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Methodologies of extraction: The mining techniques in the Early Neolithic flint mines of Southern England and their continental origins

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Abstract

Recent research on the chronology of the Early Neolithic (4000-3500 BC) in Southern England has shown that flint mines are amongst the earliest monuments to appear in the landscape. This paper will outline the findings from research into extraction methodologies at the mines of Southern England. It is proposed that these methods are also observable in the flint mines of Northwest Europe. It is also argued that at present there is no evidence of a chronological development from proto-mines to deep flint mines in Southern England. To support this hypothesis the unpublished excavation of the only known Neolithic drift mines in Southern England, on Harrow Hill, West Sussex, will be investigated. Finally, a review of the radiocarbon dates of Southern English flint mines is undertaken, which places these significant monuments into a chronological model and further demonstrates a link to their continental counterparts.

Keywords: Extraction, methodology, Neolithic, chronology, drift mines, Southern England, deep mines.

Résumé

Les recherches récentes sur la chronologie du Néolithique ancien (4000-3500 BC) du sud de l'Angleterre ont montré que les mines de silex figurent parmi les plus anciens monuments apparaissant dans le paysage. Cet article entend donner un aperçu du résultat des recherches menées sur les modes d'extraction mis en œuvre dans les minières du sud de l'Angleterre. Nous faisons la proposition que ces méthodes sont aussi présentes dans les mines de silex du nord-ouest de l'Europe. D'autre part, à l'heure actuelle, aucun indice ne permet d'envisager une évolution chronologique depuis les proto-mines vers les mines profondes en Angleterre du Sud. La fouille non encore publiée de la seule mine néolithique par fonçage horizontal d'Angleterre du Sud, à Harrow Hill dans le Sussex, sera examinée en appui à cette hypothèse. Enfin, un bilan des dates radiocarbone des mines d'Angleterre du Sud est proposé, pour placer ces monuments au sein d'un modèle chronologique et achever de démontrer le lien qui les unit à leurs homologues continentaux.

***Mots-clés** : extraction, méthodologie, Néolithique, chronologie, mine par fonçage horizontal, Angleterre du Sud, mines profondes.*

1. INTRODUCTION

In a 2014 article (BACZKOWSKI, 2014) I proposed that the Early Neolithic flint mines of Southern England show clear connections with continental mines. This was based on the observation that a shared extraction methodology can be identified at deep mine complexes across Northwest Europe. It was further suggested that the early dates for the beginning of shaft and gallery flint mining in Southern England, around the 40th century BC, are so close to those of the Northwest European sites that there could be no time for a methodology to have developed coaxially and independently on either side of the Channel.

A central point of the original hypotheses is that there is no evidence of a chronological development at the Southern English mines from simple extraction techniques, such as quarrying, to the more advanced method of deep mining. The purpose of the paper is not to repeat the findings of the 2014 article in full, but rather advances this hypothesis with a case study of one of the most recent excavations of a flint mine in Sussex, where simple drift mines were discovered. The paper will conclude with a brief reconsideration

of the chronology of deep extraction in the region. It will be hypothesised that, at present, there is no evidence for earlier, basic forms of extraction at the Sussex sites, further supporting its introduction from the Continent.

2. SOUTHERN ENGLISH MINES

In Southern England there are currently nine confirmed Early Neolithic flint mines (BARBER *et al.,* 1999), broken into three groups by their geographical location. The Worthing Group, West Sussex, comprising of mines at Blackpatch, Church Hill, Cissbury Hill and Harrow Hill, the Chichester Group, West Sussex, with mines at Long Down and Stoke Down, and finally the Wessex Group, with mines at Martin's Clump, Hampshire, and Easton Down (Fig. 1). The objective at all the Southern English mines was to win flint for the manufacture of bifacially flaked axes, which were often polished and distributed across the region (SIEVEKING *et al.*, 1972; GARDINER, 1990).

The Southern mines can be further divided by the observation that subtly different mining methods were employed at each group. For example, the Worthing Group mines are most associated with deep and wide shafts, such as those recorded at Cissbury that measured up to 20 m in diameter and 12 m in depth, and connected to a complex basal system of galleries (BARBER *et al.,* 1999; RUSSELL, 2001). In contrast, the Chichester Group and Wessex Group mines appear to have been based on a subtly different method of extraction, using shallow shafts with short galleries, or adits, as found at Easton Down (STONE, 1935) and Stoke Down (RIDE & JAMES, 1989).

Caution must be expressed in categorising the extraction methodology by location, as the Chichester and Wessex mines have not been excavated to the same degree as the Sussex mines and there is subsequently less information on the form of the subterranean workings. Nonetheless, the small amount of excavation at the Chichester and Wessex mines (see BARBER *et al.,* 1999), together with surveys of the surface remains (BARBER *et al.,* 1999; BARBER, 2014), indicates that large deep shafts with long galleries are likely to be more typical of the Worthing Group mines.

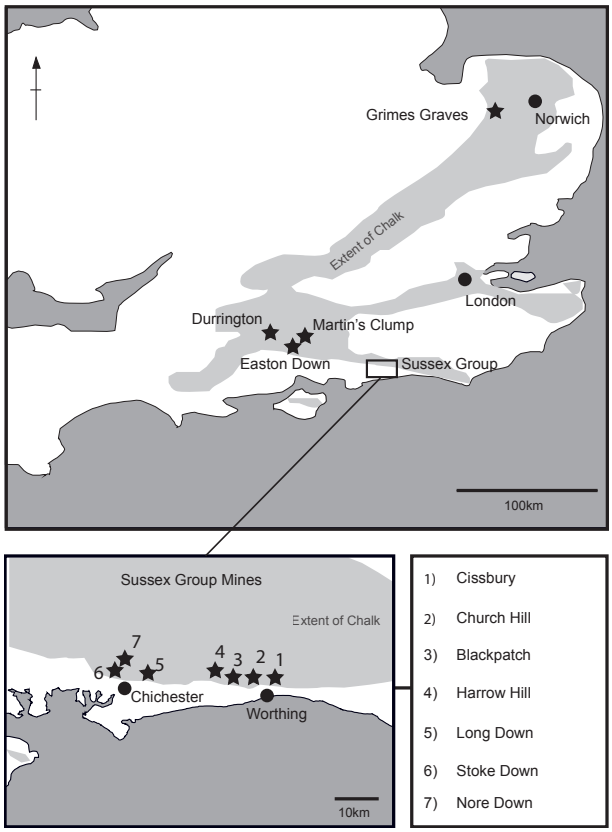


Fig. 1 – Distribution of English flint mines. Drawing: J. Baczkowski.

2.1. The dating of Southern English mines

The majority of the radiocarbon dates for the Southern English mines are obtained from red deer (*Cervus elaphus*) antler, fashioned into picks and implements for use in mining, and excavated directly from within mine workings (BARBER *et al.*, 1999). They represent short-lived radiocarbon samples from secure contexts. However, they only date individual mining events, which combined with their paucity, makes forming a precise chronology of mining in Southern England difficult.

Overall, the dates obtained from the nine Southern English mines indicate extraction activity begun shortly before 4000 BC, and ceased around 3500 BC (Fig. 2). The only other major flint mine complex in the southern half of England is located at Grimes Graves, Norfolk, and is dated to the Late Neolithic (3000-2500 BC) and Early Bronze Age (2500-1500 BC) periods

(HEALY *et al.*, 2014). The Southern English mines are therefore confined to the chalk downland and are a distinctly Early Neolithic phenomenon.

3. THE ARRIVAL OF THE EARLY NEOLITHIC AND MINING

In Sussex, as across the rest of the British Isles, the start of Neolithic has long been denoted by the arrival of new cultural material and practices from the Continent, such as Carinated Bowl pottery, polished axes and flint mining (WHITTLE *et al.*, 2011; SHERIDAN, 2010, 2011; THOMAS, 2004, 2007, 2008, 2013). From around the turn of the 40th century BC these changes announce a shift in lifestyles from 'hunting and gathering' to one based on newly adopted agricultural practices, including cereal cultivation and the husbandry of domesticated animals (ROWLEY-CONWY, 2004; COLLARD *et al.,* 2009; SCHULTING, 2013).

The early significance of the Sussex flint mines in this sequence has recently been highlighted by a radiocarbon dating program conducted on the Neolithic causewayed enclosures of Southern Britain (WHITTLE *et al.*, 2011), demonstrating that construction of these monuments began in the late 38th century BC. This means that causewayed enclosures can no longer be associated with the earliest phase of the Neolithic (4000-3800 BC), whereas flint mines are dated to the centuries before the turn of the 4th millennium BC (4100-4000 BC). Therefore, mines can no longer be thought of as peripheral to traditional Early Neolithic monuments, such as causewayed enclosures and long barrows, an interpretation that has long been advanced (BRADLEY & EDMONDS, 1993; EDMONDS, 1995; DREWETT, 2003).

At present, in Southern England only two other monuments are contemporary with the Sussex flint mines, the Coldrum mortuary monument (HEALY, 2008; WYSOCKI *et al.,* 2013) and the White Horse Stone longhouse (ASHBEE, 1993, 1998; HAYDEN, 2007), both in Kent, and both showing a continental influence (WHITTLE *et al.,* 2011, p. 257-262). Hence, the Southern mines are isolated monuments in the Early Neolithic landscape of Southern England that can

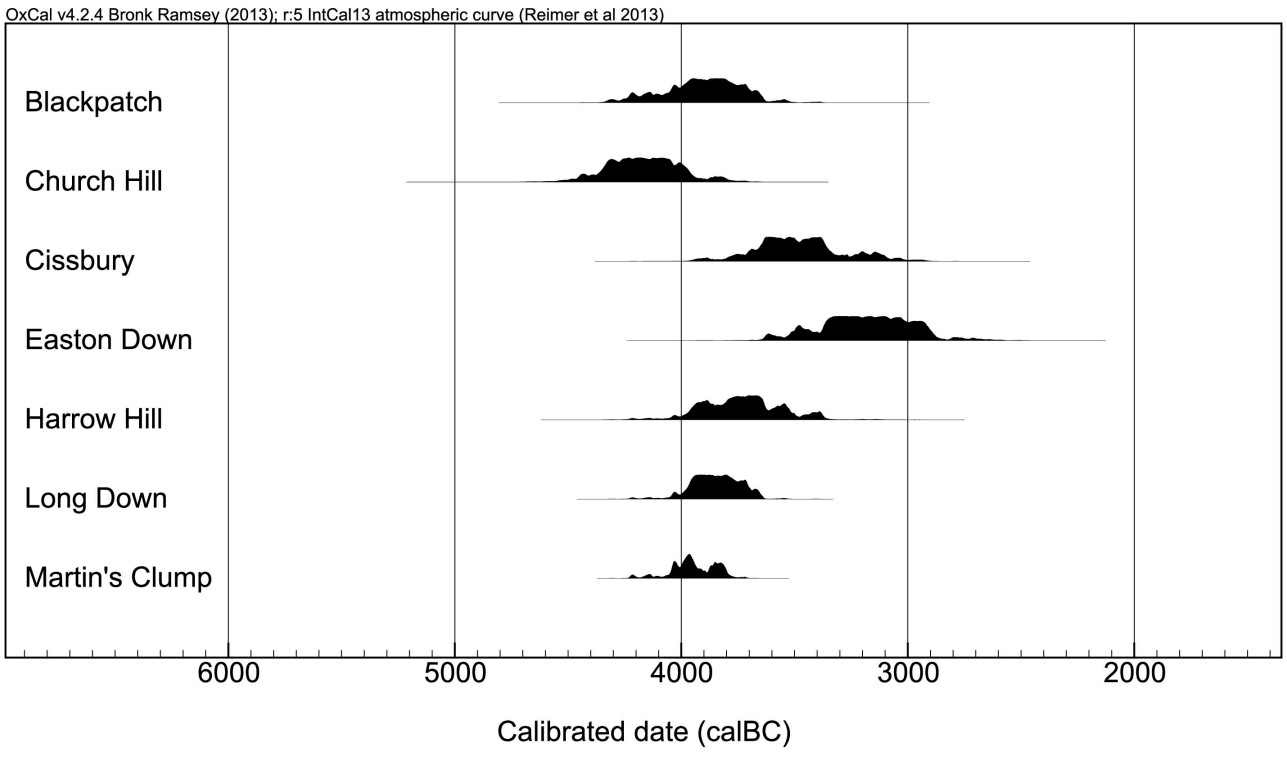


Fig. 2 – Dating of Southern English Early Neolithic flint mines.

now be considered as central to the arrival and spread of cultural practices, rather than existing on the margins of society.

As flint mines are core to the 'Neolithic Package' introduced to Southern England, it must be possible to observe a clear connection to their continental contemporaries. It is this hypothesis, a continental origin for the Southern English flint mines, which will now be discussed.

4. A COMMON METHODOLOGY?

That the Southern English flint mines share an affinity with those in Northwest Europe, particularly in France and Belgium has long been noted, since the early excavations led by 19th century antiquarians, including A. Lane Fox (later Pitt-Rivers), who noted the similarities between the Cissbury mines and those at Spiennes (LANE FOX, 1876).

It is now widely recognised that Southern English flint mining originated in the Northwestern European mine complexes, where a long tradition of deep extraction was practiced (CUNLIFFE, 2008; WHEELER, 2008, 2011; WHITTLE *et al.,* 2011), although little research has been carried out to explore this connection. Recently, parallels between the Southern English and continental mines have been noted, mostly on the mining methods, the production of axes and on a shared ideological motivation for deep mining (WHEELER, 2008, 2011). This narrative of connectivity was the basis of new research (BACZKOWSKI, 2014), when it was decided to investigate the mine workings of six sites, three in Southern England and three on the Continent, with an objective of identifying a common mining methodology.

The selection process for the sites was strict, the mines had to be well recorded, with the structures excavated both on the surface and beneath the ground. The selected English sites belonged to the Worthing Group mines, close to the West Sussex coast. The first site was at Cissbury, where a large complex of up to 300 mineshafts had been subjected to major periods of excavation from the 1870s (LANE FOX, 1876; HARRISON, 1877a, b, 1878) until the 1950s (PULL, 1956; RUSSELL 2001, p. 170-190). The second Sussex site was Church Hill, close to Cissbury and consisting of a small mine complex of around 34 mine shafts, excavated intermittently between 1932-52 (PULL, 1933a, b, c, d, 1956; RUSSELL, 2001, p. 85-158). The last site chosen was Harrow Hill, a complex of up to 250 mines, which not only has been the subject of historic excavations by the Curwen's (1926, 1937) but has also been investigated in recent times (MCNABB *et al.*, 1996; BACZKOWSKI & HOLGATE, 2017).

With regards to the continental sites it was decided not to venture far from the Channel, as it was believed a shared methodology would be best observed in mines geographically closest to the British sites (Fig. 3). The first site selected was the extensive mine complex at Spiennes, Hainaut Province, Belgium, composed of between 10,000 to 20,000 mineshafts (COLLET *et al.*, 2008, 2016) and almost continuously excavated from the late 19th century through to the present day (HUBERT, 1978; COLLET *et al.,* 2008, 2016). The second continental site examined was Jablines, Seine-et-Marne, France, where a mine complex of nearly 800 mineshafts was excavated in advance of a high-speed rail-link in 1989 (BOSTYN & LANCHON, 1992, 1995). The last continental site chosen was at Rijckholt-St. Geertruid, Limburg, the Netherlands, where a complex of around 2000 shafts had been excavated from between

Fig. 3 – Distribution of flint mines in Northwest Europe. Drawing: J. Baczkowski.

1964 to 1972 (FELDER, 1981; FELDER *et al.*, 1998; DE GROOTH, 1998).

4.1. Category of mines

While researching the mining methods employed at the six sites it was noted that although there was a variety of mine designs present, it was still possible to identify three core extraction features at all of the mines, which can be divided into the following categories,

Class 1 mines, shallow pits under 1.5 m in depth, including adits, open cast mines and drift mines,

Class 2 mines, shafts without galleries (any pit over 1.5 m of depth is classified as a shaft),

Class 3 mines, shafts that link to basal galleries.

After applying these categories to the mine complexes it was possible to identify patterns between mine complexes and understand the differing function of each feature.

4.2. Class 1 mines

Where Class 1 mines are recorded they mostly took the form of either short galleries cut horizontally into inclines to chase outcropping flint seams, or shallow pits. Of the English mines, Class 1 mines were only recorded on Harrow Hill and took the form of drift mines located close to the main deep mine complex and excavated by R. Holgate in 1986 (see below). There were also some pits on Harrow Hill, excavated by the Curwen's (1926) in the main area of deep mining. Similar features were also excavated in the 1982 excavations, and were interpreted as open cast mines, or test pits, the latter of which may have preceded the sinking of a deep, Class 3 shaft (MCNABB *et al.*, 1996, p. 24-25).

Of the continental mines, Class 1 mines have been recorded at Spiennes and Jablines. No Class 1 mines were identified at Rijckholt, although only the deep gallery system was excavated. At Spiennes, Class 1 mines included short galleries cut horizontally into the escarpment alongside the River Trouille (COLLET *et al.,* 2008, 2016). The quarries are similar in form to shallow pits discovered along the edge of the Petit-Spiennes and Camp-à-Cayaux plateaus. Although all of these features proved difficult to date (COLLET *et al.,* 2016), they nonetheless record evidence of basic extraction methods occurring close to deep mining.

At Jablines, a number of Class 1 extraction features were grouped at the northern edge of the mining field. These were shallow pits, up to 1.5 m in depth, which exploited the upper flint seams and did short develop galleries or adits (BOSTYN & LANCHON, 1992, 1995).

4.3. Class 2 mines

Of the English mines, Class 2 mines were recorded at Church Hill and Harrow Hill. On Church Hill these including one shaft, Pit A, measuring 2.2 m in diameter and with a depth of 2.5 m (RUSSELL, 2001, p. 85-158), from which no attempts to develop any galleries had occurred. A second mine on Church Hill, Shaft 2, reached a diameter of 2.4 m and a depth of 3.1 m, no galleries were developed from this shaft and again only floor flint was excavated (RUSSELL, 2001, p. 94). It was argued that these shafts never formed galleries because the miners detected previous mine workings and halted their sinking (RUSSELL, 2001, p. 87-94).

On Harrow Hill, simple 'satellite shafts' were found within the main area of deep mining. These often seemed to be abandoned before reaching the desired deep flint seams, the 3rd and 4th, either because they were placed where the chalk bedrock naturally faulted, or where earlier mine workings were detected (MCNABB *et al.*, 1996).

Of the continental sites, Class 2 mines were identified at Spiennes in the Petit-Spiennes railway cutting and along the edge of Camp-à-Cayaux, which comprised of simple shafts up to 3 m of depth (COLLET *et al.,* 2008, 2016).

At Jablines bell shaped mines were recorded in the northern area of the mine complex, ranging from between 1 m to 2 m of depth (BOSTYN & LANCHON, 1992, 1995). Depth wise these could be categorised as Class 1 mines, but because they were formed by extracting flint in all directions they can be classified as Class 2 mines, as they show a developed mining approach beyond simple open cast, or drift mining.

4.4. Class 3 mines

Deep vertical shafts joining to galleries were recorded at all of the studied sites and ranged in depth from between 2 m to 16 m. Several variations of this design do occur, and it is worth discussing these. For example at Spiennes, the shafts remain narrow, 1 m to 2.5 m in diameter, but the galleries developed in tall large rooms up to 2 m high (COLLET *et al.*, 2008). At the English sites the shafts are much wider, with diameters ranging from between 5 m to 10 m, including one example, the Large Pit at Cissbury (Fig. 4), with a diameter of 20 m and a depth of 12.8 m (LANE FOX, 1876; HARRISON, 1878; RUSSELL, 2000, p. 65).

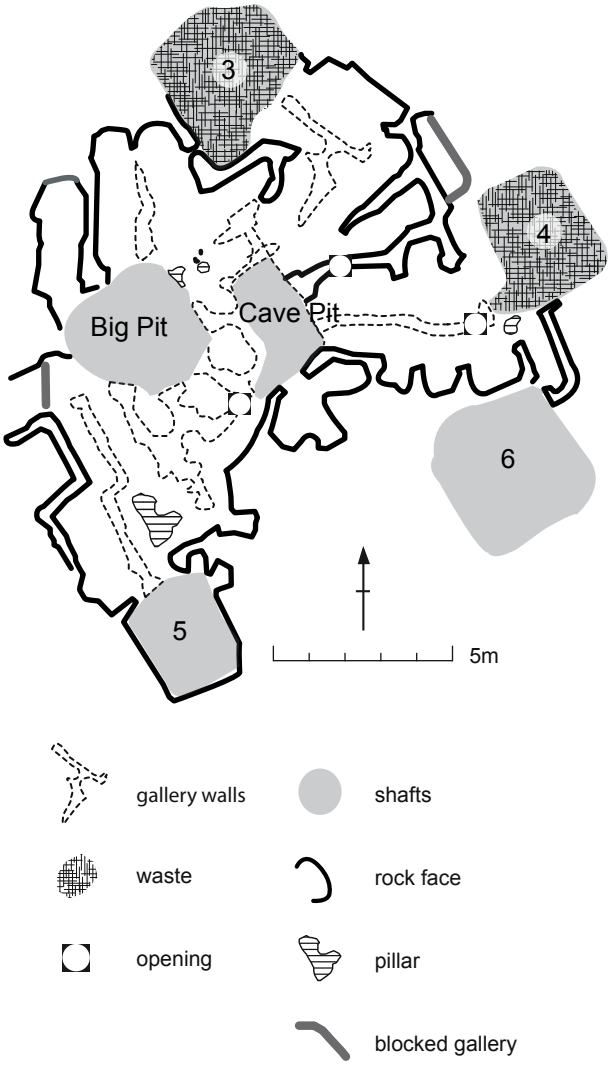


Fig. 4 – Plan of Cissbury basal system (adapted from BARBER *et al.*, 1999, p. 50, fig. 4.16c).

These differences can be mostly explained by geological factors between the sites, with miners adapting to the bedrock conditions. For example, at Spiennes and Rijckholt the upper sections of the shafts are sunk through unstable deposits and are therefore kept narrow, often less than 1 m in diameter. The small diameter may have also allowed wooden props to be added, as postulated by the excavators of Rijckholt who discovered voids that possibly indicated the presence of split timbers (FELDER *et al.*, 1998, p. 39). In contrast, the chalk bedrock in Sussex is close to the surface and extremely stable, allowing miners to excavate wide shafts and permitting as much light and air as possible to penetrate and circulate around the basal system.

Galleries on other hand uniformly remain small at most of the English and the continental mines, often only 0.6 m in height, as miners were economic and concentrated on the flints seams. Similar sized galleries existed at both Rijckholt and Jablines (Fig. 5). However, galleries at Petit-Spiennes were large, due to the size of the flint nodules being extracted and also because two seams were removed successively, resulting in galleries up to 2 m in height (COLLET *et al.*, 2008, 2016).

The principal extraction method at all sites was the use of Class 3 shafts to reach a basal system and exploit flint from deep seams. Variation, often dictated by geological factors, does exist in Class 3 mines. However, Class 1 and Class 2 mines can also be attributed to simpler extraction techniques, such as quarries or drift mines, or are produced by deep extraction practices, such as test or aborted shafts. Both Class 1 and Class 2 mines are therefore not direct evidence of a shared practice, as they are not representative of a developed methodology.

5. THE PRINCIPLE MINING METHOD

Fundamental to the deep mining methodology, observable at all deep mine complexes, is a technique known as pillar and room mining (ADLER & THOMPSON, 1992). Core to this method is the development of extraction galleries with pillars and walls left *in situ* to support the weight of the overburden, in this case

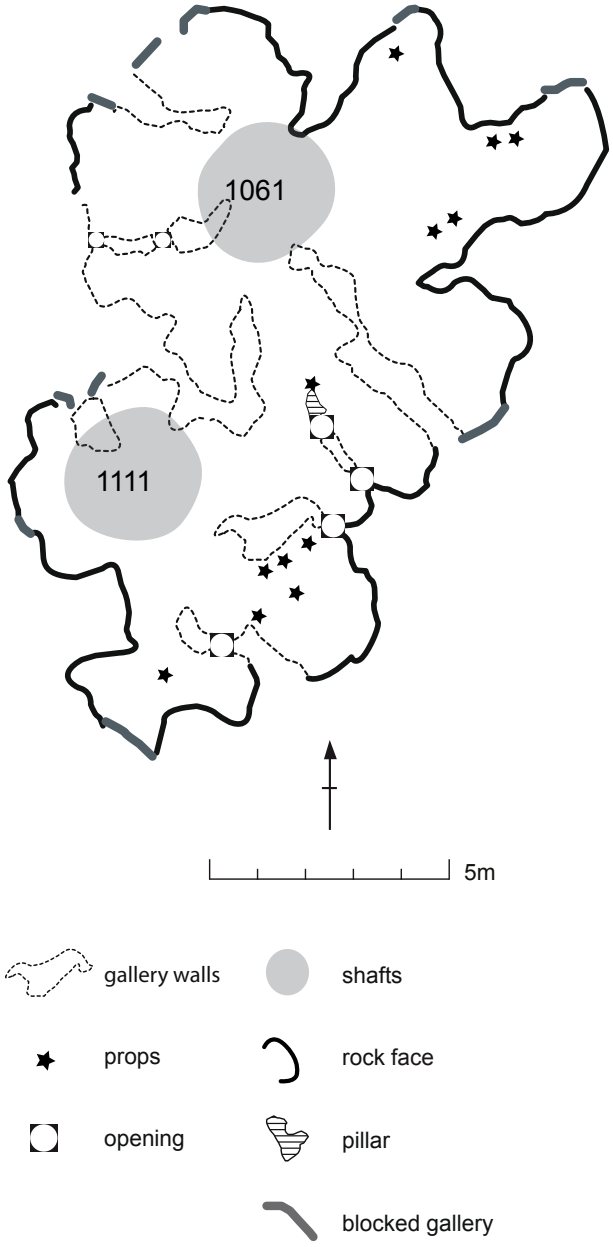


Fig. 5 – Plan of Jablines basal system (adapted from BOSTYN & LANCHON, 1992, p, 86, fig. 70).

the gallery roof. Not only does this protect the basal area against collapse, but also allows the maximum amount of material to be extracted by developing large, stable galleries.

The pairing of mineshafts is also a phenomenon observed at many mines, particularly at Harrow Hill (MCNABB *et al.*, 1996) and Spiennes (COLLET *et al.,* 2008, 2016). Such a method was probably necessary to allow air to circulate and ventilate around the gallery system, especially as paired shafts often seem associated with deep workings, as found at Harrow Hill and Spiennes.

Other similarities were observed in the mining method, including the insertion of windows or doorways at defined places in the basal gallery system. The purpose of these apertures remain mysterious: They may be purely functional, allowing access between the basal systems and air and light to be circulated, or they could be a safety feature, allowing escape in the event of a collapse. Alternatively, as some of the apertures were blocked intentionally, they may have a more symbolic role by controlling how an individual moves around the mines (EDMONDS, 1995, p. 65).

Another common technique, noticeable across all mines, is the systematic management of mine spoils (BACZKOWSKI, 2014). Exhausted galleries were universally filled with spoil from adjacent workings, which not only avoided the effort of transporting it to the surface, but also added further stability to the basal area.

Overall, it is clear that it is within the methodology of deep flint mining, represented by Class 3 mines, where a shared methodology can be observed. But how did this method progress and, most importantly, is there evidence of this development in any of the studied sites?

5.1. Simple to complex?

Across all the studied mines there is no clear evidence that basic forms of extraction, such as drift mining and open-cast quarrying, developed into complex deep mining. Simple quarries do exist, such as those at Spiennes, and although it is tempting to consider these as chronologically earlier than deep mining, this is unsubstantiated and they remain undated (COLLET *et al.*, 2016). No evidence of such a sequence at the Southern English mines is recorded, but if a progression did take place then it may be necessary to reinterpret deep mining as an insular development, albeit with a small amount of continental influence known to be occurring along the southern coast around the start of the 40th century BC (WHITTLE *et al.,* 2011).

The most likely candidates for finding evidence of earlier forms of extraction, and

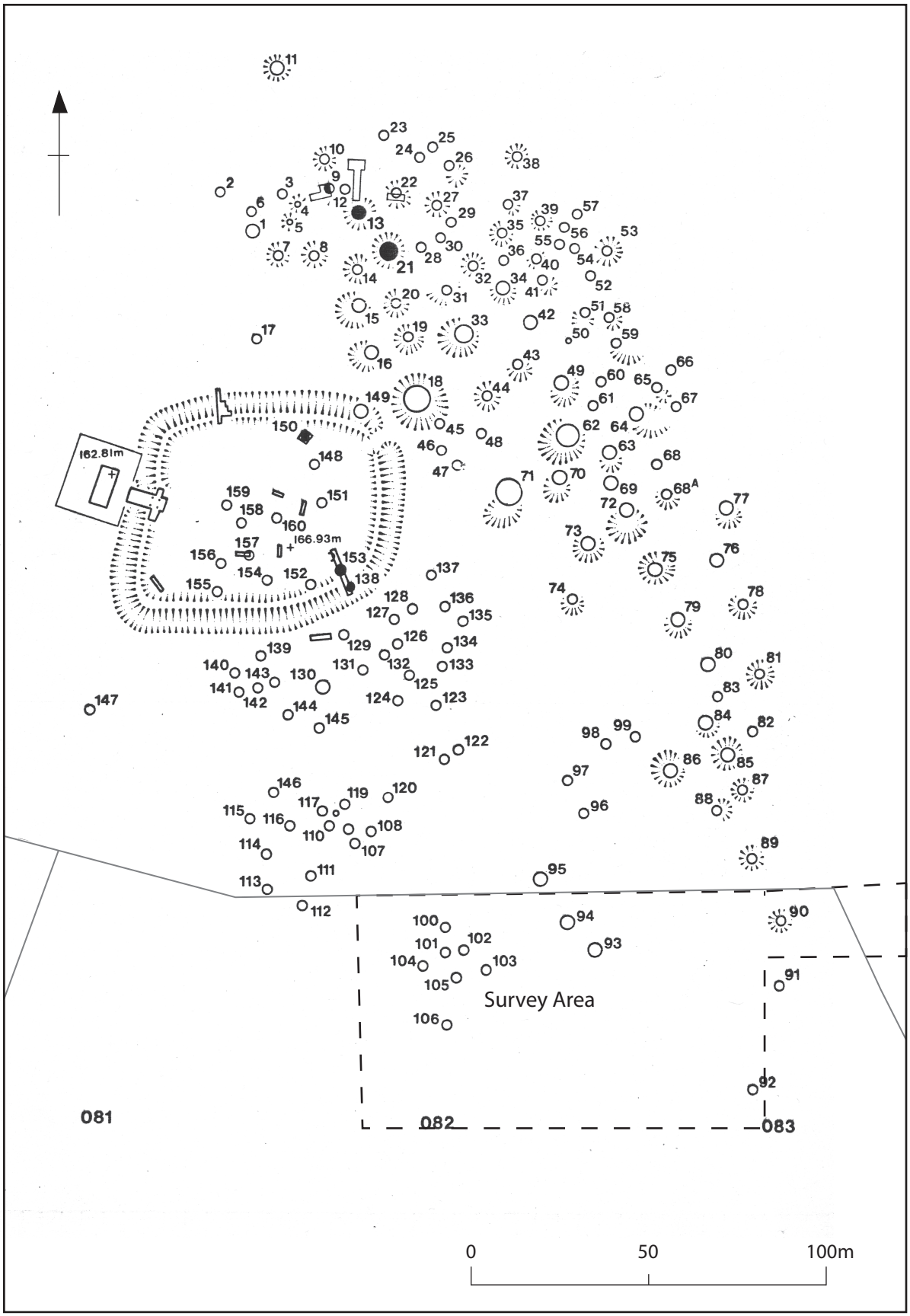


Fig. 6 – Mine workings on Harrow Hill and the survey area (adapted from a survey by F. Aldsworth).

possibly the chronological development of deep mining in Southern England, is undoubtedly the Worthing Group mines. These mines have consistently provided the earliest dates for mining in Southern England, with extraction activity beginning around the 41st century BC. It should be noted that these dates are obtained from antler picks recovered from directly within mines and therefore relate to deep shaft mining, rather than more basic forms of extraction.

A review of the excavation archives of the Worthing Group mines reveals no positive identification of simpler forms of extraction pre-dating the deep mines, possibly apart from Harrow Hill, as discussed below. Also, any simpler Class 1 and 2 mines are nearly always contemporary with episodes of deep mining.

It has been postulated that extraction may have started on Church Hill where flint naturally outcrops on a steep scarp slope (BARBER *et al.,* 1999, p. 44). Although it must be noted that J. Pull surveyed and excavated extensively outside of the main mine complex on Church Hill and found no evidence of earlier quarrying, but did record later extraction features (RUSSELL, 2001, p. 122-158).

Whether deep mining developed from earlier Mesolithic extraction methods is unknown, although, as bifacial axes are distinctly different to tranchet axes, it appears unlikely. Also, where late Mesolithic tranchet axe production in Sussex has been recorded it is focused on open-air sites, with no evidence of quarrying, such as on West Hill (BUTLER, 2001) and Bullock Down (DREWETT, 1982). Possible Mesolithic extraction pits have been recorded (CARE, 1982), but these hardly amount to proto-deep flint mines and do not involve the use of galleries.

6. THE HARROW HILL DRIFT MINES

R. Holgate excavated perhaps the best candidate for a proto-deep flint mine on Harrow Hill in 1986. The drift mines were located south of the main deep mining complex and took the form of small entrances, or adits (BACZKOWSKI & HOLGATE, 2017). It is likely that the mines were topologically positioned to exploit a thin seam of nodular flint, which naturally outcropped on the eastern flank of Harrow Hill (Fig. 6). To date, they are the only Early Neolithic drift mines recorded in Southern England and are therefore of great importance, especially for improving understandings on the possible chronological development of deep mining.

6.1. Drift mine methodology

The methodology used in the drift mines was to cut small entrances horizontally into the steep slope where the flint seams were located. A small vertical face was then driven into the bedrock, from which the nodular flint was extracted until a short gallery was formed that undercut the natural slope. Two neighbouring adits were discovered in the 1986 excavation, the openings of which measured between 1 m - 2 m in width, a little over 0.8 m in height and were divided by an arch of *in situ* chalk bedrock (Fig. 7). Of the two mines, only the left hand entrance was fully excavated, which revealed a short gallery extending only 1 m into the natural slope.

It appears that the drift mines were not immediately backfilled after extraction activity ceased, as much of the mine spoil deposited into the entrances comprised of blocky chalk rubble and chalky silts that were weathered and yellow in colour (BACZKOWSKI & HOLGATE, 2017). It was also apparent that the mines were not completely closed, as a deposit of brown-orangey clay had formed between the mine waste and the short galleries. This indicates that the spoil from the working of the drift mines was moved a short distance from their entrance, before being re-deposited back into the mine at a later date (Fig. 8). However, it is unclear if the spoil from an individual mine was re-deposited back into the same entrance from which it originated, or if spoil was moved sideward along the slope into the next mine to be excavated.

6.2. Flint working

In total 1128 pieces of struck flint were recovered from the drift mines, predominantly resulting from the production of bifacially worked implements, almost certainly axes. Although a small amount of blade production was recorded, the flintwork assemblage comprised primarily of

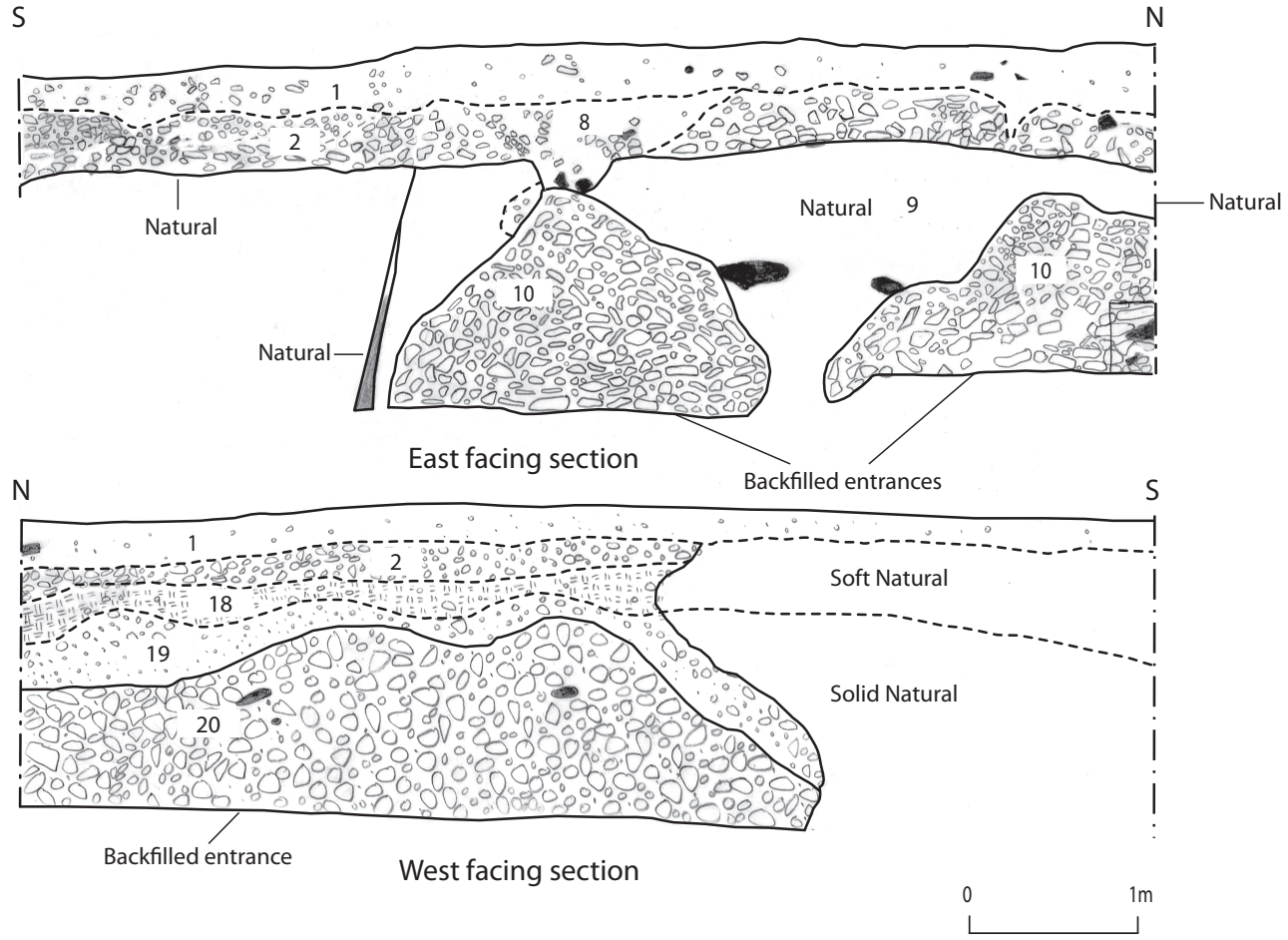


Fig. 7 – Section of Trench G showing the two drift mines (Drawing: J. Baczkowski from original site excavation record by HOLGATE, 1986).

Fig. 8 – The blocked up entrance to a drift mine. Picture: Holgate, from original site excavation record by 1986.

hard-hammer and soft-hammer flakes, including 453 axe-thinning flakes. Also recovered were five roughout axes and one preform axe, demonstrating that axes were being produced on the flint extracted from the drift mines (Fig. 9).

6.3. Dating and discussion of the drift mines

The date of the Harrow Hill drifts is problematic, as no datable material, such as antler picks or charcoal, was recovered. The lithics recorded during their excavation fit into a broad Early Neolithic date range for their opening (4000-3700 BC), rather than a Late Mesolithic one, but overall there was little evidence from the drift mines to tie them into the chronology of mining on Harrow Hill.

An approximation of their date can however be drawn from their spatial relationship with the deep mines, as examination of a large flint working floor excavated by R. Holgate in 1986 reveals. This flint working area, located uphill and to the north of the drift mines, measured roughly 30 m^2 and was revealed to contain a large density of debitage, 32,135 pieces in total, resulting from the production of bifacial axes. The production floor was difficult to date, but the fact it was found uphill from the drift mines and located within the southern most area of the deep mine complex strongly infers that it was related to shaft extraction activity.

Analysis of the association of the working floor with the drift mines is revealing and shows that the working floor in places overlaps the drift mines, or respects them (BACZKOWSKI & HOLGATE, 2017, p. 21). Therefore, it seems likely that both extraction methods are broadly contemporary, as debitage resulting from the working of flint extracted from the deep mines is both stratigraphically above and associated with the area of drift mines (Fig. 10). If the drift mines were significantly earlier than the deep mines it would be expected that the large quantity of debitage and spoil produced during deep mining would have completely covered the drift mines, a process which would have been recorded during their excavation.

Although it is difficult to precisely place the drift mines in the chronology of extraction on Harrow Hill, it seems certain that it was being carried out at the same time as deep flint mining. This implies that the simpler form of extraction, drift mining, did not develop prior to deep shaft mining on Harrow Hill.

The reason for the existence of two methods within the same mine complex is unclear. The drift mines, in comparison to the deep mines, would have produced less raw flint, but they would have been quicker and easier to open. They appear to represent a more informal approach to winning flint, focused on exploiting tabular flint seams, when compared to the difficult and developed method of pillar and room mining. It may be that drift mining was carried out in conjunction with deep extraction by less skilled individuals, different social groups, or they could have been simply to supplement the amount of flint extracted from the shaft mines. They may even attest to changes in the social motivation for mining, albeit within the community that mined on Harrow Hill (EDMONDS, 1995, p. 61).

Overall, their presence on Harrow Hill is intriguing and proves that mining at certain sites in Sussex may be more diverse than just the method of deep mining, and that more than one method may have been employed during a single mining event.

7. SUSSEX MINING CHRONOLOGY

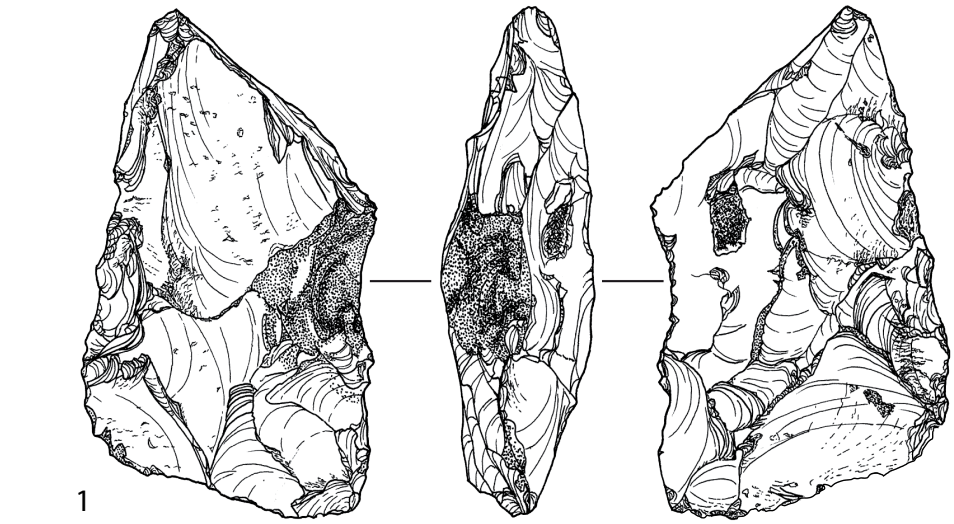
On the currently available radiocarbon dates, any attempt to define a chronology of mining is problematic, without a wider range of radiocarbon dates. However, from the dates currently available for the Southern English mines several key observations can be made that help form a brief hypothetical chronology, one which highlights some important questions on how mining may have developed and spread across Southern England.

7.1. Worthing Group mines

Of the dates obtained from the Southern English mines, the Worthing Group consistently provides the earliest (BARBER *et al.,* 1999, p. 81-82). From the Worthing Group dates, all obtained on red deer antler picks, one date from Church Hill is exceptionally early and wide in its probability range, 4490-3810 BC, and could be considered as an outlier. However, other dates, including one from Blackpatch, six from Harrow Hill and one from Cissbury all fall prior to 4000 BC at the lower date range. Therefore, mining at the Worthing Group mines possibly began around 4100 BC and was well established by 4000 BC, making them the earliest flint mines group in Southern England.

7.2. Wessex Group mines

At present, dates for the Wessex Group mines are scarce, making their chronology difficult



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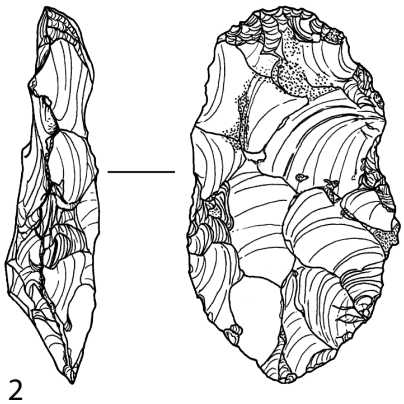

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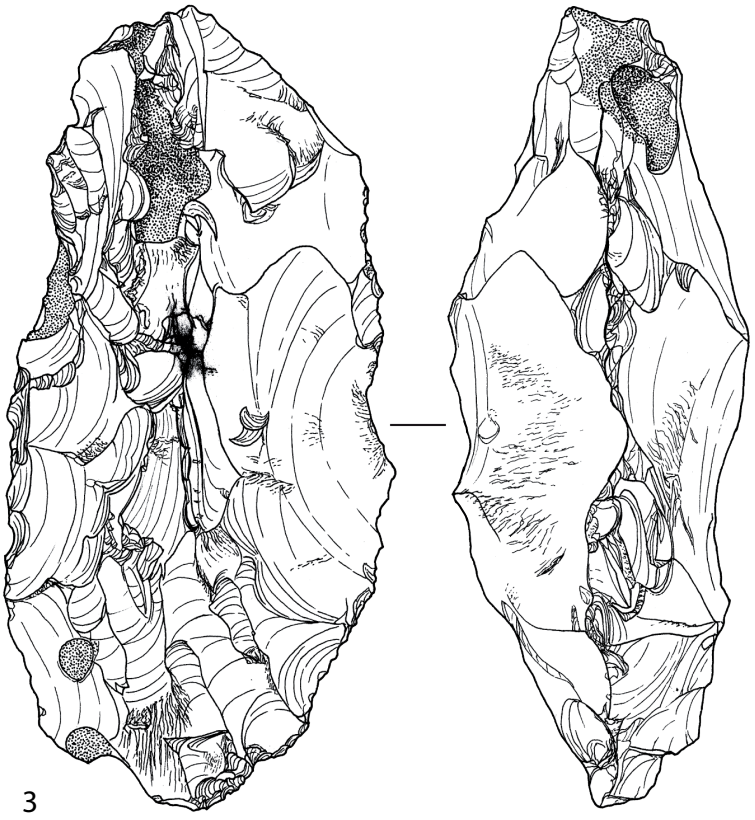

3

to understand. In consideration of the small amount of dates available, an earlier one from Easton Down with a wide calibration range, and two more recent ones obtained by Barber *et al.* from Martin's Clump, it seems likely that mining was underway by the early 40th century BC, but may have also started marginally later, at least on Easton Down. Even with a large degree of caution, with regards to postulating a mining chronology for the Wessex mines, it seems nonetheless highly probable that mining was being undertaken at the both Easton Down and Martin's Clump, between 4000-3500 BC.

7.3. Chichester Group mines

Of the Chichester Group mines, only radiocarbon dates have been obtained from Long Down. In total two were acquired during the 1984 excavation by R. Holgate, with a further five obtained recently by the author in collaboration with the ongoing project, 'Supply and demand in prehistory? Economics of Neolithic mining in NW Europe project' (EDINBOROUGH *et al.,* forthcoming). All of these radiocarbon dates were sourced from red deer antler picks collected from the upper fills of mineshafts and from working floors during J. Salisbury's excavation of Long Down in the 1950s (SALISBURY, 1961). These dates give a broad range of activity, with at least two dates demonstrating Middle to Late Neolithic activity (Fig. 11). This may be because they represent later use of the site. However, the rest of the dates strongly infer that mining was taking place later in the Early Neolithic, sometime between 3800-3400 BC. This indicates that mining at Long Down started after extraction had begun, or even waned at the Worthing Group mines, notably Harrow Hill, Church Hill and Blackpatch.

Unfortunately, no dates have been obtained for Stoke Down, but if its proximity to Long Down, rather than the Worthing Group mines is taken into consideration, then it could be proposed that it is of similar date. However, this is far from clear and at present it remains undated.

If the above chronology is taken as rough guide to the dates of the Southern English mines, it is reasonable to accept the Worthing Group mines as the earliest mine sites, with a second period of mining beginning in Chichester and possibly Wessex. In consideration of these dates it seems highly improbable that any proto-mines, and therefore a developmental phase of deep mining, may have occurred outside of Sussex. Further, it is the Worthing Group mines, where these proto-mines should exist, which are also the most excavated and best understood of the Southern English mines.

It seems then reasonable to conclude that mining in Southern England peaked between 4100-3800 BC, with a marked decrease towards 3500 BC. This is also repeated in previously obtained radiocarbon dates of the continental mines studied here and other sites (BOSTYN, 2015), with Spiennes (COLLET *et al.*, 2008), Rijckholt (FELDER *et al.*, 1998) and Jablines (BOSTYN & LANCHON, 1992) all falling within in the same 4100-3800 BC timeframe. Therefore, the peak of mining activity occurred within the same horizon in both Southern England and the Continent.

Whilst it is beyond the remit of this paper to discuss why mining appears to have intensified during this period, the dates provide yet another critical link between sites on either sides of the Channel. It is now apparent that the Southern English mines are not only connected to the continental mines by a shared method, but also by chronology.

8. DISCUSSION

The above research has demonstrated that from the very beginning of flint mining in Southern England was based on an extraction method, pillar and room mining, which can be observed across all mines in Northwest Europe. The dates for the peak period of mining, between 4100-3800 BC, further demonstrate a clear link between Southern English and continental sites.

Fig. 9 – (opposite page) Axe roughouts from Harrow Hill.
Drawing: Reproduced by J. BACZKOWSKI 2017, original drawn by DREWETT, 1990.

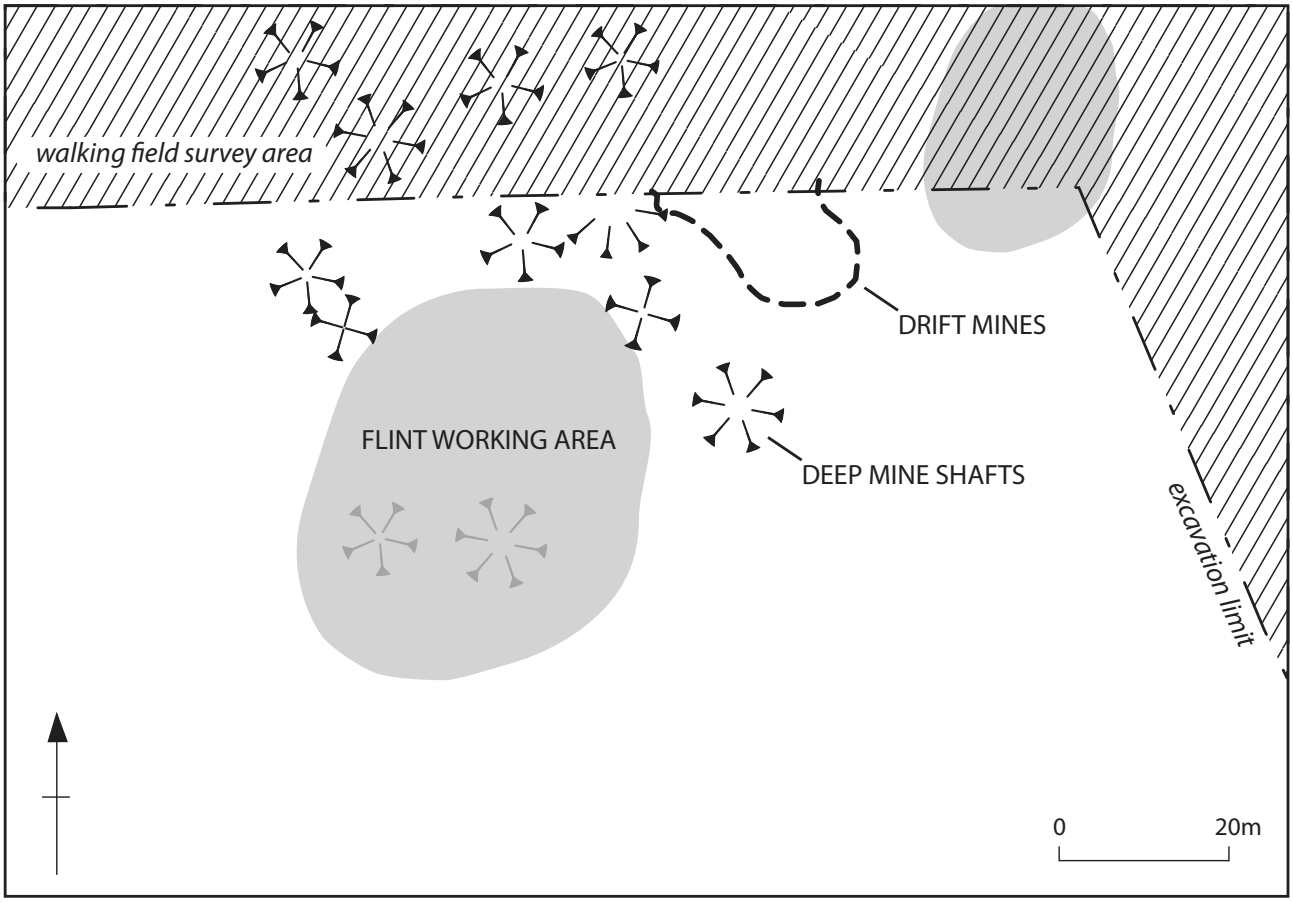

Fig. 10 – Plan of drift mines, mineshafts and working floors
(Drawing: J. Baczkowski from original excavation record by HOLGATE, 1986).

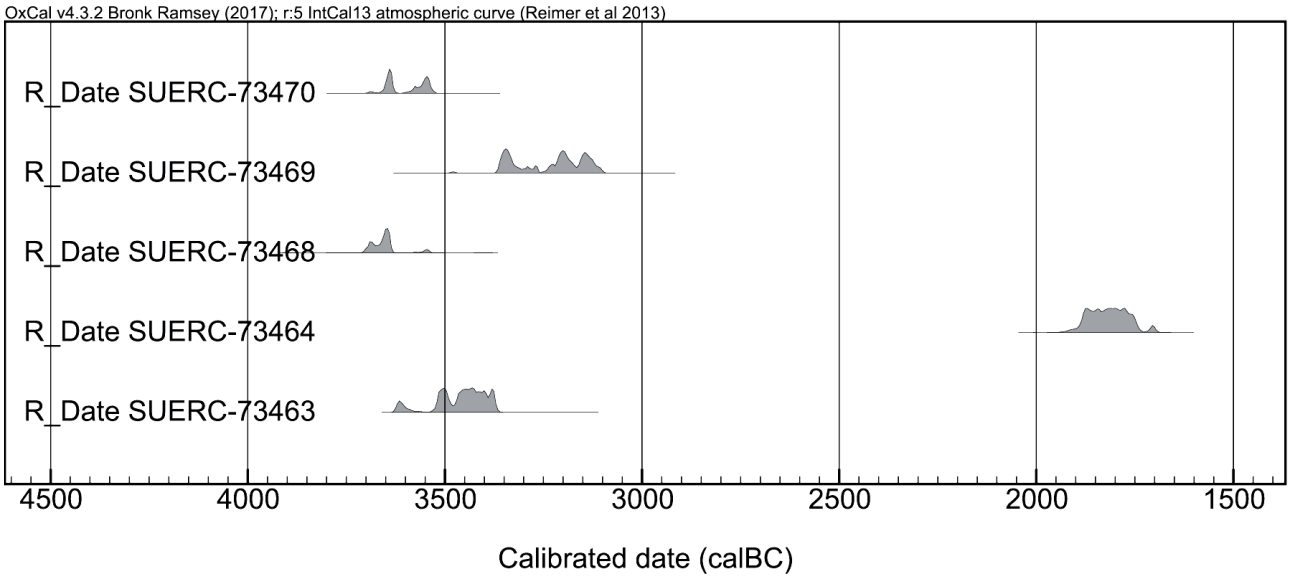

Fig. 11 – Long Down radiocarbon dates.

This finding has important implications for how the Neolithic may have spread into Southern England from the Continent, and further demonstrates the importance of mining to early communities.

Apart from the Harrow Hill drift mines there is no evidence of simpler forms of extraction at any of the Southern English sites, with the exception of Class 1 and 2 mines, which are contemporary with deep mining and mostly relate to test, or abandoned shafts. The method of pillar and room mining is most evident within the Worthing Group mines, partly because these are the best excavated, but also since they represent the most interconnected set of mine complexes. In fact, the Worthing Group mines are so close together, four mine complexes, totalling around 500 shafts in around 3 km^2, that they could be considered as one broadly contemporary complex. Therefore, if any proto-mining technique had developed at the Worthing Group mines, it is highly likely that it would have been recorded at any of the four well excavated mine complexes, which to date it has not. Of course, simpler features may have been buried by later workings, but even when drift mines were recorded, such as on Harrow Hill, they proved to be contemporary with deep mining.

If a more variable approach to pillar and room mining is found away from the Worthing Group, such as the Chichester Group and Wessex Group mines, is unknown, mostly because the mine features at these sites have only been partially excavated. A form of opencast mining has been recorded at Durrington (BOOTH & STONE, 1952), close to the famous henge monument. However, these are dated to the Late Neolithic and are therefore much later than deep mining. Shallow Class 1 mines in the form of shallow pits, between 1 m - 2 m of depth, have also been recorded at Martin's Clump (BARBER *et al.*, 1999, p. 34), but again these are broadly contemporary with deep mining in Sussex, if not slightly later.

This paper has shown that it is the method of pillar and room mining, combined with the drive to extract flint from deep seams that connects mines across Northwest Europe, including those in Southern England. This methodology is unlikely to have developed independently across Northwest Europe at the same time, without a high degree of connectivity between the sites. It is also improbable that the intricate, difficult and developed method of pillar and room mining could have been passed to new communities through informal and short-lived contact events. Therefore, the techniques and the methods at the core of this technique would have had to be learnt first hand, by direct experience of their use within the confines of the mines. Other knowledge, from learning where to look to the right flint, to the very end of the extraction process, must have also been passed on to the next generation during seasonal episodes of deep mining.

9. CONCLUSION

This paper began with a question on the beginning of flint mining in Southern England, but as the newly obtained dates from Long Down demonstrates, there is now a question to be asked on the end of mining in the region. Therefore, it may be easier to form a narrative on why mining began, based on its continental connection, than why it ended.

Naturally, there is still a wealth of information yet to be excavated from Neolithic mines across Northwest Europe that will influence current debates. But on the evidence available at present, this paper has shown clear links between both Southern English and continental sites. Further, these links were being expressed in the practice of deep pillar and room mining at exactly the same period. Overall then, mining in Southern England can be considered as part of a Northwest European tradition, rather than separate to it. Ultimately, this strongly infers that deep mining documents the direct movement of communities across the Channel sometime prior to the start 40th century BC.

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