lords of the manor of Alston appropriated the mines, usurping the rights of the Crown and the miners. As a result they caused all pleas against the miners to be heard before the King of Scotland's coroner in Tynedale.[20] An enquiry of 1278/79 rectified the situation, bringing the mines back under Crown control and restored the miner's right to self government. That right continued in force whilst the miners worked and resided together in the remote upland communities. These were referred to as 'shelis', i.e. shiel - the Northern Pennine term for shanty, summer hut or pasture - which suggests that the mines were only worked during the summer and the miners probably spent the remainder of the year on

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[19] *Chronicle of John, prior of Hexham*, p. 166. The reference is to the archbishop's forest although it is possible that he was complaining on behalf of Hexham Priory which held land at Presdale or Priorsdale to the south-east of Alston, stretching from the watershed south of Nenthead nearly to Cross Fell and including Tynehead.

[20] The King of Scotland had been granted the lordship of Tynedale although the minerals in the manor of Alston were reserved to the English Crown.

agricultural holdings.[21] By the 1350s the miners were dispersed across the mining field working in small numbers as production had, by that time, largely switched to non-argentiferous lead and, on enquiry, it was suggested that the right to self government be withdrawn.[22] The enquiry, occasioned by a complaint of the miners regarding demands made on them by the lord of Tynedale's bailiff, confirmed that the miners answered to the Crown as the minerals were reserved to the king. Shortly thereafter the miners let their interest in the mines to a foreigner, Tilmann de Colonia, in return for a fixed payment to them and the Crown, and in 1359 the king granted Tilmann and his employees his protection.[23] However, the miners right to elect a 'king's serjeant' was recited in all subsequent confirmations of custom.[24]

In return for their right to work the minerals, the miners paid a portion of the produce to the Crown. In answer to an enquiry in 1279 the miners stated that '*the King should receive each ninth disc (dish) dug by the miners. And each disc should contain as much ore as a man can lift from the ground. And as to the remaining eight discs, the King should have the 15th penny of all the ore sold*'. [25] The form in which the profits were taken was similar to other mining fields in Crown hands, although the portion is larger, with a ninth dish of ore being reserved. No reference is made to the payment of tithes to the church on the produce of the Tynedale mines but, judged on grants made by the Crown in the 14th century and later, the ninth dish represented a ninth part of the produce

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21 *OED*, vol. XV, p. 252; Unlike the Devon mines of the late 13th and early 14th century, there is no evidence for the 'permanent workforce' suggested by Blanchard ('The miner', p. 98, n. 6).

22 *Calendar of Documents relating to Scotland*, iii, p. 295; *Cal. Inq. Misc.*, vol. 3, p. 81.

23 *Cal. Pat. R.*, Edw. III, vol. 11, p. 183.

24 *Cal. Pat. R.*, Hen. V, vol. 2, p. 57-8.

25 *Calendar of Documents relating to Scotland*, ii, p. 41, quoting Assize Roll (Cumberland), 6 - 20 Edw. I, Jan. 16, 1278-9.

after the payment of the tithe and was therefore a tenth part of the ore mined. The 15th penny was probably exacted in lieu of the Crown's right of pre-emption on the produce and is unlikely to have been paid in the 12th century when the right was exercised.[26]

The privileges and liberties afforded to the miners of Tynedale were those of a 'king's field' where the Crown held the rights to all minerals by virtue of its lordship over the land, rather than regalian prerogative over certain metallic minerals, such as gold, silver, copper and tin. In Alston, in Tynedale, they continued to apply after the grant of the lordship of the manor to Nicholas de Veteripont in 1276 as the mines and miners were reserved to the Crown.[27] They had much in common with those of other 'king's fields', principally those in Derbyshire, including the payment of a portion of the produce of the mines, with the Crown exercising a right of pre-emption, later commuted to cash payment.[28] The significant differences were that the coroner or serjeant had greater power than the bermaster in the king's fields of Derbyshire, equal to his fellows in the adjoining lordships of Cumbria, and the miners were allowed the services of a refiner at the Crown's expense. The serjeant of the mine of Alston, an elected official, acted as coroner in respect of all those living within the bounds of the mine whereas the jurisdiction of the bermaster, an agent of the mineral lord, at Wirksworth, Derbyshire, was confined to the miners and the workings.[29]

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[26] Blanchard, 'Derbyshire lead production', p. 120; in Derbyshire the portion reserved to the lord was known as 'lot' lead. In the Crown liberties of High Peak and Wirksworth it stood at one thirteenth, in the smaller private liberty of Ashford at one tenth. The payment known as 'cope' was not introduced until the mid 13th century in lieu of a pre-emption on produce. The Crown appears to have exercised a right of pre-emption on the produce of the 'mine of Carlisle' with allowances made against royal writs on lead to be utilised in the king's works. The payment of the 15th penny would suggest that pre-emption had been given up by 1279.

[27] *Calendar of Documents relating to Scotland*, iii, p. 200.

[28] See Gill, *Lead Mining in the Pennines*, p. 98.

[29] *Calendar of Documents relating to Scotland* , ii, pp. 33-41; Gordon, 'Quo

3. Regulation of mining outside of Crown lordship.

Workings on the Bishop of Durham's estates in Weardale, including its tributaries and land south of the river Derwent, lay outside the bounds of the 'mine of Carlisle'[30] Rights to mine silver in Weardale were confirmed to the bishop in 1154, although in practice exercised before that date, and thereafter lay outside Crown control except during vacancies in the see.[31] The bishop was briefly, between 1189 and 1193, also granted 'the county of Northumberland with pertinences' which evidently included the right to silver-bearing ores as the farm of 'the mine of Carlisle' was reduced accordingly.[32]

Little information has come down to us on the organisation of mining within the bishopric of Durham during the 12th and 13th centuries. The mines were at times in the hands of a moneyer from the Durham mint and at other times the miners themselves seem to have worked the minerals but with the bishop retaining overall control, exacting either a royalty or leasing them on farm. The arrangement at the end of the 12th century was discussed in Chapter 3, Section 1.3 above.

Later organisation of mining in Weardale provides us with some indication of the arrangements at the period of peak silver production in the 12th century. In the early 15th century, with lead rather than silver the principal product, the mines, or parts of them, in upper Weardale were leased to individuals who were responsible for mining, smelting and

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Waranto'. See also Barrow, 'Pattern of lordship', p. 129-30, for the origins of the serjeantry in Cumbria.

30 All were part of the Bishop of Durham's hunting forest established between Tees and Tyne. Mining activity was carried out in the forest but permanent settlement was on the whole discouraged. See Drury, 'Durham Palatinate Forest Law and Administration'.

31 Surtees, *History and Antiquities*, i, App. p. cxxvi.

32 *Pipe Roll, 3 Ric. I*, PRS, NS 2, p. 55.

marketing the lead with little or no involvement by the bishop. By the second decade of that century the bishop had assumed direct control of both mining and smelting.[33]

The productive veins, or sections of them, were then let to working miners who were often also agricultural tenants of the bishop. Their agreement bound them to sell the produce of their working to the bishop and all smelting was carried out, under his control, at a single location close to sources of fuel at Wolsingham Park.[34] This may have been a return to an arrangement in place prior to the 15th century or it could have been a new initiative by the bishop to control production.[35] Smelting had only recently been centralised, and there are regular references to the removal of slag from other scattered sites for reworking at Wolsingham, but the system of renting to working miners may have its origins in the 13th century or earlier. However it is evident that no body of custom survived that would allow the early modern miner control over the means of production.[36]

One other mining field under episcopalian control which displayed similar characteristics to Durham was that part of Mendip in the lordship of the Bishop of Bath and Wells. The bishop was originally granted the right to mine lead on his land within the forest of Mendip by Richard I. In a further grant, dated 1235, this was expanded to cover iron and 'every other kind of mine' and included land which appears to have lain outside his lordship. The right to mine outside his lordship was subsequently restricted to iron and lead provided he had the permission of the landholder. Within the bishop's lordship it is evident that silver was being extracted from lead ores found to the east of Priddy in the

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33 Blanchard, 'Labour productivity and work psychology', p. 98.
34 Drury, 'Leadworks'.
35 Blanchard, 'Labour productivity', p. 100 et seq.
36 Blackburn, 'Mining without Laws'; Wood, 'Custom', p. 260, n. 41.

late 13th century. Then the argentiferous ores were removed to the bishop's court at Wookey to be smelted and refined separately under the supervision of the bishop's steward.[37] The Bishop of Bath and Wells' lordship was one of the four mining liberties on Mendip which were later confirmed as being worked according to customary law.[38] However, there is no evidence to suggest whether or not silver-bearing ores in the bishop's lordship were being worked in common in the 13th century. The ore smelted at Wookey may have been the total produce of the mines or merely the lord's portion.

Another area in which the English Crown had only limited access to silver bearing resources was that of the Marcher lordships along the Welsh border. The strength of grants of lordship in areas on the military frontier was such as to give the holder almost regalian rights. However, there do not appear to have been any discoveries of major importance despite searches made in the 15th century, and the Crown did move to reserve the mineral rights in subsequent grants of marcher lordships.[39]

4. Increased Crown involvement in silver mining.

Despite the richness of the Carlisle mines the Crown showed no inclination to become directly involved in the production process. However, with no reliable home source of silver after the decline of the Carlisle mines the Crown took an increasing interest in any

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37 Gough, *Mendip*, pp. 50-55; PRO, *Ancient Correspondence*, SC1/48/177 (for translation see Salzman, *English Industries*, p. 65 - both Salzman and Gough date this letter to the early 14th century but, as the addressee is said to be Robert Burnel, it would predate his death in 1292.)

38 Gough, *Mendip*, pp. 69-111.

39 See page 252 below.

prospect of opening up new mines. A small number of king's miners were paid to investigate such prospects although their success appears to have been limited. The north and border areas of Wales provided an area of interest; activity was noted near Basingwerk but we are not told who was involved, and there was an abortive attempt to work silver at Carreghofa near Llanymynech in 1194-5 with a view to paying King Richard's ransom.

Giraldus Cambrensis (Gerald of Wales) noted mining activity whilst journeying from St Asaph to Basingwerk in 1188, stating that the country was 'rich in minerals of silver, where money is sought in the bowels of the earth'. [40] The general assumption of later writers being that the silver found there was minted at nearby Rhuddlan. In the mid 12th century, when the area was under Welsh control, large numbers of pennies, copies of English 'Short Cross' type, were produced at Rhuddlan. These turn up in hoards across Wales although they are scarce in English hoards.[41] The close proximity of silver-bearing ores would account for their being minted so far east, away from the commercial centre of Gwynedd. It is of note that, on his journey through Wales, Gerald had passed from Lampeter through Llanddewi brefi and Llanbadarn fawr north to the Dovey valley, areas later to prove rich in silver, but made no mention of mining, despite being in the company of those who knew the locality.

When in 1262 precious metals along with copper were allegedly discovered in a mine at 'la Hole' in North Devon the Crown was quick to exercise a prerogative, ordering the

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[40] Hoare, *Giralsus Cambensis*, p. 129. 'et per divitem venam fructuosumque argenti scrutinium, ubi penitima scrutando "Itum est in viscera terræ" transeuntes' (Dimock, *Giraldi Cambrensis, itinerarium Kambriæ*, p. 137.)

[41] Besly, 'Short Cross', pp. 53-5.

sheriff to take possession of the workings. As yet the exact location of the mine is uncertain; although it could be at Molland where copper workings are to be found on a group of tenements with 'hole' placenames.[42] Early in 1263 officers were despatched to examine the mine and payments made to them in expectation of the expense. Two keepers were subsequently appointed to oversee its development, assisted by one of the king's miners, with a grant of wood for charcoal from the king's woods at Chittlehamholt. A bond of 80 marks, to be paid out of the first issues of the mine, was made to the occupier in respect of the land which he had granted to the king for the purpose of working the same.[43]

There must be some doubt as to the ability of the officials, even with professional assistance, to identify and if necessary work such discoveries. By the end of the year a group of continental miners had entered the country to prospect for mines at the king's request. They were followed, in July 1264, by Walter de Hamburg, with seven other miners from Germany. The latter group was active at "*mineris nostris cupreis, argenteis, aureis et plumbeis in comitatu Devon*", probably 'la Hole', although it is not mentioned by name. They were there for at least six weeks; their wages (102s.) paid out of funds held by the sheriff. Two years later Gerard de Brabaunt received £24 for "*the expenses of certain men coming from parts of Almain to work the king's mine in Devon*". [44] Yet there is no further reference to these or any other mines in Devon for nearly thirty years. However, the fact that the Crown could simultaneously open up mines at opposite

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42 *Cal. Close R.*, Hen. III, vol. 12, p.187.

43 *Ibid.*, pp. 214 and 227-8; *Cal. Pat. R.*., Hen. III, vol. 5, pp. 249, 255 and 256; *Cal. Liberate R.*, vol. 5, p. 120; *ibid.*, vol. 6, item 2325.

44 *Cal. Pat. R.*, Henry III, vol. 5, p. 304; *Cal. Close R.*, Henry III, vol. 7, p. 349 and 406-7; *Cal. Liberate R.*, vol. 5, p. 246; *ibid.*, vol. 6, item 1252.

extremes of the county, Combe Martin and Birland (Bere Ferrers), in 1292 presupposes prior knowledge of their potential.

5. Direct working of the silver mines in Devon.

Although the Birland workings did briefly pass to the kings bankers, the Frescobaldi, in an attempt to repay loans at the turn of the century, the appointment of Vincent de Hulton to the keeping of the Devon mines in 1292 ushered in over half a century of direct working by the Crown. This was apparently unique in Europe, no other head of state had such a close involvement in the working of their mines. For examples of a similar level of state intervention in the mining of silver-bearing ores we have to look to central Europe in the late 16th and 17th centuries. There we have instances of direct intervention, as in 1635 when the Duke of Celle-Calenberg took control of shares in a successful mine, the Turm-Rosenhof Mine in the Upper Harz, and worked it as a ducal (state) enterprise for over a century. Earlier the Austrian state had taken over failing silver mines, orginally worked by private enterprise, with a view to maintaining production.[45]

It is for this period of silver mining, 1292 to 1349, that we have the most information. Unlike the earlier period of productive working in the Northern Pennines, when production was in the hands of small partnerships of miners, the working of the Devon mines was answerable to the Exchequer, requiring the regular submission of accounts against which the actions of the keeper were judged. During this period the mine at

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[45] Dr Christoph Bartels, Deutsches Bergbau-Museum, Bochum, pers comm; for Turm-Rosenhof, see Bartels, 'The Development of the Turm-Rosenhof Mine'.

Birland was at its most productive, whereas that at Combe Martin initially failed to realise its full potential, leading to closure in 1296, after which its direct working was abandoned.[46]

5.1 Management of the Devon mines.

With the opening up of the Devon mines a centralised management structure was introduced under the Keeper, a Crown officer.[47] The Keeper was himself monitored by the Controller, or Comptroller, another Crown appointment.[48] In the early years, 1290s through to the second decade of the 14th century, the keeper and, at times, the controller were resident at the mines; first at Bicombe and after 1301 at Calstock.[49] Both sites were close to the smelting / refining operations.[50] Day-to-day operation of the mine was the responsibility of the Supervisor. In the late 13th and early part of the 14th century a

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46 PRO, *Exchequer Accounts* E101/260/4, Account of Vincent de Hulton, 20-22 Edw. I; E101/260/5, Account of mining at Combe Martin, 20-25 Edw. I; E101/260/6, Account of W. de Wymundeham, 20-25 Edw. I.

47 As keeper he had legal authority over the miners through the miner's courts or beremotes, as defined at page 232 below.

48 The role of the 'controller' in the administration of Crown finances predates the direct working of the Devon mines and is evident in the castle building programme, when work was carried out 'by the view and testimony of law worthy men' (Colvin, *King's Works*, vol. 1, p.54). Supervision of local 'collectors' of customs duty was formulated in the grant of customs in 1275 but, although a controller was appointed briefly in 1294-98, it was not made a permanent feature until the reign of Edward III in the early 14th century. (Baker, *The English Customs Service, 1307-1343*, pp. 4 and 10)

49 In 1316 the comptroller was clearly involved in activity at the mines, measuring deadwork and overseeing payment (PRO, *Exchequer Accounts* E101/261/21(1), Account of Ricardus de Wygorn, 10-11 Edw. II)

50 As controller over the Friscobaldi's activity, Thomas de Swanseye was resident at Bicombe (PRO, *Exchequer Accounts* E101/260/19, Account of Thomas de Sweyneseye, keeper of the king's mines in Devonshire and Cornwall, 28-35 Ed. I) and in 1305 keys were made for the controller's residence at Calstock (PRO, *Exchequer Accounts* E101/260/26, Account of wages at the king's mines in Devonshire, 32 Edw. I, entry for 25 July)

number of men held that post and none appear to have been from a mining background. Although described as clerks they were employed as managers. Their status being reflected in their wages. Matthew de Hechcote, 1300-7, was rewarded at the not inconsiderable rate of 6d. per day; however, his successor, Walter de Horsham, received only 21d. per week, comparable with a clerk in charge on a large estate.[51]

Other, minor, officials were from time to time involved in the operation of the mines. Weighing of lead was occasionally delegated to the 'troner,' and delay in appointment could result in the full submission of accounts to the Exchequer being held over until the following year. Thus the account for the year 20 Edw. I (1291/2) under Birland (Bere Ferrers) is qualified '*..but this ore has not been measured for the reason that the right to measure has not yet been assigned by ...* ' and similarly *'ores of Combe Martin not measured for the reason given above by the same account.* ' and some fertile lead production appears in the account for year 21 Edw. I.[52]

Accounting procedure had to be followed meticulously by the keeper if he was to avoid problems, as his account would be compared with a counter roll prepared by the comptroller. Payments of silver into the Exchequer were receipted on wooden tallies. On completion of the transaction the tally was split lengthways. one half being kept by the Exchequer and the other half given to the keeper's representative as a receipt. The receipts were placed in safekeeping until the keeper was called up to London to account for the profit of the mines before the Barons of the Exchequer. Failure to produce valid tally

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51 Burnett, *Cost of Living*, p. 41.

52 PRO, *Exchequer Accounts* E101/260/4, Account of Vincent de Hulton, 20-22 Edw. I, *'que quidem mina non fuit mensurata pro eo qd mensura nondum fuit assignata'* [the document is damaged and the rest of the sentence is illegible] *'nera de Combemartyn non mensurata ratione p'cta per idem compus'*

receipts could result in surcharges being made for any silver unaccounted for, as nearly happened to Richard de Wygornia's executors in 1332.[53]

The manner in which the keeper was to run the mines was detailed in a ordinance issued to William Daulton in the year 26 Edward I (1297/8).[54] It can be broken down into three main areas:

1) The number and specialisation of the miners. A total of four hundred miners were employed although not all were engaged in getting ore. At least one hundred locally recruited, or impressed, tinners were employed on deadwork. All were engaged *'according to the direction which shall seem to be best for the profit of the King'.*

2) The method for calculating their pay. This was either by the quantity of ore raised, or by the task in the case of deadwork. All ore had to be measured and due payment made weekly on the Saturday.

3) The facilities to be provided for the effective prosecution of the mines. This included the provision of smithies, one at each of the three mines then active at Birland (Bere Ferrers), and smelting facilities. Five refiners were to be employed, the quality of their work being monitored in regular assays of the fertile lead.[55]

The keeper(s) had an element of freedom of action - *'And if the keepers see that they can amend this ordinance in any of the articles above said, let them do it to the best of their knowledge and power'* - but were subject to the overall control of the Exchequer - *'and*

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53 Salzman, 'Mines', p. 81.

54 British Library Add. MS 24770 f 202-7, Transcript of the ordinance of the keepers of the king's mine in Devonshire, 26 Edw. I (Appendix 10, below).

55 Fertile lead - the product of smelting and still containing silver.

that from month to month they certify the Treasurer and the Barons of the Exchequer of the state of the mines and of what they shall have done'.[56]

Crown appointees with little or no experience of mining were expected to organise an activity employing hundreds of men in the extraction and processing of ores. They necessarily relied on skilled workers for the day to day supervision of mining and smelting. During the period when smelting activity was concentrated at Calstock it was clearly advisable to have two supervisors, one at the mines at Birland and another for the workers at Calstock. In 1316-17 Walter de Horsham had an assistant Robert Oliver at Calstock to oversee the workers and take responsibility for the woodland there. In addition, William de Hicch, the controller, was actively involved in supervision, being responsible for the measurement of work and overseeing payment.[57] They had, nevertheless, to have a grasp of the overall operation of the mines if they were to be worked efficiently. Inevitably the Crown drew on what expertise was available and early keepers of the mines in Devon had a Mint background; employed on wages commensurate with their responsibilities to oversee the running of operations. Some like Thomas de Swaneseye, controller whilst the mines were in the hands of the Society of the Friscobaldi in 1299-1300, appear to have had an aptitude for the job. During his time as controller he acquired sufficient knowledge to be able to take on the management of the mines, as a very effective keeper, on their departure.

At least one keeper sought greater control over the workings and their production. In 1318 the keeper of the Birland (Bere Ferrers) mines, Richard de Wygorn, requested that he be

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56 *Ibid.*, f 207

57 PRO, *Exchequer Accounts*, E101/261/21 (1), Account of Ricardus de Wygorn, 10-11 Edw. III.

granted a farm, i.e. a lease, of the mines at £200 per annum. The productivity of these mines had by that time fallen off, with losses of £108 in the preceding year. Nevertheless the Crown was unwilling to let them out at a fixed sum. Having checked the accounts the view of the Exchequer was that occasional periods of loss were acceptable when deadwork was underway to gain access to reserves of ore and profits would ensue. Wygorn was allowed to take the mines on farm at 12s. per load of ore raised, bearing all the costs incurred including deadwork. This was effectively a lease and Wygorn had a financial interest in the produce of the mine. The agreement was not taken beyond the three years and the following keepers appear to have reverted to wages with the Crown covering the expenses of the mines. New keepers were in place by 1320-21 and a portion of the mines was let to the Abbot of Tavistock. At his death eight years later, Wygorn was still in the king's debt.[58]

The Combe Martin mines abandoned after a short period of working in the late 13th century were taken on lease by at least five individual adventurers in the five years to 1330. Even the lord of the manor, Philip de Columbariis, tried his hand there; but none succeeded in making a profit from workings which were described as exhausted and affected by heavy influxes of water.[59] The Bere Ferrers mines, principal producers of silver in the 14th century, were not, with the exception of the farm to Wygorn (above) and the earlier grant to the Frescobaldi, leased out until the following century although there were potential adventurers amongst the keepers appointed there. John de Moveron the keeper from 1342 to circa 1349 had considerable commercial interests in the

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[58] PRO, *King's Remembrancer Memoranda Rolls* E159/91 f110, Memorandum re. farm, 11 Edw. II; *Cal. Memo. R.*, 1326-7, items 1211, 1858, 1920 and 1925.

[59] PRO, *Chancery: Inquisitions ad quod damnum* C143/192/10, Inquisition into the Combe Martin mines, 1 Edw. III - see Appendix 6.

South-West.[60] At least one controller, William Pasford, appointed 1332, was one of many local people who speculated in the production capacity of the stannaries; either as shareholders in the workings or advancing money to tinners against the black tin they expected to produce, smelting it, presenting it for coinage and selling it on at a good profit. At a time when usury was frowned upon such advances, or loans, proved a sound investment for those with cash to spare; the interest being hidden in the amount of black tin expected in return. In silver mining such investments did not present themselves until the latter part of the 14th century and then they were nowhere near as sound as tin.[61]

Keepers like Moveron had to be content with their salary; although, given his varied commitments in east Cornwall and west Devon, including the tenure of the manor of Calstock and a part of that at Bere Ferrers, it was hardly a full time occupation.[62] However, output from the Bere Ferrers mines had by that time declined considerably, being reduced to reworking of slags by 1348.[63] The Black Death of the following year and subsequent visitations of plague marked the abandonment of the south Devon mines and direct Crown involvement in mining ceased.

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60 Hatcher, *Rural Economy*, p. 238.

61 *Cal. Pat. R.*, Edw. III, vol. 2, p. 247; Hatcher, *Rural Economy*, p. 239; Hatcher, *Tin Production*, pp. 43-88; see also Chapter 1, Section 4.2 above.

62 *Cal. Close R.*, Edw. III, vol. 8, p. 359; for Moveron's other interests in the South-West see Hatcher, *Rural Economy*, p. 238

63 PRO, *Exchequer Accounts* E101/263/11, Account of John de Moveron, keeper of the mine of Birland, 22-23 Edw. III

5.2 The workforce in the Devon mines.

The workforce employed at the mines can be split into two groups, as outlined at Fig. 21 below: those on day wages and those on piecework. Ancillary workers, carpenters, woodcutters, the smelters and refiners, made up the bulk of those on wages. Only occasionally were miners paid wages, which for our purposes is unfortunate, for we have far more detail available from the wage rolls, piecework appearing only as a lump sum.

Piecework itself can be broken down into three categories according to the method by which it was calculated. Miners on production work were paid by the load of ore (dressed ready for smelting), 5 shillings was the rate from the late 1290s into the first quarter of the 14th century. The lower yield of the white carbonate ore, cerussite, half the lead and, more particularly, a quarter of the silver content of galena by volume, was felt to justify a lower rate for its extraction. The regulations of 1297 allowed for this but in practice the effort of mining the cerussite was as much as that for galena. In 1325 the payment for cerussite was reduced to 3s. per load. By 1331 it had been increased to 4s. eventually returning to the same rate, 5s., as galena.[64] It is on the category of ore extraction that the *Exchequer Accounts* have the least to tell us: the number of miners is not given, only their output, so no calculation can be made as to productivity or earnings. Similarly the numbers employed on deadwork are not recorded. They were paid either by the fathom, in driving adits or drainage levels, or by the task. Occasionally discrete figures would be given: in 1307 a miner engaged in driveage at a half mark (6s. 8d.) per fathom, and those clearing

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[64] British Library Add. MS 24770 f203, Ordinance of the keeper, 26 Edw. I; Salzman, 'Mines', p. 72. A load comprised 9 dishes - the dish being an unspecified volume measure (see Appendix 15, below).

and repairing levels were paid at 9d. per week The remaining category is for those ancillary workers paid by the task, for instance on ore carriage.

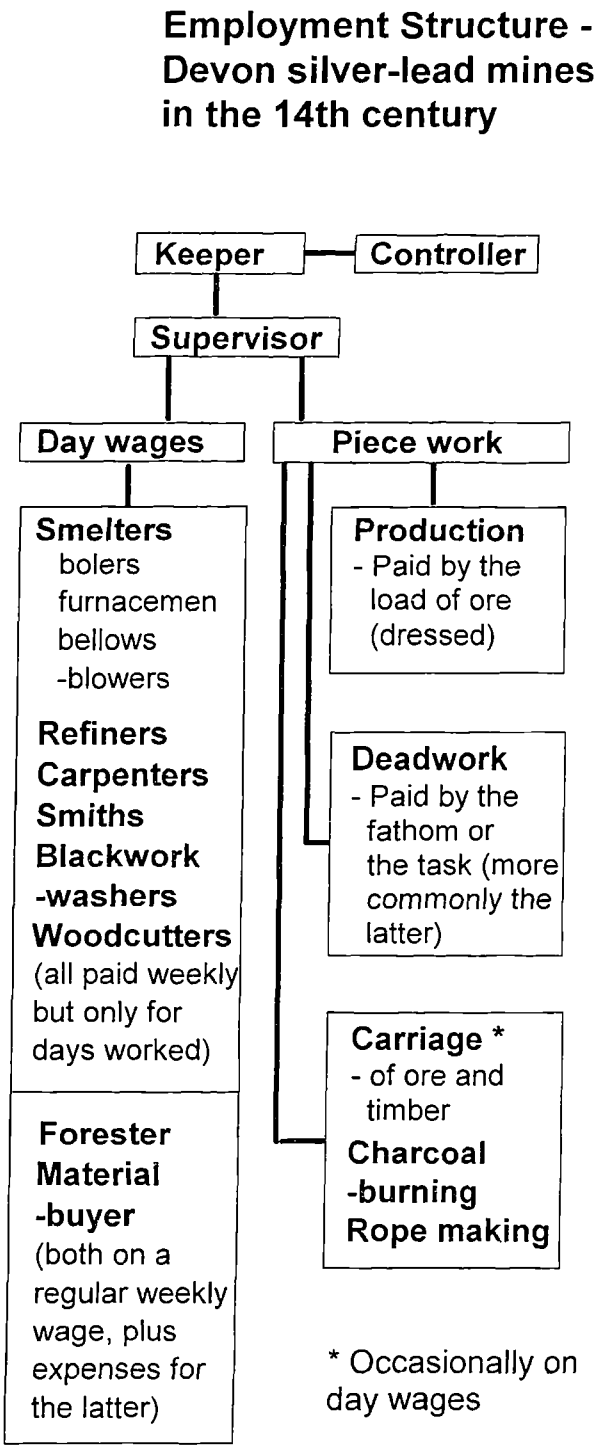

Figure 21 (based on material from PRO, *Exchequer Accounts,* quoted in the text.)

Despite the instruction given in the ordinance of 1297, for prompt payment on the Saturday of each week, the keeper of the mines could find himself short of cash to pay his workers. The silver produced was usually despatched to the Exchange in London, although on at least one occasion it was disposed of locally in exchange for cash. Cash for wages was sent down to Devon in return.[65] More often cash was drawn from local sources: profits of the Crown demense or taxation, as in 1309/10 when £100 was received from the collectors of the twentyfifth (a subsidy) in Devon.[66] This second method was more convenient and secure, avoiding the transport of large amounts of cash in small denominations over long distances. However, it relied on the co-operation of the exchequer and local officials, which was not always forthcoming. Thomas de Swanseye, the keeper in the first decade of the 14th century, had cause to complain about a dearth of cash for wages.[67] Even in the most productive years 1304 to 1307 there is evidence to suggest that miners were being paid, at least partially, in sterile lead.[68]

There were evidently limited numbers of miners and skilled workers available locally when the Devon mines were opened up at the end of the 13th century. Local men were initially employed largely on ancillary tasks with no direct links to mining. There had been little mining activity, other than tin streaming, throughout the 13th century and the Crown had found it necessary to bring in workers from Germany in the 1260s.[69] The labour force for the new mines had to be recruited primarily from the existing lead mining areas; in some cases forcibly. Surnames of skilled ancillary workers indicate that they

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65 For example, see PRO, *Exchequer Accounts* E101/261/10, Counter roll of the abbot of Tavystock, 1-2 Edw. II.

66 PRO, *Exchequer Accounts* E101/261/12, Account of Robert Thorpe, 3-4 Edw. II.

67 PRO, *Ancient Correspondence* SC1/48/81. See *Recueil de lettres Anglo-Francaises* pp. 72-76 for Anglo-Norman text.

68 PRO, *Exchequer Accounts* E101/261/2, Memo. of barren lead sold, 34-35 Edw. I.

69 See page 218 above.

were drawn from most mining fields: Walter Smaleye, from Derbyshire; Phillip and Robert de Yal, from north-east Wales; Henry de Priddy, from Mendip; and Robert de Coleford, from the iron mining field in the Forest of Dean.[70] However, although miners were pressed regularly, there must have been widespread voluntary recruitment.

There were precedents for the impressing of miners and it is apparent that the Crown could oblige their attendance much as it could for them and the populace as a whole in times of war. In 1233 miners from the Forest of Dean were even sent to Wiltshire to demolish a house at the king's behest and expense.[71] In 1295 officers of the king's mine in Devon visited Bromfield and other parts of the north-east Wales mining field, the Peak mining field of Derbyshire, Mendip and parts of Gloucestershire to select miners and return with them to Devon. The penalties for non-compliance were severe: a year later when further miners were selected Reginald de Grey, justicar of Chester, had orders that '*if any of them flees or refuses to go, he is to imprison them and seize their goods and chattels.*' In this latter case miners were expected to provide four sureties that they would present themselves for work in Devon.[72]

By the second decade of the 14th century local names were appearing amongst those employed as miners and smelters: William de Dertemore, miner employed on deadwork, 1316-25; Walter de Dertemore, miner, 1330s; William atte Birche, miner on deadwork, 1343-44; William Hache, boler, 1343. Although, even in 1343-44, men with Derbyshire

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70 See Appendix 4, below, for details of miners and other workers employed in the Devon mines.

71 *Cal. Liberate R.*, vol. 1, Hen. III, p. 228.

72 *Cal. Close R.*, Edw. I, vol. 3, p.504; PRO, *Exchequer Accounts*, E101 260 17, Documents re. the sending of miners from Wales, 25 Edw. I (see Appendix 3, below

names like Phillip de Ashford still featured amongst the miners.[73] The right of the keeper to impress miners for employment in Devon continued to be recited in grants of the mines, even after direct working was discontinued. By the mid 15th century, at the nadir of demographic decline, there was little prospect of compelling miners to move to work in Devon. Local men were by that time employed at all skill levels in the mines.[74]

5.3 The organisation of labour - the miners.

The problems of supervising a workforce in scattered, relatively inaccessible workings, obliged management to accept a high degree of autonomy amongst the miners, particularly those engaged on extractive work. The only controls exercised by Crown officers were in the allocation of workplaces and in the rejection of a poor quality produce.[75]

Miners on production work were organised in groups. Each group was responsible for raising and dressing the ore fit for smelting and, prior to 1309, the labour costs of draining water from their workings. From their inception the Crown had born the cost of driving drainage adits (avidods) or galleries, but the day to day task using leather buckets was the

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73 See Appendix 4, below, for details.

74 See PRO, *Exchequer Accounts*, E101/266/25. Counter roll of the profits and expenses of the mine of Bere Ferrers, 20-21 Edw. IV; PRO, *Chancery: Early Proceedings*, C1/9/404, Petition of John Clyff, temp. Hen. VI; see also page 236 below.

75 This was to be a feature of mining into the modern period, particularly in the non-ferrous sector. Even the coal industry of the early 19th century, at the height of capital investment, accepted the 'relative autonomy of the worker at the point of production' (Jaffe, *Market Power*, p. 48).

miner's although from 1309 the Crown met part of the cost.[76] All the tools required, picks, ropes and buckets, were furnished by the Crown.

Those on deadwork, although occasionally paid by the day, were generally similarly organised. A named member received payment for the task generally on a monthly basis as this example from Birland in 1302/3 shows:[77]

> *Thomas Robyen and associates, for repairing the galleries of the South Mine... £5*
>
> *Hugo de Morneshale and associates, for the same at the Middle Mine £4*
>
> *Robertus, son of Richard, and associates, for the same at Fershill Mine £2*
>
> *Peter le Hole and associates, for the same at the Old Mine..... £3*

In addition to the miners pressed in large numbers from the lead mining districts, by 1298 tinners were also brought in to work in the drainage adits; supplementing an already inflated workforce:

> *That there be now one hundred and fifty miners of the Peak and one hundred and fifty miners of the country, chosen from the best, on the one part and on the other, for the miners in Birlaunde amount to many more than occasion appears to require. But if it were wished that other mines as of Coumartin and of Cornewaille should be worked that there should be more miners had according as should be fit, and for this purpose, when one shall be less obstructed by those miners.*
>
> *And that there be in avidodz, one hundred tinners of the country.*[78]

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[76] See Chapter 4. Section 4.2, above.

[77] PRO, *Exchequer Accounts* E101/260/22, Wage roll, Calstock and Bere Ferrers, 30-32 Edw. I,

[78] British Library Add. MS 24770 f 202, Ordinance of the keepers of the king's mine in Devonshire, 26 Edw. I.; for details on the purpose of avidodz (drainage galleries) see

Some elements of the privileges awarded to miners in the Devon silver mines bear comparison with those later incorporated into the Charters granted to the tinners of Devon and Cornwall in 1305.[79] Exemption from local taxation is a feature common to both which was not enjoyed through custom by miners in fields outside the South-West. Right of redress in a specially designated court was common to all mining fields under customary law and was transposed to the Devon mines. Cases were heard before the keeper of the mines, but a jury of miners is not mentioned. The arrangement, although extra manorial, was firmly within the seigneurial system, with restrictions on the freedom of action commensurate with control of production.

The privileges were usually granted for a limited duration only and therefore remained in the gift of the Crown, not a right as of custom.

> *Exemption for four years, for the king's miners dwelling in the county of Devon, in all cities, boroughs, towns, fairs and markets in that and the neighbouring counties, from tolls and customs upon necessaries for food or clothing purchased by them, and from pleading or being impleaded for trespass, personal action and other pleas in the courts of the counties, court baron and other courts against their will, except before the wardens of the mines or the sheriff of Devon for the time being.*[80]

Such privileges were renewed from time to time. They were proclaimed by letters patent in 1299, to run for a period of five years.[81] A further exemption from tolls and custom was

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Chapter 4, Section 4.2 above.

79 See Lewis, *Stannaries*, Appendix D, for the text of the Charters of 1305.

80 *Cal. Pat. R..*, Edw. II, vol. 1, p.14

81 *Cal. Pat.R.*, Edw. I, vol. 3, p. 398.

granted, for a period of four years, in 1307.[82] This was reiterated in 1313, without a time limit, again listing only exemptions from local taxation.[83] However, a similar wording in the tinner's Charters of 1305 was being interpreted as an exemption from general taxation. In 1315 the collectors of a general tax on possessions, the fifteenth, in Cornwall were commanded '*to supersede until further orders the levy of the fifteenth upon the goods of the miners working the king's mine in that county, and to release any distraint that he may have levied in this behalf*'.[84] Thereafter the tinners were acknowledged to be free of national as well as local taxation.[85] But there is no evidence that such an interpretation was applied to workers in the Crown silver mines.

In 1320, a commission of oyer and terminer was set up to inquire into trespasses against miners in the king's service in Devon.[86] Although not allowed to become established as custom, the privileges were subsequently referred to in grants of the mines from the second half of the 14th century onwards as ' *the same liberties, privileges and franchises as the miners of Byer have been wont to have*'.[87] The miners courts were active until at least 1343-4 when the comptroller accounted for "*7s 6d from the profits of courts called Beremotes*".[88]

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82 *Cal. Pat.R.*, Edw. II, vol. 1, p. 14.

83 *Ibid.*, p. 526

84 *Cal. Close R.*, Edw. II, vol. 2, p. 244.

85 Lewis, *Stannaries*, pp. 164-5; Hatcher, *Rural Economy*, p. 30.

86 *Cal. Pat. R.*, Edw. II, vol. 3, p. 485. There were a number of enquiries of similar nature concerning the privileges of tinners at this period. It would be only natural that the workers in the silver mines would seek to clarify their position against the rights enjoyed by the stannaries.

87 *Cal. Close R.*, Edw. III, vol. 10, p. 663-4 (1359); *Cal. Pat. R.*, Hen. VI, vol. 2, p. 289 (1433) subsequently repeated in a further grant of 1439 (*ibid.* p. 291) but with the proviso that the privileges were to be enjoyed for the term of the grant, 12 years only.

88 PRO, *Exchequer Accounts* E101/263/8, Counter roll of John Cory, mines in Devonshire and Cornwall, 17-18 Edw. III

An influx of miners into Combe Martin and Bere Ferrers in the late 13th century would have created a demand for food which could not be fulfilled by the immediate area.[89] Food was the responsibility of the individual miner and a local market the key to its distribution. Although granted exemption from local taxes levied on market transactions the miners were prohibited from lingering there: *'And no miner shall remain in a market town under colour of buying food, or in other manner after the ninth hour on Sunday without leave'*[90] Combe Martin had a market since 1265. Bere Ferrers was granted a market, on a Wednesday, and an annual fair in 1295, no doubt in response to the opening of the mines. However, informal Sunday markets were common and took advantage of a congregation of residents around the parish church. There is no evidence for a church in Bere Alston, a borough and later the largest settlement close to the mines, until 1435 although one was reputedly built during the reign of Edward III. We must assume that the market referred to was in Bere Ferrers village, some distance from the mines, and an element of discipline was therefore required to ensure the miners returned to their work.[91] Exactly how the miners were accommodated is unclear; the accounts make only brief reference to housing and then only for workers employed in the smelting operations at Calstock in 1304.[92] There is evidence, considered further in Section 5.5 below, which suggests that by the late 15th century there was a concentration of settlements close to the

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89 Hatcher (*Rural Economy*, p. 22) identifies the south-eastern manors of the Duchy of Cornwall as sources of surplus agricultural produce and Finberg (*Tavistock Abbey*, p. 96) noted the sale of surpluses from Abbey holdings.

90 Salzman, *English Industries*, p. 53 - quoting from the *Memoranda Rolls* (Memo. R. LTR [now E368/69] 25-6 Edw. I, m. 51). The ordinance issued to the keeper, as transcribed and translated in British Library Add. MS 24770 f 204, includes a similar instruction which refers to no miner or 'dweller' remaining in the town but is evidently a mistranslation of the Anglo-Norman 'demorger' meaning to stay rather than to dwell (Henry, pers. comm.).

91 *Cal. Charter R.*, vol. 2, p. 463; Kowaleski, *Local markets and regional trade in medieval Exeter*, p. 53 and fig. 2.1; Beddow, *A History of Bere Ferrers Parish*, p. 16.

92 PRO, *Exchequer Accounts* E101/260/27, Account of wages at the king's mines, 32-33 Edw. I.

known medieval mines where workers could have been accommodated alongside or, by that date, been absorbed into the local population.

The miners were, no doubt, valued for their skills. Certain of them were well paid, for example, Henry de Priddy who travelled throughout the country buying essential supplies for the Birland mines in the early 14th century, whilst others were entrusted with the selection of miners in North Wales and Derbyshire.[93] The skill of the smelters too was in demand particularly in the early years when they were allowed the where-with-all to try new methods. But they were the king's men and ultimately under the control of his officers.

5.3.1 The production of tithe ores.

Under the system of self regulation prevailing in the Northern Pennines, payment of the portion of ore due to the church as tithe was the resposibility of the miner as producer. From shortly after the opening of the Devon mines the keeper was accounting for the tenth part of the ores given to the rector of Bere Ferrers, and production of the tithe ore was still regarded as the responsibility of the miners. The tithe was evidently allocated from ores as mined. The miners were not paid for the production of the ore but were paid 9d. per load for washing and making the ore fit for smelting, and it was routinely bought back from the rector at 2s. per load. By an agreement, dated 25 June 1308, between the miners, the rector of Bere Ferrers and the king, the rector continued to receive 2s. per load

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[93] See, for example, entries regarding travel expenses in PRO, *Exchequer Accounts* E101/260/22, Wage roll, 30-32 Edw. I, and 261/10, Counter roll of the Abbot of Tavystock, 1-2 Edw. II; for Henry de Priddy see Section 5.4, below.

on a tenth part of production but the miners were paid in full, 5s per load, for all ore produced and prepared fit for smelting.[94] The agreement has not survived and the circumstances are not known; but it came shortly after the appointment of a new keeper, Robert de Thorp, and pressure from the miners no doubt played a part in its implementation.

5.4 Ancillary workers; smelters, refiners etc.

As with mining there was a dearth of specialist, particularly smelting and refining, expertise in Devon in the late 13th century; smelters had to be brought in from the various lead fields and there then followed a period of experimentation with techniques until methods suitable for efficiently treating the silver-bearing ores were developed. The techniques of separating silver from the lead once smelted, on the other hand, were well known to mint personnel and it was from among their ranks that the refiners were drawn. They were all, smelters and refiners, expected to work in Devon at the Crown's behest under the same terms as the miners and the privileges granted to the miners were extended to them, as they were to all who worked at the mines. [95] Their value to Crown operations is indicated in that they were provided with dedicated housing at Calstock, when smelting and refining were transferred there from 1301 until circa 1316, a privilege not afforded to the miners. In some cases the smelters and refiners may have brought their families with them. Lond, the surname of two refiners at Calstock in the early part of the

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94 PRO , *Exchequer Accounts* E101/260/19 Account of Thomas de Sweyneseye, keeper of the king's mines in Devonshire and Cornwall, 28-35 Ed. I, and 261/10, Counter roll, 1-2 Edw. II.

95 PRO, *Exchequer Accounts* E101/260/30, Account of wages, 34 Edw. I.

14th century, occurs three times in the wage roll of 1306. Similarly 'le Wowere', surname of a furnaceman occurs twice in that roll. The second as the name of a blackwork washer's assistant, probably the furnaceman's son.[96]

The skills of experienced miners were utilised in at least one ancillary, although well paid, occupation. The buyer of materials for the mine was paid 18d per week, plus 9d. per day when travelling, to oversee the purchase of essential materials for the operation of the mine.[97] In the early years of the 14th century this was the responsibility of one man, Henry de Priddy and later Thomas Robyn, although it was not necessarily a full time occupation. The latter, at least, was a miner with a number of years service in the Bere Ferrers mines. From the range of tasks undertaken by Henry de Priddy, and his Mendip origin, it is clear that he also had considerable experience of mining prior to his employment in Devon. Both were employed on other tasks for up to 14 weeks of the year.

5.5 Dual occupation and the status of the miner

The miners of the Northern Pennines, particularly those in Tynedale, in the 12th century had enjoyed the freedom to follow dual occupation. Their labour in the mines was apparently limited to the summer months, occupying the upland shiels or summer holdings, restricted by an adverse climate and the problems of drainage during the winter.[98] Work on low-lying agricultural holdings was probably open to them during the periods when mining activity was restricted, as was a combination with upland stock

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96 PRO, *Exchequer Accounts* E101/260/27, Account of wages, 32-33 Edw. I.

97 PRO, *Exchequer Accounts* E101/260/22, Wage roll, 30-32 Edw. I.

98 *Calendar of Documents relating to Scotland*, iii, p. 295.

pasturing during the summer. Dual occupation of this type was common throughout the upland mining fields of England and Wales in the late medieval period.[99] There is evidence to suggest that when the Crown sought to impress miners for work in Devon in the last decade of the 13th century there were some with few, if any, agricultural ties working in areas some distance from their homes. Of the miners selected for the Devon mines in north-east Wales a number had surnames which linked them to settlements in the Derbyshire Peak and a significant proportion were not to be found in Wales in December, including all the Derbyshire men.[100] This suggests that miners were leaving the mining field during that part of the year when mining was restricted but whilst working the mines during the summer months there were some, the Derbyshire men in particular, so far from home as to be unable to contribute to agricultural activity. Similarly a small group of miners, Matthew, Ken(wrik) and Thomas de Mohald or Mohant, expected to be found in Wales were working at *'the pit of the High Peak'*; probably in that part of the Peak adjoining the Cheshire boundary, some 75 kilometres away.[101] All indicative of a mobile workforce primarily engaged in mining as might be expected at the peak of medieval population growth when land was at a premium.

Once selected for the mines in Devon their opportunity for dual occupation was restricted. They were full-time employees of the Crown: up to 150 of them transplanted from their home areas by 1297, with no known land holding in the locality. Whilst we have no

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99 See discussion in Blanchard, 'The miner'; Blanchard, 'Rejoinder'; Blanchard, 'Labour productivity'; and Hatcher, 'Myths'.

100 See Appendix 3; Derbyshire surnames are also in evidence amongst other miners employed in North Wales at this period. Two, named Asshbourne, were engaged to dig for ore in an abortive copper/lead trial at Dyserth, in Flintshire, in 1303 (Jones, *Flintshire Minister's Accounts*, App. A).

101 PRO, *Exchequer Accounts* E101/260/17 f3, Documents re. sending of miners from Wales, 25 Edw. I. The name Mohald (Mold) provides a link with the north-east Wales mining field, and what is now Flintshire, as do their mainpernors who are largely Welsh.

evidence for their repatriation, it is difficult to see how the Crown could hold them in Devon during the winter months prior to the early years of the 14th century when effective drainage had extended mining operations throughout the year.[102] It is therefore unlikely that the immigrant worker of the late 13th century would remain in Devon long enough to acquire a holding in the area although that was increasingly the case in the 14th century, as the lists of miners and ancillary workers at Appendix 4 suggests. Continued permanence of working at mines like Bere Ferrers would have allowed both local and settled immigrant miners the opportunity for an element of dual occupation.[103] However, as Crown employees, the hours worked suggest that mining was their primary occupation; as indicated by the few mining tasks for which the men were paid wages. For example, in 1308, '*25 miners working on the cleansing of the galleries of the mine, that is Middeldale and Furshill, for five weeks during which they remained the whole time in that work in the months of March and April, receiving for each man per week - 9d.*'[104]

After withdrawing from direct working of the Devon mines links between the Crown and the miners were weakened but not broken altogether as the lessees retained the right to impress miners. When that was exercised in 1360 to work the Combe Martin mines, Derbyshire miners showed a marked reluctance to move to Devon. Then the sheriff of Nottingham and Derby was ordered to detain twelve named miners '*until they shall find security for returning to Devonshire and serving the king in the mines at his wages*', as they '*were set to work and abode some time at the king's wages, and have now left the*

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102 See page 143 above.

103 For example, Smaleyes, originally smelters from Derbyshire in 1306, were tenants of the Duchy at Calstock in 1347 and 1356 (Calstock Community Archive, transcripts of Duchy of Cornwall 472 and PRO, *Augmentation Office* E306/2/1)

104 PRO, *Exchequer Accounts*, E101/261/10, Counter roll, 1-2 Edw. II

works and returned to their own parts, whereby the works remain undone'.[105] Beyond that date we have little evidence for the use of immigrant workers although a few Derbyshire surnames do appear in the surviving account roll for the Bere Ferrers mine in 1480/1.[106] A brief glimpse of one local miner working in the Bere Ferrers mine is afforded by a petition lodged in Chancery in 18 Hen VI (1439/40).[107] In this John Clyff of Milton, employed by the abbot of Buckland, then deputising for the duke of Bedford keeper of the mines from 1427 to 1435, sought redress for an assault by Roger Champernoun, lord of the manor of Bere Ferrers.[108] Clyff's ranking within the mine is unclear but he was in possession of a house at Bere Ferrers and he had access to sufficient land to support a horse and cow which, with his chattels, were taken by Champernoun's men. With only this brief glimpse to guide us it would be foolish to suggest that all miners at Bere Ferrers in the 15th century had opportunity for dual occupation. The numbers employed, at least 114 men working on the mine and smelting complex plus perhaps half as many again providing services in 1480/1, although lower than those in the early 14th century, and at a low point in late medieval population level, were probably still sufficient to put pressure on the available land resources in the area of the mines.[109] Some evidence, albeit tentative, for this has recently come to light in a manuscript list of settlements in the parish of Bere Ferrers which suggests a clustering of larger settlements in the area of the mines.

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105 *Cal. Close R.*, Edw. III, vol. 11, p. 37.

106 PRO, *Exchequer Accounts* E101/266/25, Counter roll, Bere Ferrers, 20-21 Edw. IV.

107 PRO, *Chancery: Early Proceedings* C1/9/404, Petition of John Clyff, temp. Hen VI.

108 This incident may be part of a dispute between Champernoun and the Crown lessees over the mines - see pages 202-3 above. Milton was in the abbot's manor of Buckland on the east bank of the Tavy.

109 Accurate employment figures are not possible as some work on the mine and many of the services were paid for by the task (PRO, *Exchequer Accounts* E101/226/25, Counter roll, Bere Ferrers, 20-21 Edw. IV). Blanchard , *Lead Production and Trade,* Table A1-5, suggests employment levels of from 120 to 140 men at the mines in mid century.

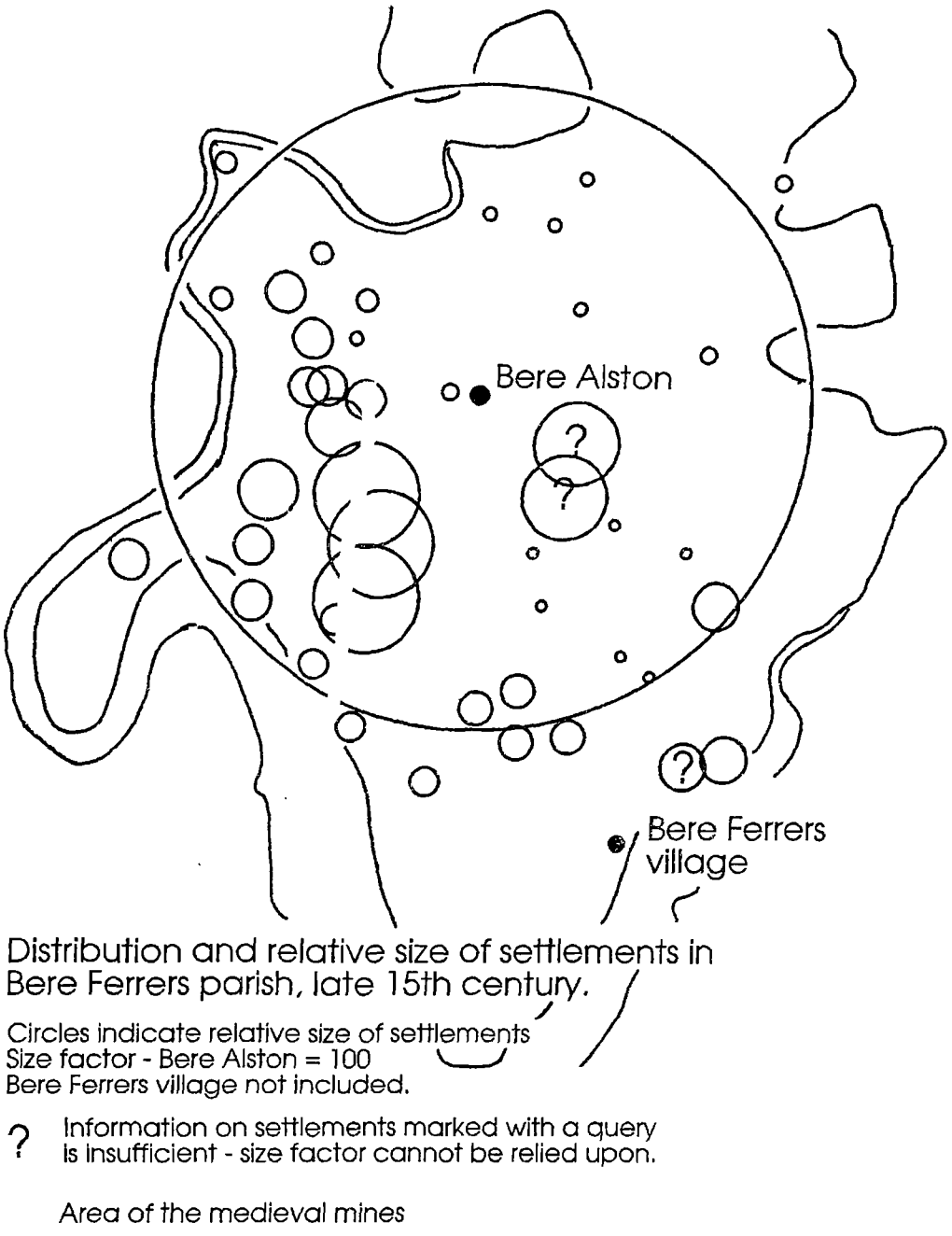

Figure 22 (based on the data tabulated in Appendix 12, Table 7.)

The list, entered on the verso of the last leaf of a 15th century copy of Quinil's guides to parish management and the hearing of confessions, dates from the late 15th century.[110] It appears to list the names of settlements and the order in which the inhabitants would take

[110] Exeter Dean and Chapter MS 3522. Professor Avril Henry, who identified the list, is unable to date it closer than between about 1440 and 1500.

confession, either being visited by a priest in the course of a 14 day itinerary around the parish or by visiting the parish church. This list or itinerary, and its purpose, are possibly unique and are dealt with elsewhere[111] It does however provide us with information on which to identify the distribution, and make a crude calculation as to the relative size, of the settlements in the parish. Calculation of the relative size of the settlements is necessarily crude as the information available is limited to the distance travelled, if it is an itinerary, and the number of settlements receiving confession each day.[112] It should also be born in mind that the village of Bere Ferrers itself and the adjoining manorial demesne are not included in the itinerary. Given these qualifications it is still clearly evident that the bulk of the population at Bere Ferrers, outside the manorial centre, in the late 15th century lived in close proximity to the mines - the majority in the settlement at Bere Alston (Figure 22 above). This suggests an element of permanent urbanisation associated with the working of silver-bearing ores.

Centralised management of the mines, the presence of a fulltime workforce and the limited opportunity for dual occupation after 1292, meant that silver mining never entered a proto-industrial phase. As Burt has shown, the non-argentiferous lead producers continued to develop as a multiplicity of small scale operations taking advantage of the ability of the workforce to switch between mining and farming.[113] They expanded to meet the increasing demand for lead into the 17th century before organisational change was

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111 Henry, 'Silver and Salvation'. Orme ('Confession') argues with some persuasion, based on the traditions of the medieval church, that the list of settlements was not an itinerary but a list of dates on which the inhabitants would attend the parish church at Bere Ferrers. Such an argument narrows the data available for a calculation of relative size but the concentration of settlements around the mines is still evident. The evidence is considered further in Appendix 12 below.

112 Appendix 12, Table 7.

113 Burt, 'Transformation'.

required to access deeper deposits below the water table. However expansion along proto-industrial lines was largely confined to those areas where customary law survived and had been codified. The new argentiferous lead fields opened up after 1500, for example, in mid Wales, and later renewed working of non-agentiferous deposits in areas like north-east Wales and the Northern Pennines, did so on the large, capital intensive, scale initiated in the Devon mines under Crown control and continued under its lessees (below), without recourse to a proto-industrial phase.

Dual occupation was to play a part in the development of the new mining fields in the modern period, buffering the workforce against the fluctuating demands for labour in the mines.[114] It may have played the same role in the Devon mines to 1500, but we currently lack the evidence required to come to firm conclusions.

6. Reduced Crown involvement in silver mining.

With the second half of the 14th century came a return to free enterprise in silver mining. From direct working the Crown moved to a form of lease covering '*All the king's mines*' in '*Devon and elsewhere in England*' this or a similar blanket prescription being common through the next two hundred years.[115]

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[114] See, for example, the Northern Pennines (Hunt, *Northern Pennines*, p. 147) and the deep tin mining region of West Cornwall (Rose, 'Home ownership, subsistence and historical change').

[115] *Cal. Close R.*, Edw. III, vol. 10, p. 98.

In mid century there was a distinct change in the form of the wording used by the Crown in granting rights to work the mines. Whereas in 1349 the Crown did '*grant during pleasure to Richard de Mewy of the keeping of the king's silver mines in the county of Devon, so that he answer at the Exchequer for the issues thereof, receiving such wages as others have received hitherto*', by the mid 1350s a much clearer form of words had appeared with all the elements of a lease in evidence.[116] In 1358 a formal *'Indenture witnessing that the king has committed and leased to John Balauncer and Walter Goldbeter, for two years, all his mines of gold, silver and copper in the county of Devonshire .... '*, providing for a dead rent, 20 marks in the first year, a royalty, one fifth part of the produce, and a pre-emption clause ensuring that all bullion was sent to the mint at the Tower of London. [117]

An earlier grant of 1354, in the form of an indenture confirming the commitment of the mines by the Crown, was to two German '*mynours*' John Hanner and Herman de Reynesthorp of Boem who were expected to render *'to the king the tenth part of their receipts and profit both of gold and silver and of lead and copper, extracted from those mines, which shall be all at their costs without demanding anything of the king, and he will appoint a sufficient man for him to survey the profit arising from those mines and to receive that which pertains to the king.*' So the comptroller was to remain a Crown officer, although usually paid out of the issues of the mines. The lessee retained the authority, vested in their predecessors as keepers under direct working, to *'.... have the judging and cognisance of all their people and serjeants, including aliens, for all manner of pleas touching their serjeants for matters between themselves, without being brought*

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116 *Cal. Fine R.*, vol. 6, p. 177.
117 *Cal. Fine R.*, vol. 7, p. 71

before any court elsewhere for any cause.' They also undertook '*that all the plate and bullion both of gold and silver which they win from the said mines, they will have sent to the Tower of London to be delivered there to the keepers of the king's exchanges to be coined, paying as much for the pound as other merchants will give'.*[118] The success of this venture is not known, there is no record of a comptroller being appointed and no accounts have survived. But the lease set the pattern for the future; royalties varied, doubling to one fifth four years later, and dead rents were sometimes imposed. [119]

By the end of the 14th century leasing on a royalty on production was established as the normal form of grant for the Crown mines in the South-West. The royalty was usually set at 'one ninth,' that is the ninth part of the produce after the payment of tithe (effectively the tenth part of total produce) or the full 'one tenth.' On rare occasions the freeholder, the lord of the soil, was allowed a proportion of produce as compensation for losing the use of the land. The grant to Henry and John Derby in 1397 allowed the freeholder one thirteenth of produce.[120] In the first decade of the 15th century John Derby was evidently advised that he could take just one of the Devon mines on farm but that was later rescinded and he took a further lease on all the mines, for which he was allowed a loan from the Exchequer.[121]

Why did the Crown abandon direct working during a period of strong regal authority ? It is evident that the accessible resources of the most productive mines, at Bere Ferrers in

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118 *Cal. Close R.*, Edw. III, vol. 10, p.98

119 *Cal. Fine R.*, Edw. III, vol. 7, p. 71.

120 *Cal. Pat. R.*, Ric. II, vol. 6, p. 107.

121 *Issues of the Exchequer*, p. 312; quoting Issue Roll, Easter 10 Henry IV. Although not mentioned by name, the mine involved was probably that at Combe Martin; William Charleton, Prior of Pilton, near Barnstaple, being appointed as controller.

Devon, were worked out and the expertise required to rectify that, and / or open up other mines, was perhaps more adversely effected by the Black Death than other sections of the population. There is evidence that some mining areas suffered badly from the effects of the plague. In Derbyshire, in the earl of Kent's manor of Ashford, there was *'a lead mine formerly worth £20 yearly, but now stopped for want of workers'*. That was in 1354; eight years later it had still not recovered its former profitability being then worth 100s. In Bromfield and Yal, North Wales, the mines were moribund for over thirty years.[122] There is also evidence, from the Duchy of Cornwall's manors, that there was a marked shift from mining into agriculture as a direct consequence of the plague and the increased availability of land.[123]

Withdrawal from the direct working of the silver mines in Devon, and leasing the minerals to enterprise interests, mirrored developments in agriculture under pressure from falling population levels. By the turn of the 14th century, with wages at high levels despite falling produce prices, most large landlords were obliged to cease working their demesne and turn to leasing as a source of income.[124] It was not until the early part of the 16th century, well after the advent of stronger central government following on Henry Tudor's victory on Bosworth field and with increased population levels, that the Crown was seen to again tighten its control over silver mining. In 1528, following a survey of mineral resources, Joachim Hochstetter was appointed 'at the king's pleasure' as 'surveyor and master' of all mines, to work them on behalf of the Crown.[125] Hochstetter's

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122 *Cal Inq. Post Mortem*, vol. 8, items 46 and 657; Pratt, 'Minera: Township'.

123 Hatcher, *Rural Economy*, p. 120.

124 Bolton, *Economy*, p. 220.

125 PRO, *State Papers Domestic, Henry VIII*, SP1/236. *Cal. Letters and Papers, Foreign and Domestic, Henry VIII*, vol. 4, pt. 2, 5110; *ibid.*, Addenda, vol. 1, pt. 1, 583. For an outline of Hochstetter's activity, see Claughton, *Combe Martin Mines*, pp. 9-10.

activity evidently met with resistance from the miners on Mendip working lead ores, which were potentially silver bearing, and was short lived. Thereafter the Crown returned to leasing those minerals subject to its prerogative, culminating in the grants in perpetuity to the Society of Mines Royal and the Company of Mineral and Battery Works in 1568.[126]

7. The role of the entrepreneur in silver mining.

The term 'entrepreneur' is generally associated with the technological and financial leadership of the 'Industrial Revolution' of the late 18th / early 19th century, so can it be used with confidence in relation to late medieval enterprise? Unfortunately it is not easily defined, as Payne points out in a 19th century context. There are *'almost as many essays discussing the function of the entrepreneur as detailed case studies of his actual role at different periods of time'*. However Payne backs the view that the entrepreneur *'brought together the capital (his own or somebody else's) and the labour force, selected the most appropriate site for operations, chose the particular technologies of production to be employed, bargained for raw materials and found outlets for the finished product'*.[127]

All of these functions were open to the entrepreneur in the late medieval period although in some branches of mining, as in other medieval industries, he could be restricted in his options by custom and practice. Spatial restraints placed on workings in those mining fields governed by custom inhibited investment in increasing scales of production. The vast majority of metalliferous ore production came from small units worked by individual

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126 See Pettus, *Fodinae Regales,* pp. 54-58, for transcript of the grants.

127 Payne, *Entrepreneurship*, p. 13-14, in the latter case quoting Flinn, *Origins of the Industrial Revolution*, p. 79.

or small partnerships of miners. Even in the late 16th century there was resistance in the Mendip lead field to the concept of joint drainage.[128] Practice in most customary mining fields restricted the miner to working within set boundaries, either a fixed length along a specified lead vein or an area of alluvial tin defined by bounds set at surface by the tinner. A miner discovering a new lead vein might be allowed an extra length but any further lateral extension would bring him into conflict with his fellows who had taken adjoining sections of the vein. On the other hand investment in drainage to work a rich vein below the water table would also invariably benefit adjoining workings. With such restricted practices the role of the entrepreneur was limited but there was scope for investment in the financing of small scale metalliferous working.

The best evidence for such investment finance comes from the Stannaries of Devon and Cornwall where it was a significant feature of alluvial tin working from the 13th century onwards.[129] Finance came, initially, in the form of loans to provide working capital to individuals or partnerships of tinners secured against future production. In time outside investors accounted for a significant proportion of production through share holding or the outright control of tin works and associated smelting works. Increasing numbers of tinners were employed on wages but tin working still remained open to the independent operator.

By comparison silver mining was, from the late 13th century, based on the exploitation of deep seated ore deposits. Under the direct control of the Crown it had developed as a centrally managed operation using wage and contract labour, divorced from the custom

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[128] Gough, *Mendip*, pp. 127-8 - quoting *Acts of the Privy Council*, NS, vol. 14, p.355 et seq.

[129] Hatcher, *Tin Production and Trade*. See also page 62 above.

which governed earlier production in the Northern Pennines. The move to leasing by the Crown opened up silver mining for the entrepreneur, making it totally reliant on enterprise finance for its future operation.

8. Enterprise in silver mining after 1350.

Between 1350 and 1500 the English Crown entered into nearly 50 leases in respect of silver mining. The first of these, in the 1350s, have been discussed above.[130] However, there is no evidence for those leases resulting in silver production before the tenure of Henry de Brislee, lessee of the Devon mines from 1359.[131] Brislee was a Crown servant and, as Master of the London Mint from 1356, he would have been familiar with the potential of the mines. During his tenure of the mines Brislee had two partners, of whom we know very little. He did however testify that the first, Richard Colle, had *'not intermeddled with the mines'* and might be described as a sleeping partner, providing only financial support. Brislee himself was evidently closely involved in the operation of the mines and relinquished the tenancy for a period when appointed to oversee the mint in Calais, because he could 'in no wise be attendant about the mines'.[132]

The status of subsequent lessees of the Devon mines varied but came largely from amongst the ranks of those associated with the royal household: no longer receiving wages, as they had before 1350, but speculating on the profits of mining. Even as late as 1427-35 the mines were in the hands of the Duke of Bedford, an absentee lessee who

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130 Page 243 above.
131 *Cal. Pat. R.*, Edw. III, vol. 11, p. 371.
132 *Cal. Pat. R.*, Edw. III, vol. 12, p. 313.

assigned control of operations at Bere Ferrers to the Abbot of Buckland.[133] Little evidence survives to indicate the level of success. However, at the turn of the 14th century Henry and John Derby, described as 'miners', evidently had some success, probably at Combe Martin, which encouraged them to renew their lease in 1406.[134] Similarly, there is little evidence to indicate the level and source of finance for mining, although some might be drawn from the securities provided by lessees not associated with the royal household. In 1385 guarantors from Devon gave mainprise for Nicholas Wake, clerk, and in 1418 for Robert Hethe and William Eggecombe, suggesting local support, whereas it was London men, including at least one with mercantile connections, who stood security for Hethe and Medelond in respect of Bere Ferrers, and Boweland and Rede, 'dutchman', for the Combe Martin mines, in 1423.[135]

The search for profit in mining silver-bearing ores was not confined to the South-West of England, even prior to 1350 individuals were granted the right to search for and work silver mines in the north. The mines of Harcla, in Westmoreland, along with Silverbeck and Minerdale, in Cumberland, investigated in 1331 were the product of a prolonged search initiated by the Crown twelve or thirteen years earlier '*on learning that there was a mine of copper and silver at Caldebek, co. Cumberland, and elsewhere in the parts adjacent in Cumberland and Westmoreland*'[136] The terms of the grant indicate that Silverbeck and Minerdale were probably in Caldbeck, not that part of Cumberland which lay in the Northern Pennines, i.e. the manor of Alston, as the rights of the Crown to the

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133 PRO, *Chancery: Early Proceedings*, C1/9/404, Petition of John Clyff, temp Hen. VI. *Cal. Pat. R.*, Hen. VI, vol. 1, p. 393; *ibid.*, vol.2, p. 289.

134 *Cal. Pat. R.*, Ric. II, vol. 6, p. 107; *ibid.*, Hen. IV, vol. 3, p. 124.

135 *Cal. Pat. R.*, Ric. II, vol. 2, p. 572. *Cal. Fine R.*, vol. 14, p. 265; *ibid.*, vol. 15, p. 40 and 48.

136 *Cal. Fine R.*, vol. 2, p. 389-90. *Cal. Pat. R.*, Edw. II, vol. 3, p. 273.

minerals was based on prerogative rather than lordship.[137] Whereas, in the 1330s as earlier, the right to work lead and silver within Alston was in the hands of the miners

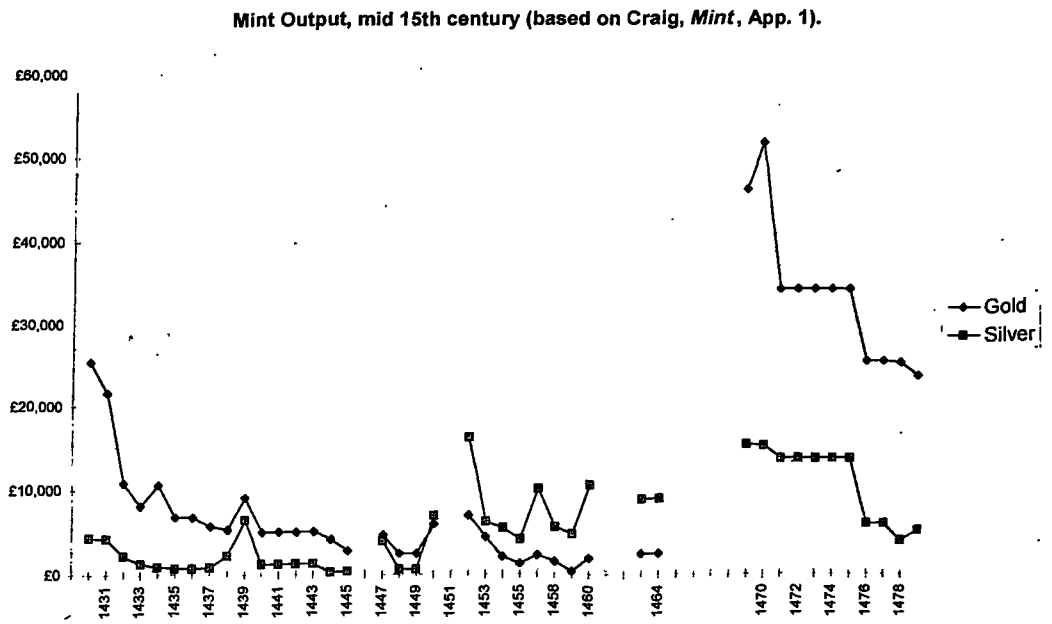

Figure 23 (based on data in Craig, *Mint*, App. 1.[138])

there, being farmed to Tilmann de Colonia in 1359 with the consent of the miners and the Crown.[139] Mines at Alston and elsewhere in Tynedale were revisited in the 15th century, for which see page 188 above, but there is nothing to suggest that these northern ventures were successful.

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137 *Fine R.*, Vol. 4, p. 280. Harcla is Hartley, immediately south-east of Kirby Stephen, where there is field evidence for early lead smelting. (Smith, The Place-names of Westmorland, pt. 2, p. 2. Dunham, *Stainmore to Craven,* p. 115.)

138 Prior to 1465 output was at £16 13s. 4d. to the Tower pound (12 ozs) for gold and 360d. to the pound for silver; 1465 onwards, it was at £22 10s. to the pound for gold and 450d. to the pound for silver. Mint output for 1465-66, inflated with the recoinage, is omitted for clarity.

139 *Cal. Pat. R.*, Edw. III, vol. 11, p. 183.

Mercantile interests are again in evidence in 1446 when William, earl of Suffolk, in partnership with men from Southampton and London, took a sub lease of the mines in Devon and Cornwall from the lessee at the time, Richard Curson, esquire of the body, at £100 per annum.[140] The attraction of the mines, and their perceived value, was increased by the scarcity of bullion, both gold and silver, in the European economy. As output from the central European, Sardinian and Balkan mines fell, mints across the continent were closing due to a lack of silver or turning to the production of 'black', copper rich, coin. Of the northern European mints, only London remained open but even there output had fallen to the low levels shown in Fig. 23 above.[141]

9. Responses to the 15th Century bullion crisis

With the fall from favour of Suffolk, and his subsequent murder, silver mining became briefly enmeshed in the web of intrigue which preceded a period of civil conflict in England, the Wars of the Roses. Shortly after the death of Suffolk the king made a grant, dated 29 July 1451, of the mines in Devon and Cornwall to Adrian Sprynker, described as 'clerk, born in Duchelande', i.e. Germany. The grant recited the details of a scheme whereby the royalties to the Crown would be increased and the mines at Bere Ferrers returned to full operations by subdividing the workings. There may have been factional interests within the nobility behind Sprynker's appointment and he was only in post for a

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140 *Cal. Close R.*, Hen. VI, vol. 4, p. 398; *Cal. Close R.*, Hen. VI, vol. 5, pp. 293 and 323.

141 Spufford, *Money*, pp. 357-9. See also Day, 'Great bullion famine'.

few years, being replaced by Bottright in June 1453.[142] His mining skills were, however, later utilised by Humphrey Stafford, 1st earl of Buckingham, in the Welsh Marches.[143]

During his tenure Sprynker entered into agreements, confirmed by letters patent, with five individuals and partnerships allowing them to work sections of the Bere Ferrers mines for a period of twelve years (see Fig. 24 below), retaining one section to be worked on behalf of the Crown. This radical change in leasing policy, moving from grants based on entire counties to short sections of the lode, in some cases less than a kilometre in length, had the advantage of increasing capital investment in the search for new deeper deposits. Again mercantile interests are in evidence, particularly continental interests: Falron and Nicholo from Venice, Deloreto from Genoa, and Ram from Utrecht.[144] Falron surrendered his lease after only a few years, having spent over £250 on drainage without profit.[145]

The other lessees had moderate success, although subdivision of the mines was not continued beyond the term of the leases. Despite an earlier petition of Parliament that silver mining be opened up to all comers, the system of leasing reverted to a county basis.[146] Whilst subdivided, the remaining mines in Devon and Cornwall, including the shafts retained by the Crown, were farmed out to members of the household at £110 per annum.[147] The problems of drainage at Bere Ferrers were address by Sir John Fogge,

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142 *Cal. Pat. R.*, Henry VI, vol. 6, pp 110-111.

143 Williams, *History of Wales*, vol. 3, p. 74. See Lander, *Government and Community*, pp. 175-222, for details of the factional interests amongst the nobility which preceded the Wars of the Roses

144 *Cal. Pat. R.*, Henry VI, vol. 5, pp. 467 - 8, 569, 571; op. cit., vol. 6, pp. 47, 110, 142.

145 PRO, *Exchequer Accounts* E101/265/18, Particulars of the account of James Falleron, 30-36 Hen. VI

146 *Rotuli Parliamentorum*, vol. 5, p. 272.

147 *Cal. Pat. R.*, Henry VI, vol. 6, pp. 158, 291; *Cal. Pat. R.*, Edw. IV, p. 19.

Bere Ferrers; sections of the mines farmed out in 1451 - 53

(*Cal. Pat. R.*, Hen.VI, vol. 5, pp. 467-8, 569, 571; op. cit., vol. 6, pp. 47, 110 and 142)

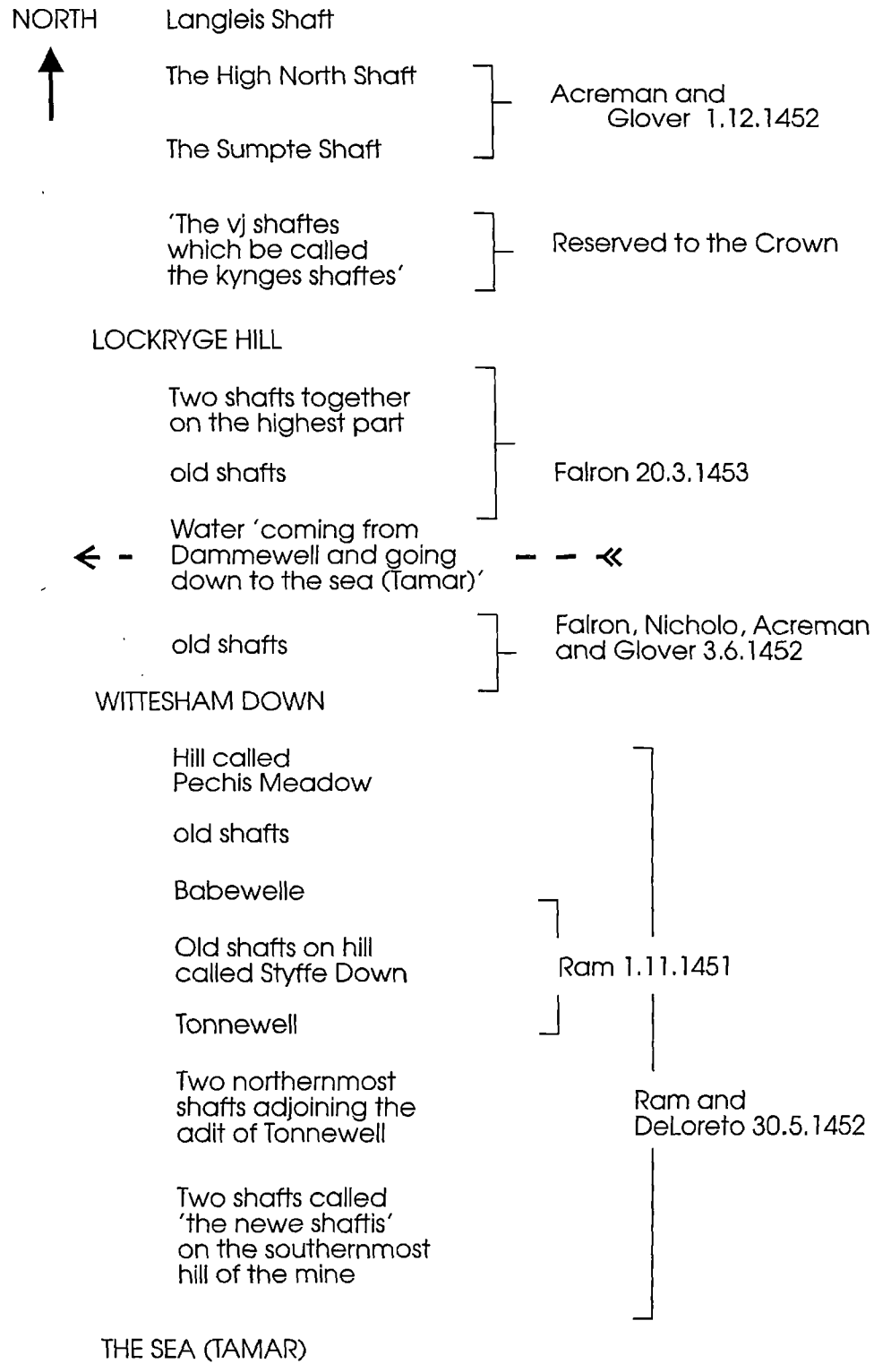

Figure 24 (based on *Cal. Pat. R.*, Hen. VI, vol. 5, pp. 467-8, 569, 571; *ibid.*, vol. 6, pp. 47, 110 and 142.)

treasurer to the royal household, during his tenure as lessee in the 1470s. Success was, however, limited and respite from the bullion famine came not from home production but from revived continental production.[148]

No outstanding example of entrepreneurship emerges from the record of English silver mining prior to 1500. Skilled miners were in evidence amongst Crown lessees but made no significant technological breakthrough which might have boosted production. The increased prominence of mercantile interests reflected the scarcity of silver, and consequent damage to trade, in the mid 15th century. One member of the royal household, John Fogge, showed real promise, employing innovative technology and forward thinking, but came too late to counter the high drainage costs of the 1450s. That he and early lessees failed to realise the full potential of the Devon mines was due largely to the pattern of mineralisation, the limited technology and high cost of labour at the nadir of demographic decline.

10. Conclusions

During the period under consideration the responsibility for the organisation of silver mining in England and Wales shifted from lord of the soil to the state. Whilst we cannot be certain as to the position at the Conquest, the remote upland frontier environment in which the silver-bearing ores of the 12th and earlier centuries were found made a virtue of self regulation. Custom prevailed in Tynedale at least, with the mineral lord taking a

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[148] For an account of technological developments in drainage see Chapter 4, Section 4.2. Also see page 32 above, outlining the effect of renewed mining on the continent.

portion of the produce as profit and restricting its interest to the refining process; that the income thus generated was farmed out to others emphasises how far the mines were from centres of royal administration. Our view of the other silver producing lordship in the Northern Pennines is clouded by poor documentation but there is the suggestion that a similar arrangement prevailed in the bishopric of Durham although the custom did not survive. Closer to its administrative centre, Mendip silver production was subject to greater seigneurial control without impeding the survival of custom.

Throughout this earlier part of our period silver mining was an artisanal activity largely under the control of the producers. Some silver production, at a low level, will have continued under that organisational framework beyond the end of the 12th century. The working of new deposits was, however, to be organised at a quite different level.

In taking the ownership of silver-bearing ores into its own hands in the 13th century, whilst respecting existing grants, and directly working the Devon mines the English Crown was following a trend established in estate management influenced by the inflation of the preceding century. The new centre of silver production lay in areas with established lowland agricultural communities and associated infrastructure, benefiting from well used routes of communication by land and sea. Labour was in surplus and control over mining could be exercised through regular contact between officers and the Exchequer with the fully benefit of profits accruing to the Crown. The manner in which the Crown organised the Devon mines was unique. It did, however, satisfy the capital demands of deep mining, particularly in drainage, and gave rise to a management structure which was outside the capacity of the independent miners or mining partnerships which characterised the customary mining fields prior to the early 17th century. The Crown introduced centralised

management, used wage and contract labour, and employed capital to good effect in deep working. Although the state then maintained a element of control up to and beyond 1500, its withdrawal from direct control allowed for the involvement of the entrepreneur and, eventually, the introduction of mercantile capital.

In effecting a transition from self regulation to centralised management in the organisation of silver mining the English Crown enabled the capital intensive working of deep seated deposits. The mode in which mining was returned to the private sector ensured the involvement of early capitalists and opened up that sector of non-ferrous mining for the entrepreneurs of the early modern period. When technological innovation came in the late 15th century it was not 'revolutionary' but the culmination of gradual change. No new sources of finance or forms of organisation attended its introduction, the roots for change had been instituted by the Crown nearly two hundred years earlier when silver mining was divorced from self regulation.

Conclusions

The supply of silver was one of the most important factors in the late medieval economy, and during the latter part of the 12th century silver mined in the Northern Pennines, from the Crown demesne and that of the bishop of Durham, probably made a significant contribution to the amount of coin circulating in the English and Scottish economies. Production between 1130 and 1200 is estimated here, using secondary statistical evidence, to have been in excess of 2.5 million ounces worth over £222,000. The contribution of other mines, particularly those in north-east Wales, to the English, and Welsh, economy has yet to be quantified but was probably small in comparison.

Northern Pennines production probably made silver the most valuable sector of the mining industry up to the end of the 12th century; exceeding by a factor of at least 40 the value of English tin production during the same period. From the outset these mines were recorded as 'silver' mines - *Mineirie Argi* - and the available statistical evidence suggests that silver was the primary objective and lead a by-product.[1] However, any conclusions made as to the level of silver production in the 12th century, and earlier, must be tentative given the sparse nature of the evidence. The indications are, however, that during the 12th century English silver production, from the Northern Pennines, reach peaks which were not emulated in other fields until at least the 16th century.[2]

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1 *Magnus Rotulus Scaccarii de anno 31 Henrici I*, p. 142.

2 The profits given for the mines at Combe Martin, north Devon, in 1587-91 suggest a production peak of at least 50,000 ozs (Atkinson, *Discoverie and Historie*, p. 53) and the Cardiganshire mines in the 1620s returned from 34,000 to 52,000 ozs per annum (Boon, *Cardiganshire Silver*, pp. 9-11).

Northern Pennine production was probably of sufficient magnitude to account for the major part of the increase in money supply noted by Allen and others for the 12th century.[3] Determining the inflationary consequences of an increase in money supply must be addressed elsewhere but a credible estimate has been provided on which that debate can be anchored. Whether inflation resulted from the mobilisation of hoarded silver, as suggested by Latimer, or an increase in bullion entering the economy through increased exports, as suggested by Harvey, it appears to have been underpinned by Northern Pennine production prior to 1200.

The contribution of Northern Pennine silver also calls into question assumptions, based on increased English money supply, about the growth of exports, particularly wool and cloth. In the late 12th century the growth in the volume of the English currency, an estimated minimum of £170,000 between 1158 and 1210, can largely be accounted for in the estimated production from the Northern Pennine mines. Thereafter, however, with no significant home sources of silver until the end of the century, growth in the volume of currency would be the result of silver being drawn into the economy by increased exports; suggesting that the significant rise in exports should be assigned to the 13th rather than the latter part of the 12th century.

Once the shallow rich deposits exploited in the Northern Pennines were depleted, the output of silver from the mines in Devon, opened up by the Crown in the late 13th century, did not have the same impact. Production from the mines, centred on Bere Ferrers, reached a peak of 21,783 ozs in 1297, maintained at slightly lower levels over

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[3] Allen, 'English currency'. Latimer, 'English Inflation', in which he refers to a forthcoming paper on 'The Quantity of Money in England, 1180-1247: A Model', to be published in the Journal of European Economic History.

three years. A further peak of 20,177 ozs was achieved in 1306 once the problems of neglect and poor provision for drainage, associated with the brief tenure of the Frescobaldi, had been overcome. Thereafter, production fell back as the silver-bearing deposits were worked deeper. The amount of coin in circulation had, however, risen substantially since the end of the 12th century, fed with silver from continental sources, and at their peak between 1295 and circa 1310 the mines contributed less than one percent to circulation. Only in the mid 15th century at the height of the bullion crisis did the mines attain significance, albeit at low output levels, in maintaining production when supplies from the continent had dropped to negligible levels. Silver nevertheless remained the primary objective of production, with its value far exceeding that of the by-product lead.[4]

We know from the archaeological and early historical evidence that large scale mining and smelting techniques were available prior to the medieval period. However, we have little information on those employed in England and Wales prior to the end of the 13th century. What we have suggests that silver mining in the early part of our period was technologically undemanding, exploiting shallow lead deposits carrying very high levels of silver, and carried out by miners working independently and organised according to custom using a system of self regulation. In Tynedale, a remote upland lordship in the Northern Pennines, the Crown took its royalty for the workings known collectively as the 'mine of Carlisle' as a portion of the ore mined but had no direct involvement in mining. Instead it elected to farm out its interest in the produce. Unfortunately, lack of evidence does not allow us to come to come to any firm conclusions regarding the organisation of mining on the Bishop of Durham's estates. In the 'mine of Carlisle', if not the mines in

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4 See Figure 15 above for a clear illustration of the relative values.

Durham, as in the Stannaries of Devon and Cornwall throughout the latter part of the period, high output levels were achieved under an organisational structure that was de-centralised and based on the small unit of production but, like the Stannaries, the silver mines of the Northern Pennines were exploiting a shallow rich resource.

Like other branches of mining, the organisation of silver mining was to some extent conditioned by the nature of the ore deposits.[5] Prior to the 13th century the small unit of production was adequate for easily accessible rich deposits and a system of self regulation was well suited to a remote frontier environment. The ore deposits were, however, shallow; the vestiges of the oxidised zone, with an enhanced silver content, exposed by glaciation. When the Devon mines were opened up in the late 13th century they exploited extensive concealed deposits, with the full range of supergene enrichment, unaffected by glaciation. Techniques and technology were adapted and supplemented to answer the demands of deep mining and a requirement to extract the full value from the ore raised. Smelting in particular was quickly adapted to the new circumstances. The smelters showed themselves capable of developing the existing techniques and supplementing the windblown 'bole' hearth to the best advantage in processing all the ore mined, and re-processing the residues to gain the maximum silver values. They experimented with new furnace techniques including a liquation process in the 'hutt' and, with some continental assistance, also treated small quantities of silver-bearing copper ores. Although the techniques perfected in the 1290s worked well through the 14th century a new process in the 'fynyngmyll' had been adopted by 1480, advancing smelting along the same levels as contemporary practice on the continent.

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[5] Schmitz, 'Big Business and Copper', identifies the requirement for increasing scales of organisation and techniques in working larger, lower grade, copper deposits.

Capital was applied to good effect using existing techniques, as with adit drainage. The forward thinking of Crown officers like Thomas de Swaneseye, keeper of the Devon mines in the early 14th century, allowed for the recovery of production levels through expenditure on maintainence and new drainage adits. Such 'deadwork' carried out as a planned programme of capital expenditure marked out the English silver mines as a unique enterprise in medieval European mining, using state funding and centralised management to maximise production. This was an early example of the capital intensive mining industry, which was carried forward beyond 1350 and the end of direct Crown involvement in mining. The capital intensive nature of silver mining techniques was again in evidence in the 15th century with the introduction of mechanised pumping at Bere Ferrers.

With a dramatic fall in population during the second half of the 14th and through the 15th centuries reliance on manual labour was reduced. Water power was first applied to smelting and refining. The planning involved in building the leat and the use of water-powered suction lift pumps at Bere Ferrers in the 1470s was a significant event, not only as a response to the high cost and scarcity of labour, but as an example of the rapid diffusion of mining technology across Europe. Continued contact with other mining fields, and the continental entrepreneurs amongst the Crown's lessees after 1350, suggests possible routes for the transfer of such techniques.

Some marginal production may have continued in the old silver mining fields like Tynedale but, from the late 13th century, the major silver producers were divorced from self regulation and centrally organised, and there was no opportunity for the development of a proto-industrial phase. The techniques employed were those appropriate to the

development of the deep resources in Devon. Whilst the occasional presence of central European miners and the diffusion of pumping technology suggests that English silver mining was not working in isolation from that on the continent, the industry was capable of deploying 'home grown' expertise in areas like drainage and the smelting of lead-based ores. By the close of the period English silver miners and smelters was as capable as any on the European continent.

The silver mining sector was technically competent and was organised in a manner which allowed it to deploy the techniques required to work a restricted resource, displaying the characteristics of ''bigness'' noted by Cipolla for continental mining in the 16th century and earlier; with its reliance on wage labour, capital investment in drainage and ultimately its mechanisation. Although this runs counter to Burt's conclusions for small scale non-argentiferous lead mining in the 16th century and later, it reinforces his underlying argument that English mining was not necessarily inferior to that on the continent.[6] As it entered the early modern period, the mining of silver-bearing ores did so within an organisational framework which allowed it to deploy the resources and technology to exploit new discoveries in mid Wales, and elsewhere, as it had in Devon prior to 1500.

The English Crown invoked a clear prerogative over silver-bearing ores from the mid 13th century, not challenged until the second half of the 16th century, and subsequently became directly involved in the working of the Devon mines although there is no evidence to suggest that this was done with a view to facilitating deep working. Rather, it was probably rooted in estate management influenced by the inflationary economy of the 13th century. The early use of tinners in large numbers for the construction of avidods, or

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6 Burt, 'International diffusion'; Burt, 'Transformation'.

adits, does, however, suggest that the Crown was quickly aware of the need for drainage on a large scale. But deep working of silver-bearing deposits required hard rock mining skills not possessed by the tinners. Nevertheless, the organisational structure introduced by the Crown and its ability to marshal resources, human and financial, not accessible to individuals or small partnerships of working miners, was effective in opening up the deeper deposits at Bere Ferrers in the first half of the 14th century. It allowed for capital expenditure in securing and draining the older workings with a view to accessing new deposits, benefits particularly apparent in the subsequent rise in production after 1304. Its continued use was conditioned by the nature of the deep seated deposits and the ability to employ mining and smelting techniques effective across all the workings was maintained beyond the period of direct working when, after 1350, the mines were leased as a whole. A move to split up the workings at Bere Ferrers in the middle of the 15th century was attended by high manual drainage costs and only after the mines were again brought under one lessee was innovative mechanised pumping introduced.

The direct involvement by the Crown and, after 1350, its lessees in silver mining reduced the opportunity for dual occupation amongst miners. Self regulation was confined to the extractive process and most workers were employed full time. The workers were granted privileges but they were renewable and remained in the gift of the Crown. Initially at least the majority of miners were immigrants to Devon with little evident opportunity to acquire land holdings around the mines. Some did settle in the Bere Ferrers area and local men were increasingly employed in mining. What little evidence is available does however suggest that, by the 15th century, population was concentrated around the mines, dominated by the settlement at Bere Alston.

Between 1066 and 1500 silver mining in England and Wales effected a transition from an industry where miners, working on their own account and regulated by custom, exploited shallow sometimes extremely rich deposits, to one in which all workers were subject to central management calling on capital intense techniques to mine and process ores found in deep deposits. Unwittingly perhaps, the catalyst for change was the English Crown. In moving from its position as mineral lord, content to farm out its interest in the ores found on its demesne, to exercise a prerogative on all silver-bearing ores. and subsequently working those ores found in Devon, the Crown established an industry capable of engaging in deep mining.