CHAPTER SEVEN

IDENTIFYING ANCIENT MIGRATION CASE STUDIES I: ANGLIAN BURIALS AT WEST HESLERTON

"What is he, this 'god-like Anglo-Saxon', whom you insultingly hawk about the world as an object of worship? ....The Saxons were always in the minority in Britain....your Saxons hold a very inferior position in number and importance. There are some fine men amongst them, and they are capable of improvement; but they have not the cranial capacity nor the physical energy of a dominant race....The best of your people are Britons and Gauls, and Highland Scots…the hard-working Irish…The intelligent and progressive English are Celts of "various hues"....Sir, your Saxon tradition is false, and you are heaping dung on the graves of your forefathers"

Dr. John M'Elheran October 1st 1852, letter to the Editor of the Times

7.1 Introduction

The Anglian cemetery at West Heslerton was initially broached as a case study for this project by Christine Flaherty (UMIST and Columbia, N.Y.) who was investigating the site using aDNA methods to identify sex and familial groupings. The burial ground dates from the Early Anglo-Saxon period (5th – 7th centuries) and is situated near the east coast of North Yorkshire (Figure 1.4 and Figure 7.1). It is one of only a handful of Migration Period cemeteries in England that has an associated settlement. The distinctive Anglian (as opposed to Saxon or Jutish) nature of the female dress accessories: cruciform, square-headed, and small-long brooches, bucket pendants, braids and wrist-clasps, found in the graves strongly suggest links with both Schleswig-Holstein and Scandinavia, specifically western Norway and southern Sweden. Furthermore, there are indications of two distinct skeletal types being present: the minor, and perhaps foreign, group being best represented by a series of tall, gracile individuals buried with weaponry (Haughton & Powlesland 1999b, 93).

7.1.1. Aims of the study

The aims of this case study were:

1. To investigate whether Pb and Sr isotope analysis could identify the presence of two distinct groups within the cemetery.
2. To use geological and archaeological evidence to determine whether such groups were consistent with a local and an immigrant contingent.

3. To assess the traditional archaeological methods of identifying native Britons and Anglian immigrant burials against the isotope results to see which, if any, supported or refuted such methods.

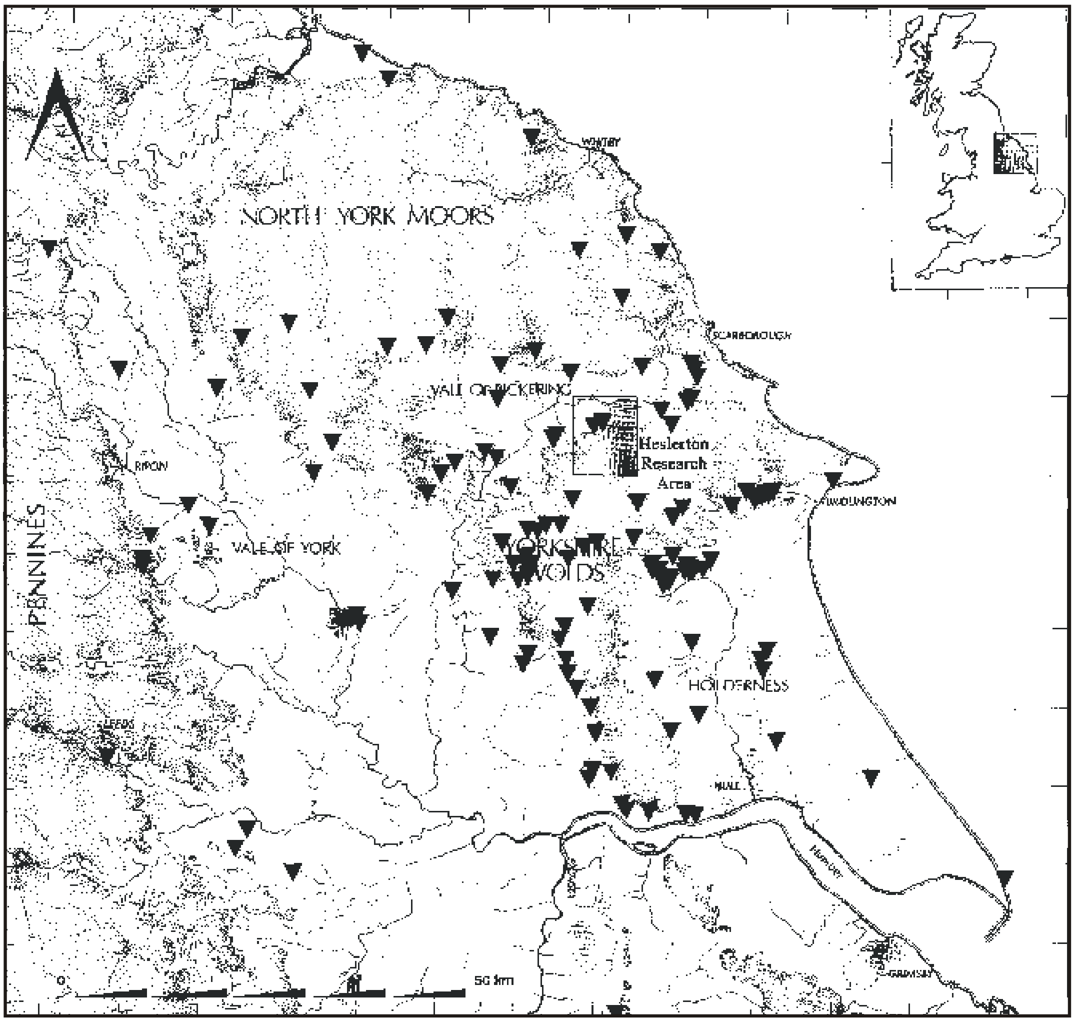


Figure 7.1 Map showing the distribution of Anglian cemeteries (▼) in northern and eastern Yorkshire.
Adapted from Haughton and Powlesland 1999.

7.1.2 The paradox of the adventus Saxonum

The *adventus Saxonum* is arguably the most tantalising and controversial migration of people to Britain. There is little agreement by academics over its scale, whether it was indeed a "coming" or a conquest or even whether it happened at all. The evidence from both the sparse historical documents and the incomplete archaeological record is frequently contradictory and interpretation is thus fraught with difficulty. The migrants themselves left no written records and existing accounts were mostly written centuries afterwards (Hamerow 1997, 33).

Nonetheless, there is undisputed archaeological evidence that the traditional homeland of the Anglian migrants, Angeln, was effectively depopulated during the Migration Period (Hamerow 1994, 165). However, archaeological evidence in Britain that indisputably requires either a mass migration or smaller-scale, elite cultural dominance is non-existent. Along with the early scholars of British Anglo-Saxon archaeology, E.T. Leeds and J.N.L. Myres, most German archaeologists accept that the mass migration of people with the concomitant replacement of the indigenous British population recorded by Gildas, Bede and the *Anglo-Saxon Chronicle* did take place (Härke 1998, 19). However, in recent years many British scholars have tended to concur with the aforementioned minority 19th century viewpoint expressed by Dr. M'Elheran that no wholesale population replacement took place: *"interdisciplinary scholarship of the past 25 years has largely put to rest the once undisputed tenet of cataclysm and massive invasion in fifth-century Britain"* (Hamerow 1994, 166). They prefer to interpret the evidence as an invasion and political conquest by a (predominantly male) warrior elite (Arnold 1984; Hawkes & Dunning 1961; Higham 1992).

Processual archaeologists of the 1960s and 1970s went even further and rejected migration in its entirety as an explanation for social change, effectively relegating the *adventus* to an origin myth. They claimed such change was explained by a rapid process of indigenous acculturation and assimilation of an available material culture into the Post-Roman void (Adams *et al.* 1978). Nevertheless, there is a considerable amount of evidence to suggest that there was neither cultural, settlement nor governmental continuity from Roman to Early Anglo-Saxon periods and such changes cannot be entirely explained by trade and contact alone (Hills 1999, 22). No traditionally "British" cemeteries dating from the Migration Period have so far been found in England (Crawford 1997, 45) and it is not known whether the Britons were simply absent or had adopted wholesale the Anglo-Saxon burial rite. The situation becomes even more perplexing because large areas of England, such as Hertfordshire, Essex, the Weald of Kent and the Sussex Downs are completely devoid of Anglo-Saxon cemeteries, despite many being attractive areas for settlement (Lucy 2000, 140). Migration theory would suggest that this is evidence for chain migration as migrants followed kin to targeted destinations rather than *"wash(ing) heedlessly over entire landscapes"* (Anthony 1997, 24).

In England, the vast majority of Early Anglo-Saxon cemeteries, many of them displaying a distinctively Germanic style, ideology and burial rite, are sited away from the previous Romano-British cemetery sites. Only a few, such as Wasperton, Warwickshire (Wise 1991), Dorchester (Hawkes & Dunning 1961) and Lankhills, Winchester (Baldwin 1985) appear to contain both Romano-British and 4th – 5th century burials with Germanic grave goods. Moreover, there is evidence for Anglo-Saxon burials being made amongst Roman villa ruins (Ellis 1997; Welch 1992, 104). Archaeological evidence for Anglo-Saxon settlements is extremely rare, whilst most Romano-British settlements appear to have been abandoned by the sixth century (Hamerow 1994, 174; Lucy 1998, 3). For many researchers, the settlement by considerable numbers of Scandinavian and Germanic peoples is an unavoidable conclusion (Härke 1990; Hills 1999, 22; Hines 1984; Welch 1992).

Quite what this immigrant population was made up of as regards men, women and children and the subsequent degree of survival and incorporation of the indigenous British is, however, unknown. The limited archaeological evidence for the Migration Period consists mainly of rural farming communities living in unfortified, wooden settlements (Lucy 1998, 1) which would suggest that the conquest was inherently peaceful or land was plentiful. Nonetheless, whatever the explanation for this sudden and startling adoption of a Continental material culture in Early Anglo-Saxon England, a brooch of foreign manufacture cannot move by itself. Whether such goods originated as items through trade, ideas through contact or as the personal property of a Germanic or Scandinavian settler, some movement of people must have occurred throughout this period. The difficulty lies in relating the artefacts to the identities of the people wearing or using them (Lucy 2000, 173). Whether migrants exist in any great numbers in English cemeteries remains to be seen: *"as Härke has noted, most of the direct evidence for the Anglo-Saxon migration itself is likely to lie at the bottom of the North Sea (especially if both the Continental evidence for large-scale migration and the minimalist view of Anglo-Saxon immigration are correct!)"* (Hamerow 1994, 175).

The opportunity to apply isotope methods in tandem with the complementary methods of aDNA to investigate the geographical origins of the Anglian population at West Heslerton was compelling. Furthermore, West Heslerton has been extensively and thoroughly excavated and a wealth of specialist post-excavation reports and archaeological information about the site, funded primarily by English Heritage, has been brought together under the direction of Powlesland and Haughton (Haughton & Powlesland 1999a; Haughton & Powlesland 1999b; Powlesland 1998). Accordingly, it presented the opportunity to compare the isotope results against the methods traditionally used in archaeology to identify the presence of migrants amongst a burial population, e.g. grave goods, skeletal traits and burial practices. Moreover, the presence of Norwegian or Swedish immigrants offered a more promising opportunity to distinguish immigrants from the indigenous population. Norway and Sweden are primarily formed from ancient rocks formed during the Palaeozoic, whereas Denmark and northwest Europe is mainly composed of more recent Tertiary and Quaternary deposits (Figure 1.1). There are, however, outcroppings of Cretaceous chalk in northern and western Denmark and the southernmost tip of Sweden where isotope signatures would be very difficult, if not impossible, to distinguish from those of the Yorkshire Wolds.

All site information is reproduced from the recently published grave catalogue and cemetery synthesis (Haughton & Powlesland 1999a; Haughton & Powlesland 1999b) and the West Heslerton Assessment (Powlesland 1998).

7.2 Archaeological background, context and samples

The Anglian cemetery at West Heslerton was discovered in 1977 as a consequence of sand quarrying and excavated over the next ten years. It is located at the foot of the north facing scarp slope of the Yorkshire Wolds on the southern edge of the Vale of Pickering, east of the present village. In total 186 inhumations and 15 cremations have been excavated although it is not known how many were lost to quarrying prior to discovery. Many burials and features were near the current land surface and had been damaged by ploughing whilst others had been buried beneath aeolian sand deposits. In both cases the original burial depth and land surface were difficult to ascertain. Moreover, additional burials are highly likely to be preserved underneath the A64

Malton to Scarborough road, which now bisects the cemetery. The Anglian settlement is located on slightly higher ground 450m to the southwest (Figure 7.2).

The cemetery was in use for a relatively short time (125-175 years) from the late 5^{th} to the early 7^{th} centuries and utilised an established Late Neolithic and Early Bronze Age ritual site comprising a hengiform enclosure, timber post circle, round barrows and associated burials. This re-use of barrows from earlier periods is a characteristically distinctive feature of Anglian cemeteries in East Yorkshire (Lucy 1998, 3). Two square barrow Iron Age inhumations were also discovered during the digging of a pipe trench beside the A64. Unfortunately, radiocarbon dating of remains from the few hundred years spanned by the Migration Period is often not of sufficient precision to improve the dates obtained from burial assemblages. Furthermore, the low incidence of intercutting graves at many Anglo-Saxon cemeteries makes it difficult to obtain a secure sequence of material. This problem was particularly marked at West Heslerton where very few graves cut into early burials (Figure 7.3). Over 100 burials have, however, been assigned to overlapping development phases on the basis of grave goods and there are indications that the cemetery developed polyfocally in what are perhaps, family, household or kinship groupings rather than from a single centre (Haughton & Powlesland 1999b, 83). The lack of intercutting suggests that most graves remained visible throughout the life of the cemetery, although there is little evidence for surface grave markers. It has been suggested that pottery may have been used to mark individual graves and that the cemetery was maintained through grazing which kept the grave mounds visible (Haughton & Powlesland 1999b, 88).

Evidence was sought for individuals who might be considered from archaeological evidence to be associated with goods, burial customs or skeletal traits that could indicate either ethnic (i.e. local or immigrant) origin or burial during the founding period of the settlement and cemetery.

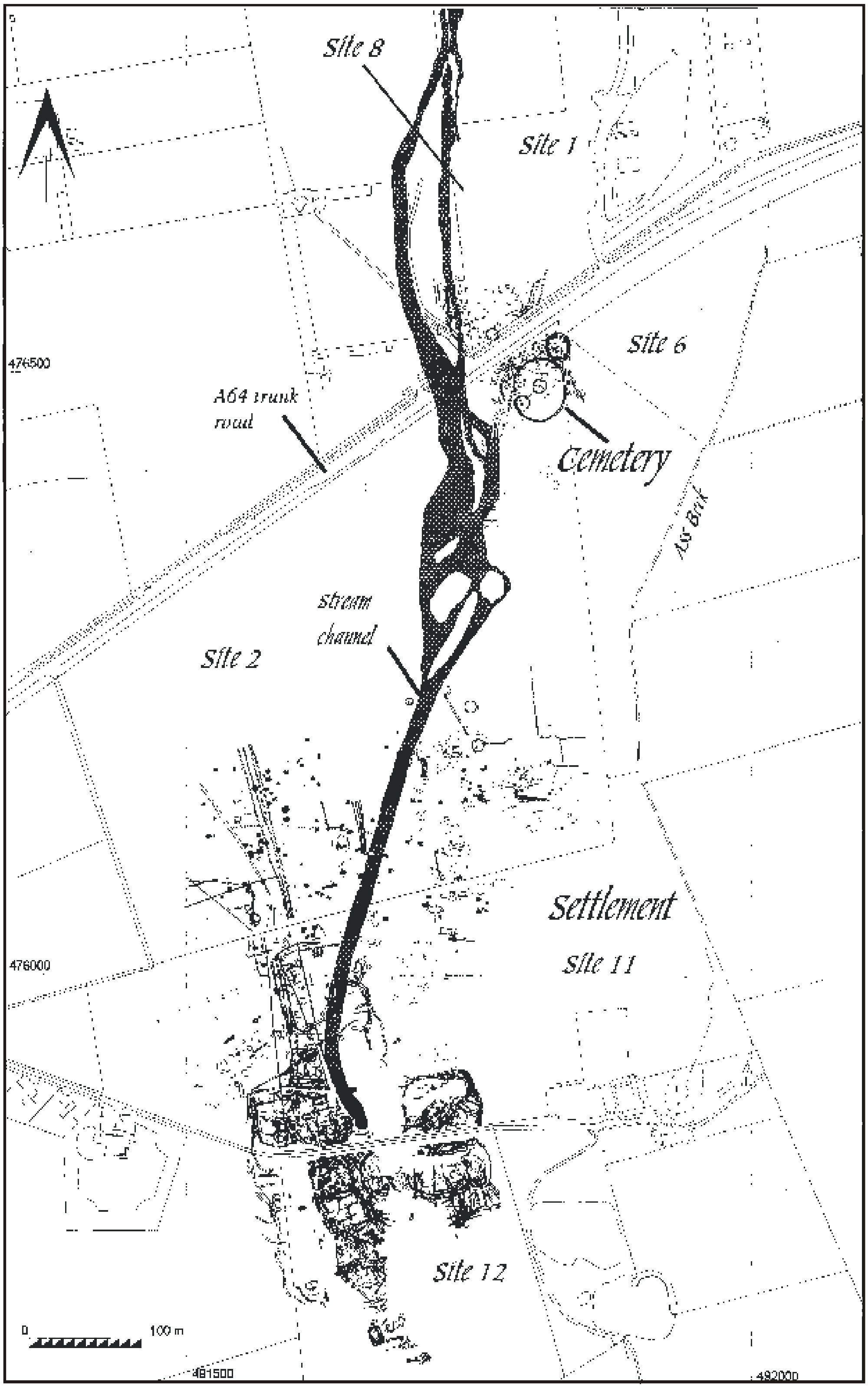


Figure 7.2 Plan of the West Hestlerton settlement and cemetery sites. All the samples analysed in this project were excavated from site 2, south of the A64. They are shown in more detail in figure 7.3 . Adapted from Haughton and Powlesland 1999.

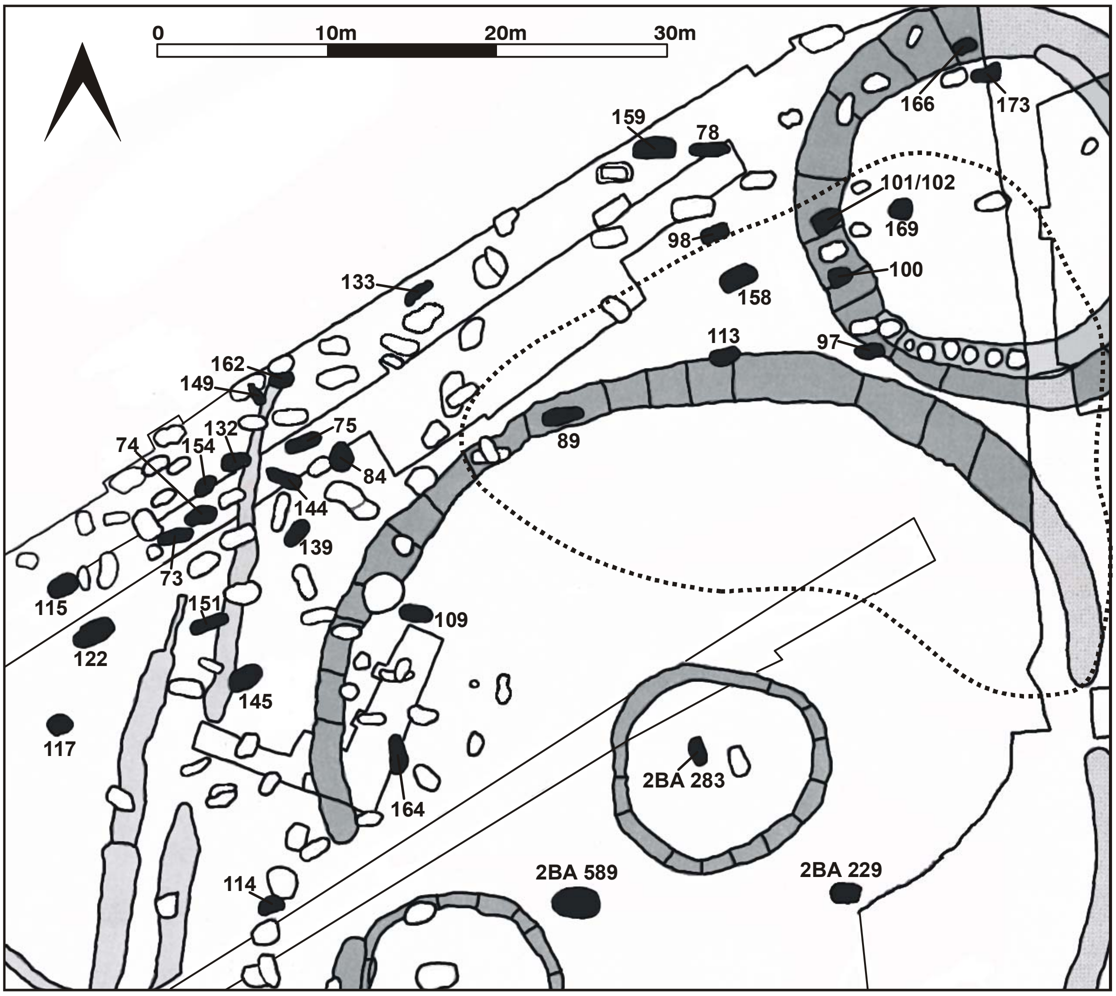


Figure 7.3 Plan of West Heslerton Anglian and Neolithic / EBA burials in areas 2B and 2BA. Burials analysed in this study are filled black and numbered. The chalk outcrop is marked by the dotted line in the northeast corner. Adapted from Haughton and Powlesland 1999.

7.2.1 Site geology

The village of West Heslerton is located at the intersection of two environmental niches: the chalk uplands of the Yorkshire Wolds and the flat, glacial valley of the River Derwent. The Wolds are formed from the northernmost outcropping of Cretaceous chalk in Great Britain (Figure 1.4). The steep, north-facing chalk scarp gives way first to gentler foothills where small deposits of clay are exposed between the outcropping chalk knolls and then to the older, Jurassic deposits of Kimmeridge and Ampthill clay which form the valley bottom (British Geological Survey 1979b). However, between the Wolds and the flat, former fen bordering the river Derwent, the underlying Jurassic clay is covered by extensive Quaternary drift: sands and gravels of lacustrine and aeolian origin, which in the locality of the sand quarry particularly, are many metres deep (British Geological Survey 1977). The cemetery is thus located on these free-draining sands and chalk gravels with an exposed chalk outcrop on the eastern edge (Figure 7.3). Such light, sandy soils are highly typical of many Anglo-Saxon cemeteries founded in this period. Today the sandy soil is unreliably productive and markedly alkaline (Haughton & Powlesland 1999b, 9), doubtless due to the incorporation of considerable amounts of eroded and weathered chalk. Bedrock erosion rates may have been accelerated in the intervening period by the intensive open agricultural practices of more recent times.

7.2.2 Settlement and subsistence evidence

The Anglian settlement lies between the cemetery and the steep scarp of the Wolds. It sits astride a relict stream channel that was fed by an emergent spring at the centre of the southern half of the settlement (Figure 7.2). It was, therefore, sensibly located at a source of freshwater but upstream from, and on higher ground than, the cemetery. It would seem to be a large *de novo* settlement of over 220 post-hole structures and Grubenhäuser with the housing zone to the east of the stream (Powlesland 1998, 6.5.5). However, rather than being a small farming hamlet it is believed to be a *"large, planned, or at least highly organised settlement, incorporating characteristics which might be interpreted as proto-urban in nature, laid out during the late 5th century"* and covering around 32 acres (Powlesland 1998, 2.1). The settlement continued in use until the mid-9th century when it appears to have been deliberately dismantled, but the burial ground associated with this later phase has not been found (Rahtz 2001, 306/8).

There is considerable evidence for differential use of space within the settlement. Metalworking, a malt-kiln, butchery and storage were taking place in the northwestern part of the site where the structural evidence comprises only Grubenhäuser (Powlesland 1998, 6.5.4). Plant macrofossil evidence indicates the majority of crops were grown on the light soils of the flat land to the north of the site rather than on the chalk uplands or the small areas of heavier clay soils and charcoal evidence suggests both woodland and orchards were maintained (Powlesland 1998, 1.4). The large amount of animal bone recovered consisted mainly of domestic species of cattle, sheep, horse, pig, goat, dog and cat with relatively few wild animals such as wild pig, red and roe deer, hare and rabbit present. Fish bones are scarce, although this may be due to their relatively poorer preservation and recovery. The majority of the animal bone was recovered by hand-trowelling and the excavators consider recovery to have been excellent. Bones of both wild and domestic birds, particularly geese, are plentiful (Powlesland 1998, 4.3.2.3). Sheep are considered to account for over a half and cattle a third of the total meat consumption at the site (Rahtz 2001, 307). On the whole therefore, it would appear that wild resources constituted only a very minor part of the diet. Soil analysis suggests the presence of stock pens in the southern part of the settlement, perhaps to enable animals to be over-wintered on site (Powlesland 1998, 1.4). As at other Anglo-Saxon settlements in England, there is no evidence for the aisled long houses found on the Continent, which contained stalls for animals. Droveways to the Wolds indicate the use of the chalk upland pastures for grazing. The environmental evidence suggests, therefore, that the majority of food was obtained or produced locally on sand or chalk substrates

It was originally thought that the Roman remains at the site pointed to the presence of a Late Roman farmstead and continuity of settlement through to the Late Saxon period. However, the stone structures have been interpreted subsequently as a shrine and temple complex rather than a habitation site (Powlesland 1998, 1.1). Evidence from the small valley immediately to the south of the settlement site indicates that there was a *"major terracing event reshaping the entire valley floor during the late 4th century"*. The excavators found evidence for housing during the Late Roman period negligible and concluded that *"the site operated as some sort of sanctuary supporting a large but short term visiting population"* (Powlesland 1998, 6.3). Throughout the Late Iron Age and Roman periods, habitation appears to be concentrated in the valley bottom, along the fen edge but this area shows increasing wetness during the 4th century making it unsuitable for continued settlement (Haughton & Powlesland 1999b, 94). Such a change in environmental conditions could explain the relocation of the settlement to the drier and lighter soils of the higher land to the south during the 5th century. However, access to the dry valley appears to have been physically controlled both during the Roman period and throughout the Anglian occupation. Access restrictions were maintained during the Anglian settlement by means of *"a large and very deliberate separator between the settlement to the north and the ritual valley to the south"* including fences and other structures across the entrance and up both sides of the valley

(Powlesland 1998, 6.6). Ceramic evidence may indicate continuity of use of a ritual landscape through until the mid-9th century and it has been suggested that the southern area of the settlement immediately adjoining the valley was of a somewhat higher status than the area to the north.

Throughout eastern England, Roman and Iron Age sites appear to have been rejected in favour of new settlement sites on lighter and easier to plough soils. Whether this was a result of an increasingly wet climate that made heavier soils more difficult to cultivate or that the lighter soils were simply more suitable to the farming methods of the Anglian settlers is unclear. It is also evident that many Anglo-Saxon cemeteries founded in this period re-used older Neolithic and Bronze Age ritual sites. The evidence for the presence and continued use of a Roman ritual landscape within the Anglian settlement is thus intriguing. It raises the question of whether the foundation of the new Anglian settlement was dictated by primarily environmental concerns or to enable ritual continuity or appropriation of a sacred space.

7.2.3 The skeletal remains

Despite the alkalinity of the current soils, bone preservation at the site overall was poor and 16% of burials contained no surviving bone at all. Approximately 34% of burials were represented by tooth crowns only, and where bone was preserved it was frequently too fragile to lift intact. Exceptions were present, however, and greater quantities of bone were present in burials made directly into the chalk outcrop or into the barrow ditches that contained a high proportion of chalk gravel (Haughton & Powlesland 1999b, 18). As a consequence, burials in Site 2, south of the A46, were better preserved than elsewhere on the site and all the Anglian samples analysed in this project were excavated from area 2BA and 2B (Figure 7.3). As this area also appears to contain the highest proportion of early graves (Haughton & Powlesland 1999b, 84), the likelihood of locating the original founders of the settlement was not compromised by poor survival. However, as discussed in Chapter One, migration theory suggests that subsequent migrants are far more likely to choose to follow family and friends to known places rather than seeking out alternative or new locations (Anthony 1990, 903). It follows, therefore, that a migration between two places may actually continue for many years rather than occur in a single, discrete founding event.

The skeletal collection from West Heslerton was examined and assessed by Margaret Cox (1999). She stressed the *"appalling"* (Cox 1999, 183) survival of the assemblage, noting that over 50% of burials were represented by only small fragments of bone or teeth and an osteological assessment of age or sex could not be made in many cases. Where bone did survive the cortex was frequently abraded, preventing complete skeletal assessment. Furthermore, she did not consider the sample numerically large enough to give sufficient weight to statistical assessments of most metric or non-metric traits.

Where burials could not be sexed by morphological and/or metrical methods the gender indicated by the grave goods (i.e. weapons = male, jewellery = female) was recorded in the published catalogue (Haughton & Powlesland 1999a). However, osteological sex is clearly not the same as gender and for problematic individuals as well as juveniles which are always difficult to sex osteologically, aDNA can be successfully used to ascertain biological sex (Cunha *et al.* 2000). In the case of G132, a juvenile 15-20yrs, aDNA analysis has demonstrated this individual was male despite being buried with a considerable amount of "female" jewellery (Christine Flaherty pers. comm.). There are also three osteologically sexed females buried with weapons (G144, G164 and G184). Interestingly, neither G144 nor G164 were young adults and Cox refers to G144 as "elderly" (1999, 185). Both females had extensive caries, periodontal disease and severe tooth attrition, G164 had severe osteoarthritis and G144 bilateral fusion of the distal humeri and proximal ulnae, effectively immobilising both elbow joints (Cox 1999, 184/5). Whilst the underlying causes of these conditions may be pathological and are not necessarily age related, Cox drew her conclusions from an assessment of the rates of attrition and osteoarthritis present in all material at the site. She observed no instances of caries in sub-adults or juveniles at West Heslerton and the rate amongst adults was low for Anglo-Saxon remains (1999, 181). Whether due to age, trauma or lifestyle, such degenerative changes nevertheless suggest that the weapons may have been symbolic rather than functional. Härke (1990, 36) has pointed out that neither ability to fight nor actual participation in combat determined whether children and adult males (he did not address female examples) were accorded a weapon burial. G184 was tentatively sexed on the basis of a poorly preserved "female" skull, the pelvis being absent. As tooth attrition was slight, this could possibly have been a young male yet to develop prominent adult male cranial features and thus classified incorrectly as female

(Walker 1995, 43). Nonetheless, at least one of these weapon burials has been positively confirmed as female by aDNA. In the majority of cases, aDNA results were in agreement with osteological or grave goods sexing if the individual were male. This was not the case for individuals sexed as female by either bone or grave goods: 35% of females sexed by bone and 45% of skeletons buried with female grave goods (particularly annular brooches) were subsequently shown to possess male DNA (Christine Flaherty pers. comm.). These results indicate that at West Heslerton males are securely sexed by whatever method used, whereas females are considerably less so and many may, in fact, be male.

It was noted by Cox in the skeletal report that, *"Both the males and females appear to have been taller than modern British adults…..and are generally taller than adults from many Romano-British sites"* (1999, 178). Due to the fragmentary and incomplete nature of the remains, this conclusion was necessarily based on a small number of individuals (5 males, 6 females). However, it was supported by observations made from other burials which could not be directly measured: *"Inhumation 2BA467 (G92) was a very tall female but the condition of her long bones was such that her stature could not be estimated"* (Cox 1999, 178). The traditional view is of two different skeletal types being present in Migration Period cemeteries, represented by tall, well-built Anglo-Saxon immigrants and shorter, more gracile Romano-British (Welch 1992, 60). An increase in stature during the Anglo-Saxon period has been confirmed by Roberts and Cox (in review). They obtained a mean stature for males in the Anglo-Saxon period of 172cm (n = 996) and for females 161cm (n = 751), which is taller than preceding Romano-British populations and later mediaeval populations. A positive correlation between weapon burials, tall males and certain non-metric traits (e.g. sixth lumbar vertebrae, foramen olecranon) has been demonstrated by Härke (1990, 42) whilst wormian bones were negatively correlated, i.e. associated with the native population. Wormian bones (Figure 1.2) have no known functional or environmental expression and are, therefore, considered to be a developmental trait which has a high genetic component through the male line (Sjøvold 1995, 250; Tyrrell 2000, 294). He concluded that burial with weapons was only performed by the wealthier families of Germanic descent and estimated that this group constituted ~50% of the Anglo-Saxon population (Härke 1990, 42)

The cranial index (a measure of cranial shape) of the individuals buried at West Heslerton was dolichocranic (narrow or long-headed). Although only four females could be directly measured, this trait was apparent in all observed crania, apart from one brachycranic (broad or round-headed) individual. This, however, was an Early Bronze Age male skeleton 2BA241 (see detailed notes for each skeleton, page 7, located at the back of the original AML report Cox 1990; Haughton & Powlesland 1999b, 44) and not the Anglian burial G166 as listed in the recently published skeletal report (Cox 1999, 179). G166 is actually an adult female and *"clearly dolichocephalic"* (Haughton & Powlesland 1999a, 291) which is consistent with both Anglo-Saxon and Iron Age populations in England, who were only differentiated by their cranial height (Morant 1926, 57). This measurement does not contribute to the cranial index (Figure 1.2). The relationship is not straightforward however, as in contrast to the situation at West Heslerton where all the Anglian individuals able to be assessed were dolichocranic, at Spong Hill only one dolichocranic individual (Inhumation 44) was reported (Hills *et al.* 1984, 14). The cranium was, however, not complete enough to enable the cranial index to be measured (Putnam 1984, 98) and the basis on which this conclusion was reached is unclear. However, this crouched burial was interpreted as an indigenous Romano-Briton on the basis of cranial shape. As it is the increased calvarial *height* rather than the degree of dolichocrany that traditionally distinguishes the invaders from the invaded at this time (Howells 1937; Morant 1926, 57), such a conclusion is rather confusing, especially as it is not clear what cranial shape the rest of the burials at Spong Hill possessed.

Apart from anaemia there is no evidence to suggest nutritional deficiency at the settlement (Cox 1999, 172). Cribra orbitalia was observed in both adults and juveniles, together with one case of porotic cortical hyperostosis, also an indication of iron anaemia, the aetiology of which may be multi-factorial (Cox 1999, 183). The caries rate of 2.44% is lower than the mean of 4.3% (38,431 teeth from 36 Anglo-Saxon sites) found by Roberts and Cox (in review) and also lower than the preceding Roman period (7.5%) and the later Mediaeval period (5.7%). None of the juveniles or sub-adults observed at West Heslerton were affected (Cox 1999, 181). Fourteen cases of enamel hypoplasia were present and all bar one (G98) were very slight. The hypoplasia in this child is present in teeth forming at ~3-4 years of age and the child did not survive for much more than a year afterwards (Cox 1999, 182). Fracture rates at West Heslerton were low, although it seems likely that adolescents were employed in fairly arduous physical labour (Cox 1999, 172).

7.2.4 Burial practice

Cremation was not performed in Britain as a burial rite during the Late Roman period (Welch 1992, 56). It therefore represents a distinctive change in the 5th century and is viewed as a newly arrived practice. As a result, it has been suggested that inhumations in a predominantly cremation cemetery may represent the surviving British. Although cremation cemeteries are amongst the earliest Anglo-Saxon sites in England, both inhumation and cremation are found together in cemeteries in Scandinavia, France, the Netherlands and Germany before and during the Migration Period (Crawford 1997, 66). North of the Humber inhumation predominated, as is the case at West Heslerton, but this preference varied geographically (Lucy 1998, 4). It is possible that either the deceased or the mourners had a choice of rite or the decision to inhume was made for more prosaic reasons such as a shortage of wood (Crawford 1997, 67). Clearly, however, inhumation was not a solely British practice.

No perinatal deaths and only one infant (< 2yrs) are represented in the cemetery, a situation typical of many Anglo-Saxon cemeteries (Cox 1999, 172). However, a quantity of juvenile bone was recovered from the Grubenhäuser in the settlement, signifying few children were accorded burial in the cemetery. Furthermore, there is a lack of infant-sized graves suggesting the discrepancy is not due to preferential survival of adult bone. Cox (1999, 176) says *"All known Romano-British cemetery sites of consequence have produced skeletal evidence of perinatal and infant deaths; in fact the evidence for perinatal mortality alone is usually higher than that for both perinatal and infant mortality in Anglo-Saxon sites"*. This would appear to point to change in either burial practice or infant mortality rates between the 4th and 6th centuries. However, there is no evidence that mortality rates would have changed significantly because there is little evidence for any marked improvement in standards of hygiene or aetiology of infectious diseases during these centuries (Cox 1999, 176). The apparent difference in the interment of infants would, therefore, seem to result from cultural change. In marked contrast to those deposited in the Grubenhäuser, several young children at West

Heslerton were accorded burial accompanied by either weapons or jewellery (e.g. G97, G98, G100 and G154).

It has been suggested that crouched burial was an indigenous British rite in the East Yorkshire region: *"In northern Britain the native burial rite, going back to Neolithic times, is of contracted (i.e. crouched) burial, usually in stone cists under barrows. In the Iron Age in some areas, such as the East Riding, burials were made under square barrows, but still in the contracted position, and frequently with the head at the northern end of the grave."* (Faull 1977, 5). Crouched burial is rare in continental Germanic cemeteries (Crawford 1997, 65). Its use in Anglian cemeteries might therefore allow the Anglian settlers who would be expected to use their traditional supine, extended burial rite to be differentiated from the surviving Britons. However, the predominant position for Romano-British burial was also extended and supine and it is possible that the choice of burial position owed more to affiliation to certain gods rather than ethnic origin (Crawford 1997, 65). Interestingly at West Heslerton, none of the 25 crouched burials were amongst the 27 graves that contained wrist clasps (see Table 7.3 for burials analysed in this thesis). More unusual positions such as prone burials and placing the hands under the head are considered anomalous and are found mainly in female burials. They are suggested as being indicative of surviving British burial traditions known from areas such as the Vale of Pickering (Faull 1977, 8/9). As in England, prone burials in Germanic cemeteries on the continent are rare, but not unknown (Crawford 1997, 65).

Both crouched and extended burials along with flexed, bound and prone variations were found at West Heslerton (Table 7.3). Distribution does not seem to be zoned within the cemetery and prone burial which has been suggested as a punishment for adulterers and witches in particular, is often observed along with a relatively rich burial assemblage (e.g. G113, G132). It is unclear whether such burials were intended to be placed in this position or have resulted from a somewhat carefree disposal of the body within the grave. Many burials at West Heslerton appeared to be simple soil burials that were *"neither neatly arranged nor neatly cut, and the body positions in some cases almost suggests that a hole was simply dug and the body thrown into the pit."* (Haughton & Powlesland 1999b, 90). Furthermore, burials were frequently interred in undersized graves although this has been explained by the need to prepare graves in advance of the winter whilst the ground was soft. This might explain the mismatch of grave and body size in many cases and also the presence of graves which appear never to have contained a body (Welch 1992, 56).

Burial within a coffin is common in Germanic continental cemeteries (Crawford 1997). Plainly, the use of a coffin indicates that considerable time and effort has been expended on the burial. It has also been associated with extended weapon burial: *"individuals in weapon graves were twice as likely to be buried in a coffin or wooden chamber than men and children without weapons"* (Härke 1990, 38). At West Heslerton, several graves appear to have contained a wooden coffin (e.g. G73, G78, G95, G107, G130, G151 and G159), although the excavators found no correlation between evidence of a coffin and the associated burial assemblage (Haughton & Powlesland 1999b, 88).

Orientation of the body within the grave has also been suggested as a way of differentiating between native Briton and immigrant Anglo-Saxon: *"Orientation with the head pointing somewhere between the north and north-east is typical of Iron Age burials throughout the whole of Britain: it sometimes veers even further east but very rarely indeed to the west. Examination of 5293 Anglo-Saxon inhumations excluding those of Northumbria, shows that the normal pagan rite was extended or loosely-flexed burial, either supine or on one side, with the great majority orientated with heads pointing somewhere in the western sector of the compass…burials of the Roman period in Northumbria seem to continue the native traditions"* (Faull 1977, 5). However, placing the head to the west is also known as a Christian, as opposed to pagan, burial rite. Furthermore, north-south orientation is also found on the Continent during the Migration Period and it appears likely that factors other than ethnic origin, such as the presence of prehistoric barrows, influenced body orientation (Crawford 1997, 63). There is unlikely, therefore, to be a simple explanation and Crawford warns *"the fact that the same range of practice seen in Anglo-Saxon cemeteries is mirrored on the Continent is enough to warn against offering British influence as the obvious explanation"* (1997, 65).

7.2.5 Grave goods

West Heslerton does not appear to be a particularly rich or high-status cemetery; most artefacts are of base metal, sometimes gilded and a few of silver but no gold or gemstones were present. No obvious "founder" graves have been identified and there is no evidence for any burials being set apart within primary barrows. It has been suggested that burial with a sword may constitute a founder burial (Hills 1999, 20) and at West Heslerton G74 is the only such example discovered. Such a lack of obviously higher status burials would seem to concur with the evidence from the settlement for the division between the higher and lower status areas being that between the *"comfortable and the more comfortably off"* (Haughton & Powlesland 1999b, 95). Nevertheless, any burials at the centre of the cemetery remain unexcavated beneath the A64.

It is not clear, however, what items were highly prized during this period either for their value, scarcity or symbolism and many organic goods may not have survived burial. Unaccompanied burial in the Early Anglian period has been suggested to indicate poor social status, perhaps even the presence of enslaved Britons (Crawford 1997, 67). However, burials lacking grave goods are not confined to a specific "poor" area of the cemetery, nor are they marked out as different in any other way in either English or Continental cemeteries. Most tellingly perhaps, English cemeteries do not contain a higher proportion of unaccompanied burials than those on the Continent where British slaves are unlikely to be present, indicating that a similar wealth structure existed in both places (Crawford 1997, 67). The excavators at West Heslerton concluded: *"There seem to be no specific indicators amongst the grave goods that could be used as ethnic indicators; most burials were accompanied by grave goods and there is no particular focus to those that might be considered poorly furnished."* (Haughton & Powlesland 1999b, 93).

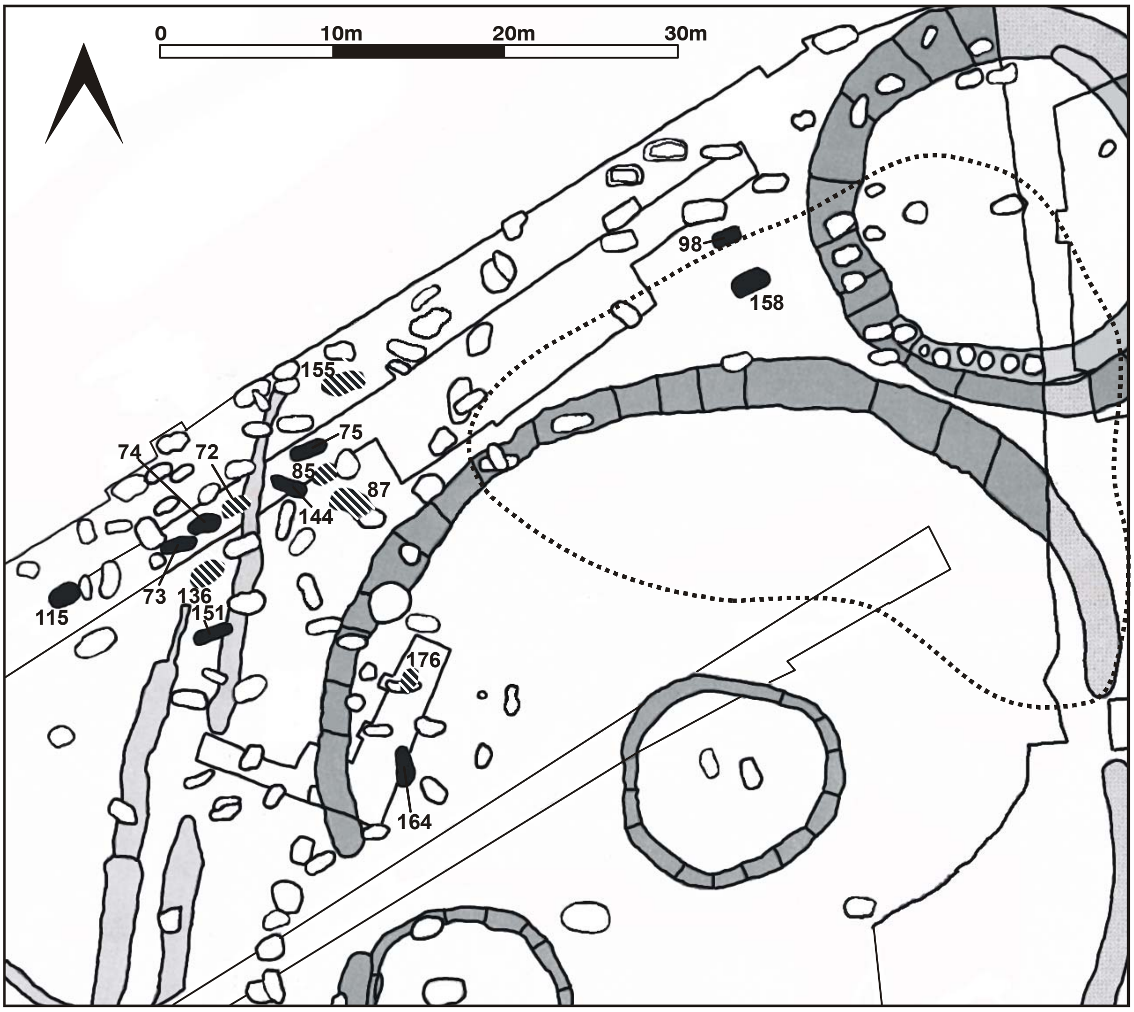


Figure 7.4 Plan of the Anglian weapon burials in part of area 2B and 2BA. Individuals analysed in this study are filled black. Unanalysed weapon burials have diagonal hatching.
Adapted from Haughton and Powlesland 1999.

Unusual burials do, however, exist. A young child (G98) was buried with a spear and a knife, two elderly females (G144 and G164) were buried with an identical assemblage of spear, knife and a buckle and a younger female (G184) with a shield, spear, buckles and knife. There were several male weapon burials with spears and shields but only one (G74) contained a sword (Figure 7.4). Burial with weapons has been suggested as a symbolic act indicative of status and Germanic descent rather than actual participation in or ability to fight (Härke 1990, 42) which would not seem to preclude females and children being accorded this rite. Weapon burials occur on the Continent during the Migration Period but are entirely absent from some cemeteries such as Hjemsted in Denmark which contained wrist clasps similar to many found in England (Crawford 1997, 51). Crawford suggested that in England *"the habit of inhuming males with* *weapons (contra the 'old ways' as illustrated by Hjemsted), might be to emphasise the difference between Anglo-Saxons and Britons."* (Crawford 1997, 65). Alternatively, such differences may arise because "*regional cultures do not migrate. Only specific subgroups migrate, and they generally carry a simplified version of the culture"* (Comments by D. Anthony in Härke 1998, 26). Child weapon burials are also found on the Continent but are exceedingly rare (Crawford 1997, 59). Burial G74 was buried with a rare design of pattern-welded sword, two spears, a shield and a knife. Swords are infrequent finds in Anglian cemeteries and this one was of a very unusual snake design running down the blade which has not been seen amongst the Anglo-Saxon pattern-welded swords so far discovered in England. Two similar examples have, however, been found in Finland and Holland but both date from the 9th to 11th centuries (Gilmour 1999, 120) and there are several references to snake patterns on sword blades in early Norse literature (Gilmour 1999, 122). It has been suggested that a deliberate row of weapon burials (G72, G73, G74, G75) is present at West Heslerton (Figure 7.4) (Haughton & Powlesland 1999b, 84/85).

The jewellery was typical of that found in Anglian cemeteries in the north of England. Items considered to be of native British origin such as penannular brooches (Faull 1977, 9; Hamerow 1997, 35) were found in burials G28, G141 and G147 only, but as part of assemblages that included Anglian artefacts, such as wrist clasps, that are clearly Scandinavian. Hines (1984, 109) concludes that the sudden appearance of wrist clasps, that were both functional and decorative, to be explainable only by the migration of people from western Norway *c.* 475 AD, around the time the cemetery at West Heslerton was founded. Wrist clasps are indicative of a sleeved garment with fastenable cuffs and are found in female and some, but not all, male burials in Norway. Interestingly, in England they are found only in Anglian female burials (Hines 1984, 275) which may be indicative of Anthony's (Comments by D. Anthony in Härke 1998, 26) simplification and alteration of "imported baggage" at the destination, although the reasons are unclear. There are 27 graves containing wrist clasps at West Heslerton, those in G173 are amongst the earliest and date from late 5th to mid 6th centuries. All accompany adult females bar two incomplete sets (G66 and G97) which were recovered from juvenile burials. Similarly, Hines (1984, 13) considers bucket pendants, found in 4th century graves in Schleswig-Holstein, such an odd invention that their presence in 5th century England can only be as a result of direct influence from the

Continent. Bucket pendants were found in four graves at West Heslerton (G152, G167, G172 and G177). Two prone burials (G113 and G132) contained unusual walnut amulets together with a considerable quantity of jewellery, and in G113 notably, a beaver-tooth pendant.

Of note amongst the brooches are the early 6th century small-long brooches recovered from G78 and G84, the former being very similar to an example from Brunnhem, Sweden and the latter of continental ancestry. These two graves also contain the earliest cruciform brooches dating from the early 6th century (Haughton & Powlesland 1999b, 99/100). The only equal-armed brooch found at West Heslerton in burial G122 is of a type previously only found in England in East Anglian cemeteries. Its continental distribution is restricted to Norway and Sweden and is considered to be from a Norwegian source (Haughton & Powlesland 1999b, 102; Hines 1984, 259/374). G143 and G154 contained copper alloy disc brooches manufactured between 450 and 550 AD. The example from G154 is believed to be the earlier as a single amber bead is also present (Haughton & Powlesland 1999b, 102). Burials containing a single amber bead (e.g. G159) are deemed to be of early date (Haughton & Powlesland 1999b, 112) and several examples were found at West Heslerton. Three burials (G50, G55 and G139) contained scutiform pendants believed to be amulets with some religious, rather than just decorative or functional, significance. As a consequence they are considered to demonstrate the movement of ideas and beliefs, and therefore possibly people, from western Norway (Hines 1984, 236). The example from G139 is a type that is known from Migration Period Norway and Denmark, that first appears around the beginning of the 5th century (Haughton & Powlesland 1999b, 114).

Evidence of Continental influence is scarce amongst the surviving textiles: *"Most of the WH textiles whether whole cloths or bands could have been woven near at hand using locally grown wool and flax…Only a single example of a piled cloak may not have been made locally and one braid has been shown to be almost certainly of Scandinavian origin."* (Walton Rogers 1999, 158). The production of this braid from G47 is restricted to the Migration Period and is essentially a Scandinavian technique. Along with three other tablet woven bands (G62, G123 and G152) which also have close parallels in Norway and Sweden, it would seem to support Hines' view that wrist-clasps are indicative of a Scandinavian element in Anglian cemeteries (Walton Rogers 1999, 152). G152 also contained fragments of a fabric considered reminiscent of types produced in the Anglo-Saxon homelands during the centuries preceding the Migration Period. Whether this is a later copy or very old fabric is unclear (Walton Rogers 1999, 146). Finally, the diamond twill recovered from G74 is reminiscent of examples from trousers found in both southern Schleswig and northern Germany (Walton Rogers 1999, 157).

7.2.6 Samples

All the Anglian tooth samples were taken from Site 2 and specifically from areas 2B and 2BA (Figure 7.3). Teeth were sub-sampled from the selection already made by Christine Flaherty for aDNA analysis. Only enamel samples were analysed from this site as the pilot studies in Chapter Six had clearly demonstrated that dentine was an unreliable reservoir of biogenic Sr and probably biogenic Pb also. Putative migrants were sought in graves containing evidence of Scandinavian or Germanic material culture or burial rites and from graves possessing assemblages suggesting inhumation had occurred early in the life of the cemetery. One permanent tooth from 32 Anglian individuals were analysed plus as additional deciduous tooth from G97 making 33 teeth in total (Table A6, Appendix II). Samples were chosen to include adults and juveniles, males and females, those with weapons, jewellery, other types of grave goods and unaccompanied burials. Sampling was not, therefore, random. In addition, two burials from the Iron Age and six from the Late Neolithic/Early Bronze Age were also analysed bringing the total number of individuals to 40 (41 teeth). These individuals may throw light on *in situ* isotope change over time with different subsistence strategies and indicate the range of isotope ratios that could be obtained from individuals buried in this region during periods when migration from Scandinavia and northern Europe has not been proposed.

Unfortunately, as is often the case with archaeological case studies, the ideal sample selection was not available. Although constituting the largest data set in this study, 32 burials still comprises only a small sub-sample of the total Anglian burial population. Many burials were selected only to subsequently prove impossible to investigate. The reasons were varied but primarily stemmed from the very poor bone preservation encountered at this site. Individuals were not sampled in cases where no teeth survived, root dentine decay was extensive or complete, enamel was stained green from proximity to copper artefacts, or attrition was so severe that insufficient enamel could be removed for analysis. Of particular concern was the inability to obtain a suitable sample from any of the four graves containing bucket pendants, G87 (earliest grave goods in the cemetery) or a sufficient number of adult crouched burials without Anglian grave goods. Juveniles and individuals with no grave goods or an assemblage that included neither weapons nor jewellery were also particularly difficult to sample in sufficient quantities. Burials analysed are listed in Table 7.3. Notable burials which could not be sampled are listed in Table 7.1.

Table 7.1 Notable burials which could not be analysed

Grave No.	Attributes	Sampling problem
6	Prone burial, no grave goods	Preservation too poor
12	Early small-long brooches, earliest wrist clasps types in cemetery	Sole surviving tooth was copper stained
19	Weapon burial possibly associated with the horse burial G186	No surviving teeth
23	Elderly female with rare spin-patterned "piled" cloak – high status, imported item?	Severe attrition and copper stains on the few surviving teeth
47	Tablet braid of Scandinavian origin	No surviving teeth
62	Earliest wrist clasps type in cemetery	No surviving teeth
71	Well preserved male with non-weapon grave goods	No teeth available
72	Flexed, male weapon burial	No teeth available
83	Grave was cut by G87 (see below)	No surviving teeth
86	Extended coffin burial of aged adult – well-furnished jewellery burial with earliest wrist clasp type in cemetery	Severe attrition
87	Large, robust male weapon burial with earliest (C5) grave goods in cemetery – class E1 spearhead	No surviving teeth
92	Prone burial of very tall, gracile female isolated on edge of cemetery and squashed into very small, sub-circular pit	No surviving teeth

Grave No.	Attributes	Sampling problem
107	Adult crouched jewellery burial	No teeth available
130	Weapon burial in coffin	Preservation poor and attrition on the two surviving teeth severe
134	Well-preserved robust, aged male(?) burial with no grave goods but severe tooth attrition	Tooth obtained was small and has no attrition – unlikely to be from this individual
141	Penannular brooch	Preservation poor
143	Early disc brooch, earliest wrist clasps type in cemetery	Severe attrition on the few surviving teeth
147	Penannular brooch	No surviving teeth
148	Adult male? with no grave goods	No teeth available
152	Well-furnished burial with bucket pendants	No teeth available
155	Well-preserved male weapon burial	No teeth available
156	Adult crouched burial with no grave goods	Preservation poor
167	Well-furnished burial with bucket pendants	Only tooth had severe attrition
170	Crouched, robust adult with pottery sherds only	No teeth available
172	Juvenile burial with bucket pendants	Preservation poor and crowns incompletely mineralised
177	Well-furnished female burial with bucket pendants	No teeth available
184	Female weapon burial	Preservation poor

There were only 15 extant cremations excavated at West Heslerton; none were sampled. Tooth enamel does survive the cremation process, particularly if the teeth are unerupted or impacted and thus protected by the mandible or maxilla (McKinley 1989, 69). It is quite possible that the *in vivo* Pb and Sr isotope signature would survive the cremation process. Cremation would, however, have introduced an additional and currently untested variable and such research, whilst perhaps crucial to the question of early Anglo-Saxon migration in East Anglia, was not within the scope of this current project. Soil samples were taken of both the chalk and the sand in the vicinity of the now back-filled cemetery (Table A9, Appendix II). All burials were interred in chalk, sand or a mix of the two. As discussed in section 7.2.2, it is considered that crops were grown on this sandy soil, rather than on the small deposits of clay found locally or in the valley bottom and animals were grazed either within the immediate vicinity of the settlement or on the chalk uplands. Consequently, no soil samples from further afield were taken.

7.3 Results

Results are presented in Tables A1 and A4, Appendix I, and graphically in Figures 7.9 to 7.13 located at the end of the chapter.

7.3.1 Sr results

Sr enamel ratios appear to form a continuous string of data points between 0.7082 and 0.7110 (Figure 7.9). Sr isotope ratio errors are encompassed by the symbols and allow for both measurement and intra-enamel biological variation but not the variation observed between siblings in Chapter Six. Only 21 of the 40 individuals analysed fall between the local geological end members of the Cretaceous chalk leach and sea/rainwater and these are concentrated in the more radiogenic half of the "local" range, i.e. between the rainwater and sand ratios. It is noteworthy that the Sr isotope ratios obtained from Early Bronze Age and Iron Age individuals, as with the Pb isotope ratios, encompass virtually the whole range of values obtained from the Anglian population. None of the 13 juvenile samples have Sr isotope ratios greater than 0.709895 and only two juveniles (G97 and G122) have ratios greater than 0.709032. Five of the eight prehistoric samples fall within the local Sr isotope range bounded by the chalk and rainwater. Of the remaining three, 2BA229 and WHIA-2 have the most radiogenic values found at West Heslerton.

As was found in the modern and archaeological pilot studies, the majority of enamel-Sr concentrations are <100ppm. There is a weak negative correlation between Sr concentration and isotope ratio in the Anglian population (r_s = -0.24) which is not significant (P = 0.05). This may imply a tendency towards increased strontium content with less radiogenic Sr isotope ratios, i.e. in this case, more like the burial soils.

However, there is no correlation between enamel-Sr ratio and that of the corresponding burial soil or between enamel-Sr concentration and the burial soil. In contrast, a significant *positive* correlation (r_s = 0.75, P = 0.05) exists between Sr ratio and concentration for prehistoric individuals.

7.3.2 Pb results

Most enamel-Pb isotope ratios obtained at West Heslerton form a cluster within measurement error of each other and between the two geological end members provided by the sand and chalk leaches (Figure 7.10). Most also fall within, but on the very lower edge of, the field of English ore Pb. The cluster straddles the Pb ore growth curve. The exceptions are WHIA-1, WHIA-2 IR304, G98 and G151.

The prehistoric enamel-Pb concentrations are remarkably consistent: $\bar{x}$ = 0.06 ±0.02ppm (1σ), (n = 8, range 0.04 – 0.11 ppm) with only WHIA-2 over 0.08ppm (Figure 7.11a). These concentrations are of the same magnitude as those obtained from the Cnip Bronze Age individual (Chapter Eight). Anglian Pb concentrations are an order of magnitude greater than those from prehistoric individuals, but nevertheless are

still mostly within the range of what is considered today to be low Pb exposure (i.e. $<$ 2ppm). Thirty of the 33 enamel samples produced an average Pb concentration of only 0.34ppm (n = 30, σ = ± 0.23ppm, range 0.13 – 0.99ppm). The three remaining individuals have Pb concentrations >1ppm: G75 - 8.16ppm; G78 - 1.66ppm; G133 - 2.96ppm. All three are located in the centre of the Anglian isotope cluster. There is no statistical correlation at this site between enamel-Pb isotope ratios and concentration (Anglian $^{207}Pb/^{206}Pb$ r_s = 0.01, Prehistoric $^{207}Pb/^{206}Pb$ r_s = -0.29). However, Figure 7.11b shows that the six greatest Pb concentrations all have a $^{207}Pb/^{206}Pb$ ratio of 0.846. Figure 7.6a (section 7.4.3) shows the frequency distribution of $^{207}Pb/^{206}Pb$ ratios.

7.3.3 Pb and Sr results combined

The weak negative correlation between Sr and Pb concentrations of enamel in the Anglian population (r_s = -0.26) is not significant (P = 0.05) and is practically non-existent amongst the prehistoric individuals (r_s = -0.006). This indicates that Sr and Pb incorporation is not interdependent *in vivo* or during burial. Neither is there any significant statistical correlation between Sr ratio and any of the Pb isotope ratios amongst the Anglian population (n = 33), e.g. $^{87}Sr/^{86}Sr$ v $^{207}Pb/^{204}Pb$, r_s = -0.05 and $^{87}Sr/^{86}Sr$ v $^{207}Pb/^{206}Pb$, r_s = 0.11 are the "best" (Figure 7.12). However, there is a much greater correlation amongst the prehistoric individuals (n = 7), e.g. $^{87}Sr/^{86}Sr$ v $^{207}Pb/^{204}Pb$ r_s = -0.71 and $^{87}Sr/^{86}Sr$ v $^{207}Pb/^{206}Pb$ r_s = 0.78, although these just fall short of being statistically significant (P = 0.05, critical value = 0.79). Nevertheless, it does corroborate the conclusions reached in Chapter Six that the introduction of anthropogenic Pb traded over large distances appears to break the link between an individual and the place of origin in the case of Pb isotopes.

7.4 Discussion of results and data analysis

7.4.1 Diagenesis

Considering the poor skeletal preservation at West Heslerton, it is encouraging that, with perhaps one exception of an incompletely mineralised tooth (G98, discussed below), none of the enamel samples have equilibrated with their burial soil and consequently retain, to some degree, an *in vivo* Sr and Pb signature. Most tooth samples were macroscopically poorly preserved compared to those from other sites in this study. However, no clear association was apparent between skeletal preservation as a whole and individual teeth. For example, G166 was a relatively complete skeleton with >75% of the bone present but the tooth had an enamel/dentine preservation score of only 4/5. Conversely, G132 had 25-50% of the bone present but a much better enamel/dentine preservation score of 2/3. There is no statistical correlation between the preservation scores of enamel or dentine and either enamel-Pb or enamel-Sr ratios or concentrations (dentine was not analysed). Interestingly, the two Anglian samples possessing Sr isotope ratios *most* different from the burial soil leaches, are teeth where enamel preservation was graded as only satisfactory (preservation score = 4). Of the four samples with enamel graded as poor (preservation score = 5), two fall within the local end-members (G73 and G151) and two are more radiogenic (G74 and G75).

There is no correlation between Anglian enamel Sr or Pb isotope ratios and the ratios of the associated burial soil leaches, i.e. chalk or sand (e.g. $^{206}Pb/^{204}Pb$ r = -0.12,

$^{208}Pb/^{204}Pb$ r = 0.07). Neither is there any correlation between the amount of Pb or Sr in the enamel and the associated burial soil ratio, nor between enamel-Pb concentration and the presence of metal grave goods (r = 0.09), suggesting that burial context was not the factor determining the enamel ratios or concentrations. Furthermore, as at Monkton, the aqueous chalk leach produced so little mobile Pb that the sample could not be analysed by TIMS. There is, however, a significant correlation between the soil ratio and gross enamel preservation (r_s = 0.67, critical value 0.36, P = 0.05) (Figure 7.5). This confirms the observation made in Chapter Six that teeth from chalk burials have better preservation scores (i.e. 2 and 3), whereas those buried in sand are more variable (i.e. 2 to 5). Moreover, there is much more variability between the Pb isotope ratios of Iron Age and Early Bronze Age individuals than amongst the Anglian population and their Sr ratios encompass the range of Anglian ratios. There is no obvious reason why the Anglian burials should be prone to equilibration with the burial environment whilst the prehistoric burials, which have spent much longer in the same ground, should not.

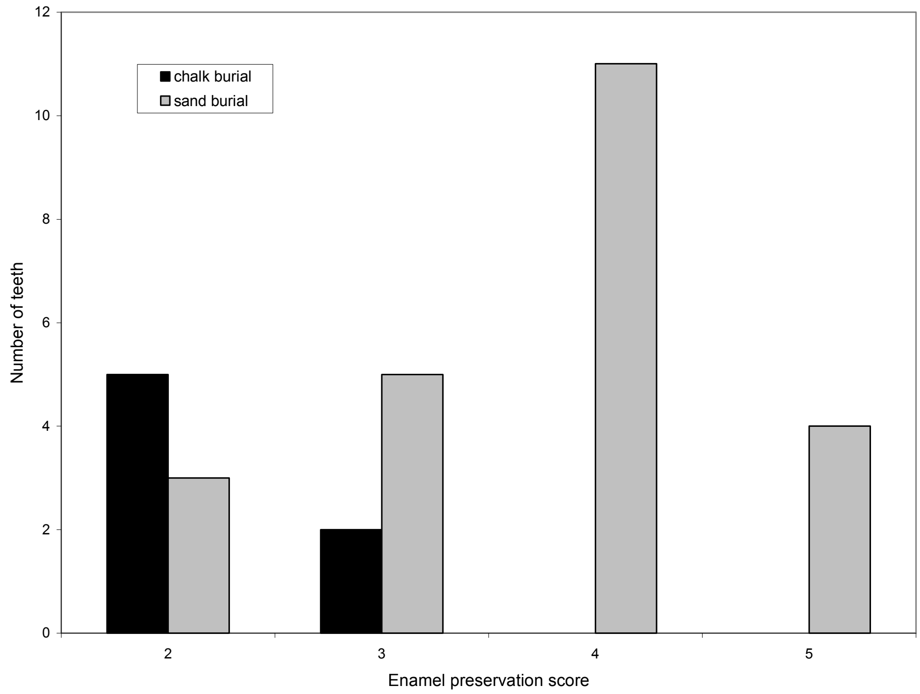


Figure 7.5 Histogram illustrating the relationship between the type of burial soil and the gross morphological enamel preservation at West Heslerton. Samples were scored according to Table 5.1 (2 = excellent, 3 = good, 4 = satisfactory, 5 = poor). See Table A6 for individual sample data.

The Early Bronze Age individual 2BA229 has the highest Sr concentration (256ppm) but crucially, the Sr isotope ratio *most* different from the local burial soils. From the evidence obtained so far, this amount of Sr would indicate either considerable diagenetic accumulation post-mortem or a childhood diet notably different in source and subsistence practices from that consumed by the majority of the individuals at West Heslerton. It would appear that, unless the *in vivo* Sr isotope ratio was *considerably* more radiogenic, little diagenetic Sr can have been incorporated in this sample and the difference is due to a non-local childhood diet higher in bioavailable Sr. Most of this evidence, therefore, suggests the enamel Pb and Sr results reflect *in vivo* values and that gross morphological preservation is not relevant to the integrity of the enamel isotope signatures. It is interesting to consider these results in the light of the assertion of Radosevich (see section 3.5.3) that good morphological bone preservation arises *because* of incipient fossilisation, and hence accumulation of mineralising elements such as Sr. Enamel, is already highly mineralised and these results suggest that poor preservation does not necessarily indicate a loss of the biogenic isotope signature, whereas the survival of less well mineralised tissue (including incompletely mineralised enamel) suggests, as at Monkton, early fossilisation.

Only two Anglian individuals (G98 and G151) have Pb isotope ratios out of analytical error of the rest of the Anglian population. The most straightforward explanation of this is that it is within the expected variation available from geological sources in the locality of West Heslerton, G98 having a predominantly sand-derived diet whilst G151 received a greater dietary input from chalk-derived sources. Clearly, at West Heslerton, such enamel values could equally arise from either *in vivo* natural or anthropogenic Pb exposure, or from post-mortem diagenesis from either the chalk or sand that comprised the burial context. However, both were sand burials, which effectively rules out extensive post-mortem Pb contamination in the case of G151, despite it being a very poorly preserved third molar (enamel and dentine preservation = 5).

However, it is necessary to consider diagenetic incorporation or turnover of Pb to explain the atypical Pb isotope ratios obtained from G98, as this was one of three juvenile teeth that were incompletely mineralised. The enamel Pb concentration (0.19ppm) is amongst the lowest found within the Anglian population and G98 also lies very close to the Sr isotope ratio of the burial sand leach. The other two incompletely mineralised teeth were chalk burials, but nevertheless had very similar Pb concentrations to G98 (G101 - 0.21ppm, G169 - 0.19ppm). Pb is both depleted and considered largely immobile in alkaline chalk (section 2.2.2 but see dentine diagenesis of Monkton samples in Chapter Six) suggesting that if post-mortem Pb incorporation had occurred in G98 it may contain more Pb than chalk burials. That it does not, is circumstantial evidence for a lack of post-mortem Pb incorporation but the results of the two Pb coffin burials in Chapter Six indicate post-mortem Pb incorporation is by no means a straightforward, nor necessarily inevitable, event. Moreover, the low-Pb concentration may be related to the low level of enamel mineralisation. G98 must, however, remain suspect as the *in vivo* concentration cannot now be ascertained with certainty. The tooth from G98 was the only one available from this child weapon burial and it was noted during sample preparation that it was very poorly preserved, incompletely mineralised and extremely difficult to prepare. It proved impossible to obtain an enamel sample that was not discoloured brown and quite a thick layer of soft enamel had to be removed from the tooth. No such difficulties were encountered when preparing G101 or G169.

The Pb mixing diagram (Figure 7.13) illustrates how the prehistoric individuals separate out from the Anglian. The majority of Anglian points fall within a small triangular "ore Pb field" enclosed by the hypothetical mixing lines extending from the leaches of chalk (both at West Heslerton and elsewhere in England) and the burial sand. The majority of prehistoric ratios are taken to represent the "natural" geological field without Pb ore inputs. There is no evidence from this diagram for post-mortem Pb diagenesis: burials show a trend with increasing Pb concentration towards a $^{207}Pb/^{206}Pb$ ratio of 0.846 rather than mobile chalk or sand-Pb. Similarly, G97, a child 8-9 years of age and the only extended burial of a juvenile under 12 years of age in the cemetery, shows this trend with increasing age (i.e. from deciduous tooth to permanent). This is a well-preserved, chalk burial (deciduous enamel preservation = 2, permanent enamel preservation = 3). The $^{207}Pb/^{206}Pb$ isotope ratio indicates a time vector from less like (deciduous), to more like (permanent), the local chalk with increasing age (Figure 7.13). However, the movement indicated by the Sr istope ratio is in the opposite direction and demonstrates a vector from chalk-like to less chalk-like in the later forming tooth (Figure 7.9). This could be interpreted as a change in dietary Pb source between the mother (i.e. *in utero*) and child and may indicate a migration in the intervening period. Alternatively, as shown by the mixing line, it could indicate incorporation of Pb into the permanent tooth (M^2R) relative to the deciduous tooth

(dm^2L) from the chalk in which both were buried. However, the results obtained from the molar tooth from the Spitalfields Pb coffin (Chapter Six) would cast doubt on this interpretation. The Sr results, however, complicate the issue as the two teeth show the opposite trend with time from more to less like the local signature in this individual.

Interestingly, this apparent contradiction of isotopic compositions has also been observed in a Neolithic juvenile (D) chalk burial from Monkton (Chapter Six). Currently, no sure basis for this phenomenon can be established but it could arise from several factors. Pb and Sr are not transferred identically *in utero* either from the mother's skeletal stores or diet. One element could, therefore, be derived from the mother's diet during pregnancy at her current place of residence whilst the other is derived from old skeletal stores, which may originate from somewhere different. Alternatively, as both are chalk burials, it is possible that either or both teeth have been affected by post-mortem diagenesis but both elements have not been incorporated from the chalk in a similar manner. For example, it is possible that in chalk, Sr is more mobile than Pb and, therefore, more likely to be derived from the burial environment than the Pb and that the deciduous tooth was more prone to Sr diagenesis than the permanent. The permanent tooth of G97, although unerupted, appeared fully mineralised but had an enamel preservation score = 3, i.e. slightly poorer than that for the deciduous enamel. Conversely, the permanent teeth of G97 and Monkton D had incomplete root formation whilst the two deciduous teeth were resorbing. Such a complex situation clearly requires more research but accumulating evidence from these teeth, as well as G98 and the modern subject MN, suggests the level of *in vivo* enamel mineralisation is more relevant to isotope analysis than post-mortem preservation. **Accordingly, it would be best to avoid incompletely mineralised enamel, and only sample recently mineralised (i.e. unerupted and rootless) and resorbing deciduous teeth of juveniles with extreme caution until their significance is resolved.**

7.4.2 Pb and Sr data

Of the individuals who fall outside the cluster of points (WHIA-1, WHIA-2 IR304, G98 and G151) only the first three prehistoric individuals appear to have had a different dietary source of Pb from both local geological sources and the rest of the West Heslerton population. WHIA-2 and especially WHIA-1 separate on both the ^{208}Pb and the ^{207}Pb plots and IR304 quite noticeably on the ^{207}Pb (Figure 7.10). WHIA-1 is more radiogenic (i.e. higher in all three ratios) than the West Heslerton chalk. However, results obtained from Cretaceous chalk leaches at Monkton-up-Wimbourne and Winchester indicate that chalk leaches can produce variable and considerably more radiogenic Pb isotope ratios that plot in this region. Moreover, enamel ratios similar to WHIA-1 have been obtained for some Neolithic individuals at Monkton-up Wimbourne in this study. However, a chalk source is simply one possibility; other unknown and unanalysed sources could also exist. Country rock Pb isotope ratios may plot below or above the growth curve depending on the relative enrichment (above) or depletion (below) of U or Th relative to Pb. The Pb source of WHIA-1 and IR304 would, therefore, appear to be enriched in U whilst that of WHIA-2 is depleted in both U and Th. All three individuals plot on the outermost edge of the English ore Pb field where only a very few outlying values for the North Pennines (WHIA-1 and IR304) or the Mendips (WHIA-2) are also found. It is unlikely, therefore, that such enamel-Pb values derive predominantly from exposure to anthropogenic Pb; they are much more likely to be related to underlying bedrock geology at the place of childhood residence.

The enamel-Pb concentration mean of 0.34ppm is an order of magnitude lower than concentrations obtained in this study from English burials from both the preceding late Roman period and the later Mediaeval period. It is comparable with those obtained from the Neolithic pre-metallurgical individuals from Monkton (0.15 – 0.68ppm, $\bar{x}$ = 0.31ppm, n = 7, Chapter Six). This would indicate the majority of the Anglian population had limited exposure to ore Pb and that the local country rocks contributed some of the Pb in their diet. The location of the West Heslerton enamel-Pb isotope ratios below the growth curve where the chalk and sand leaches are located adds weight to this interpretation. Moreover, the late Roman and Mediaeval individuals discussed in Chapter Six cluster above the growth curve and more towards the centre of the English ore field (Figure 6.19). Protection from Pb uptake is derived from high-Ca and high-phytate, provided by hard water sources and high cereal diets (section 2.3.4). As the West Heslerton inhabitants probably obtained their water from the spring emanating from the chalk Wolds at the centre of the settlement and were cultivating cereal crops, this may have contributed considerably to their low Pb burden. The restriction of the greatest Pb concentrations to ^{207}Pb/^{206}Pb ratios of 0.846 implies that whilst low Pb concentrations can be obtained over a wide range of Pb isotope ratios, concentrations

≥1ppm can only be obtained from a source or sources possessing a $^{207}Pb/^{206}Pb$ ratio ~0.846. Clearly, this source is Pb-rich and most likely to be of anthropogenic, rather than geological, origin. Results from other post-metallurgical individuals investigated in Chapter Six with >1ppm Pb follow the same trend and have $^{207}Pb/^{206}Pb$ between 0.846 and 0.849. These Pb isotope ratios are typical for English ore Pb (Table 2.1).

There appears, therefore, very little justification to explain the Anglian Pb data as arising by anything other than residence in England and exposure to characteristically English ore and country rock Pb isotope ratios. Very similar, but more tightly focussed, isotope ratios have been obtained from Mediaeval and Late-Roman individuals at other sites in this study such as Blackfriars, Mangotsfield and Winchester. However, the observation that very similar isotope ratios are obtained from people in different parts of England suggests that metal products were transported over great distances and, therefore, reveals more about trading patterns than movement of people. English Pb was exported to Continental Europe during the preceding Roman period (Tylecote 1992, 71) and may have remained in circulation there enabling immigrants to be exposed to it prior to arrival at West Heslerton. Nevertheless, resulting enamel-Pb burdens at West Heslerton were not as high as in the preceding Roman period or the Late Mediaeval period and the isotope signatures are more diffuse. They are however, more tightly clustered than those of the prehistoric individuals which implies an isotopically uniform source that swamped the natural geological variation suggested by the Sr data (section 7.3.2). Furthermore the co-incidental presence of the two end members of the chalk and sand encompassing the English ore Pb signature indicates that locals would be expected to fall within this range in pre-metallurgical periods also.

The observed Sr isotope ratio variation is quite wide and seems unlikely to stem solely from *in situ* population variation. Twenty-one individuals fall between the local geological end members of the Cretaceous chalk leach and sea/rainwater and these are concentrated in the more radiogenic half of the local range, i.e. between the rainwater and sand ratios. This suggests that these two inputs made a greater contribution to the local diet than Sr derived from the chalk uplands. The greater Sr isotope ratio variation found amongst the Early Bronze Age and Iron Age individuals, as with the Pb isotope ratios, suggests all of the Sr isotope ratios obtained may have an English, and possibly local, origin. However, the majority of juveniles and prehistoric individuals fall within the local Sr range bounded by the chalk and rainwater. It is interesting to note that WHIA-2 has a more radiogenic Sr isotope ratio than WHIA-1 and a Pb isotope ratio on the edge of the English ore field, whilst WHIA-1 has enamel-Pb and Sr isotope ratios more like chalk signatures than WHIA-2 (Figures 7.9 and 7.10). This evidence argues that both Sr and Pb signatures were still derived from country rock and remain unaffected by anthropogenic exposure during the Iron Age. The enamel-Sr concentrations (<100ppm) are at the lower end of known human concentrations but widely found in contemporary British populations consuming a high-dairy diet (i.e. 50 – 300ppm, Chapter Two) and in line with modern enamel-Sr concentrations obtained in this study (Chapter Six). Such physiologically low concentrations do not require justifying in terms of significant incorporation of soil derived Sr. However, this is circumstantial evidence only, as it is clear that in dentine, although rarely in enamel, both addition *and* turnover of Sr can occur (Budd *et al.* 2000a).

7.4.3 Pb data analysis

Although West Heslerton represents the largest number of samples from a single site in this study, it still numbers only 40 individuals (two teeth were analysed from juvenile G97 making 41 measurements in total). Even if all individuals proved to be of local origin, it is by no means certain if this is a sufficient number to properly characterise the local isotope field as the sample size required depends on the specific model appropriate for describing the field (Baxter *et al.* 2000, 979). Furthermore, sampling was not random; samples were deliberately chosen in an attempt to investigate certain specific attributes such as weapon burial and further constrained by skeletal preservation. Neither is it likely that the extent of variation will be the same at every site – the underlying geology may be more, or less, homogeneous and the factors affecting the resulting weighted mean will vary both in number and magnitude from site to site. Many statistical tests may not, therefore, be valid. Moreover, it has been pointed out that the data points that characterise a Pb isotope ore field are far more likely to have a non-normal than normal distribution, being bi- or multi-modal (Baxter 1999, 123; Baxter *et al.* 2000, 979). However, it appears that the $^{207}Pb/^{206}Pb$ results from West Heslerton are uni-modal and exhibit a considerable degree of kurtosis

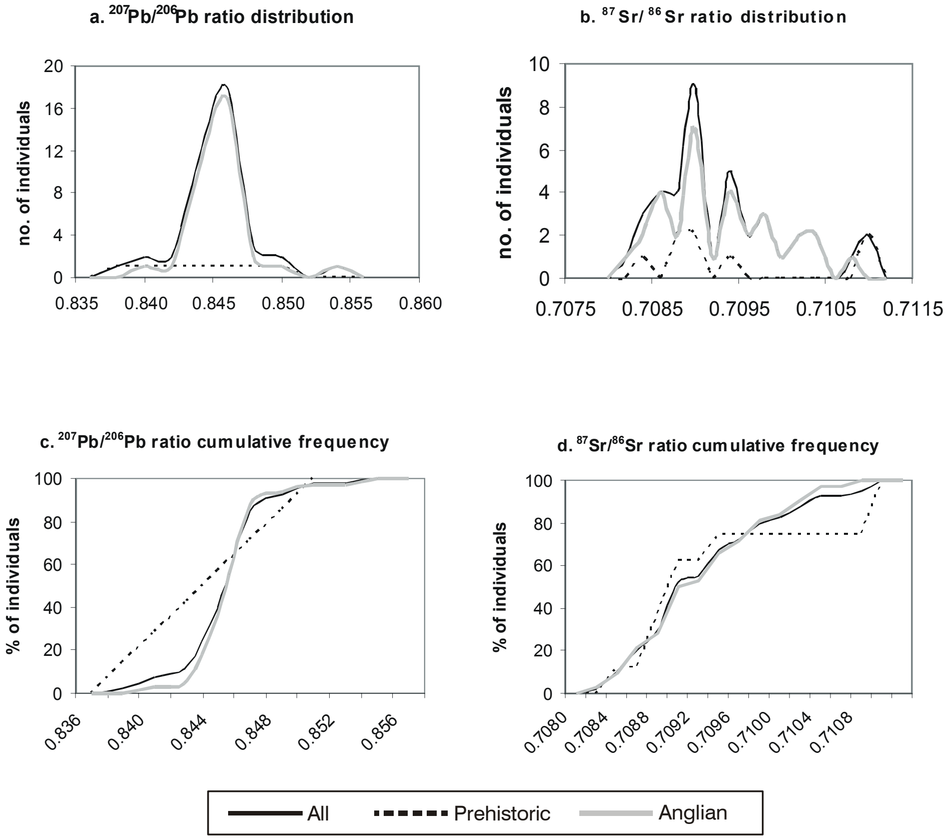
(kurtosis = 4.3) and slight skew to more positive values (skew = 0.45) (Figure 7.6a, c and e). An assumption of normality can, therefore, be made.

Dispersion and central tendency are given in Table 7.2. The results do not include the prehistoric individual 2BA589 for which no Pb isotope data was obtained or the additional tooth (deciduous) for G97. Only one measurement for each individual was used.

Table 7.2 Statistical analysis of $^{207}Pb/^{206}Pb$ enamel ratios

	Anglian adults	**Anglian juveniles**	**Anglian**	**Prehistoric**	**Adults**	**Juveniles**	**Total**
n	22	10	32	7	26	13	39
$\bar{x}$	0.845	0.847	0.846	0.845	0.845	0.847	0.846
σ	0.0018	0.0029	0.0023	0.0043	0.0024	0.0030	0.0027

Characterising the isotope fingerprint of a population is not the same process as characterising an ore-deposit. The former is the result of one or more dietary inputs of varying concentrations and ratios, during a restricted childhood period with a single resulting weighted mean value. The latter is characterised by many separate determinations of specific and discrete ore samples. Obtaining a Pb isotope value from an individual is, therefore, somewhat akin to producing a pewter bowl by combining and homogenising several pieces of scrap metal, those of a small farming community represented by many such pewter bowls. The community would, therefore, be expected to have a small range of values normally distributed about a mean. Any outliers would have had one, or more, very different dietary inputs during childhood. It follows that under these circumstances outliers, rather than being the result of normal statistical spread may have a valid and important reason for being so. As Shennan (1988, 46) states: *"When such peculiarities as skewness, multiple peaks or the presence of outliers (values very different from the bulk of the observations) do exist, the shape of the distribution, rather than its central tendency or dispersion, is likely to be its most important characteristic"*.



e. Numerical summary of $^{207}Pb/^{206}Pb$ ratios

	Minimum		Lower hinge		Median		Upper hinge		Maximum
Ratio	0.838		0.844		0.846		0.846		0.855
Interval		0.006		*0.002*		*0*		0.009	
Spread			**0.008**		0.002		**0.009**		

f. Numerical summary of $^{87}Sr/^{86}Sr$ ratios

	Minimum		Lower hinge		Median		Upper hinge		Maximum
Ratio	0.708228		0.708915		0.70916		0.70988		0.71108
Interval		687		*245*		*720*		1200	
Spread			**932**		965		**1920**		

Figure 7.6 Preliminary statistical analysis of the $^{207}Pb/^{206}Pb$ and $^{87}Sr/^{86}Sr$ ratios for the West Heslerton enamel samples. Note the near normality of the $^{207}Pb/^{206}Pb$ distribution compared to the non-normality of the $^{87}Sr/^{86}Sr$ ratios. Note that only one individual is present in the $^{87}Sr/^{86}Sr$ range 0.7092-0.7094.

Figure 7.6a illustrates that the Anglian $^{207}Pb/^{206}Pb$ data from West Heslerton is almost symmetrically distributed. This supports the interpretation that the individuals at this site belonged to a single statistical population with the spread of values resulting from normal statistical spread around a mean, i.e. there is no evidence from the Pb data of the existence of two discrete groups representing an indigenous and a migrant population. However, this distribution would also occur in populations spread over a wide geographical area if they were all exposed to a low level of traded Pb products such as pewter tableware, Pb pipes and water vessels originating from a single source. In effect, they would appear to come from the same population but this would be a population identified by status (e.g. access to Pb artefacts) rather than its geographical origins. This would make immigrants difficult to distinguish from the indigenous population using Pb isotopes. The degree of kurtosis and slight skew towards the centre of the ore Pb values would support the choice of anthropogenic rather than natural Pb sources for the Anglian population at West Heslerton. It is clear from Table 7.2 that the mean $^{207}Pb/^{206}Pb$ ratio is similar across all groups although juveniles have a slightly higher mean value. However, this is because the outlier G98 ($^{207}Pb/^{206}Pb = 0.855$) has a significant effect on the small sample number. This sample is probably affected by post-mortem contamination. The mean and standard deviation ($\bar{x} = 0.845$, $\sigma = \pm0.0013$) was identical between the Anglian males (n = 6) and females (n = 11) indicating no differences in Pb exposure between the sexes.

The prehistoric data are more variable although the sample number is small (n = 7). The data clearly demonstrate the variability amongst individuals during the prehistoric periods prior to the large scale Pb extraction that occurred during the Roman period. It contrasts with the increasing homogeneity seen in individuals exposed to Pb in later periods (Figure 9.3). The mean value and standard deviation of all individuals at West Heslerton ($\bar{x} = 0.846$, $2\sigma = \pm0.0054$) is, however, within the range of known English ore Pb (Table 2.1). The Pb data, therefore, does not demand an explanation in terms of origin outside England, although due to the possibility of English Pb exports in preceding centuries, neither can it rule it out.

7.4.4 Sr data analysis

Of considerably more promise for the identification of immigrants at West Heslerton is the apparent non-normality of the Sr data in the total data set and specifically in the Anglian population (Figures 7.6b, d and f). Rather than forming the normal distribution expected from a single sedentary community, the Sr isotope ratios suggest bi-modality. There is only a single individual between 0.70919 and 0.70948. It is possible that this gap in the data is an artificial one resulting from too small a sample and the data may actually form a log-normal distribution, which is commonly found when a single measurement is taken on each of a number of biological specimens (Miller & Miller 1993, 38). Neither is there any significant correlation between age at death and Sr isotope ratio (r_2 = -0.1, P = 0.05).

However, this absence of data points coincides with the watershed immediately beyond the West Heslerton Sr isotope ratio end member of the estimated rainwater value of 0.7092. As discussed above in the context of Pb, bi- or multi-modality would not be expected in a sedentary, farming community unless there was a marked difference in access to food sources between two groups of children. An individual living at West Heslerton yet possessing a Sr isotope ratio greater than 0.7092 would have to have ingested a more radiogenic source of Sr that represented a considerable proportion of their dietary Sr in order to balance the local inputs from the chalk, sand and rainwater. "Non-local" signatures may also result from an imported rich source of radiogenic Sr (e.g. plants, not meat and milk which are low in Sr); a greater subsistence role for the small areas of clay in the vicinity of the settlement; the individual living elsewhere during the period of enamel formation, possibly following a different subsistence strategy.

Non-parametric box and whisker plots have been used to display the Sr isotope ratio data (Figure 7.7). 50% of individuals are enclosed within the box with the median value indicated by a vertical line. The crosses indicate the actual range of the data with dots representing possible outliers. Enamel ratios of the individuals dying in childhood (n = 13), i.e. a short life span, have a different and much more tightly constrained distribution than those who attained adulthood. In the Anglian plots particularly, the boxes do not overlap. As enamel retains childhood ratios, this difference should not arise as a function of different access to food products between adults and children; enamel provides a direct comparison between the childhood diets of all individuals. The juvenile distribution also coincides with the local parameters, suggesting that the majority of individuals who died at a young age were of local origin (Figures 7.8 and 7.9). This would be expected, as the window in which they could have undertaken a long-distance migration is considerably smaller. The time-depth perspective offered by the prehistoric individuals also displays a more restricted Sr isotope ratio range skewed towards local values. In contrast, the Anglian results appear almost symmetrically distributed but this plot obscures the scarcity within the box of data points between 0.70919-0.70948.

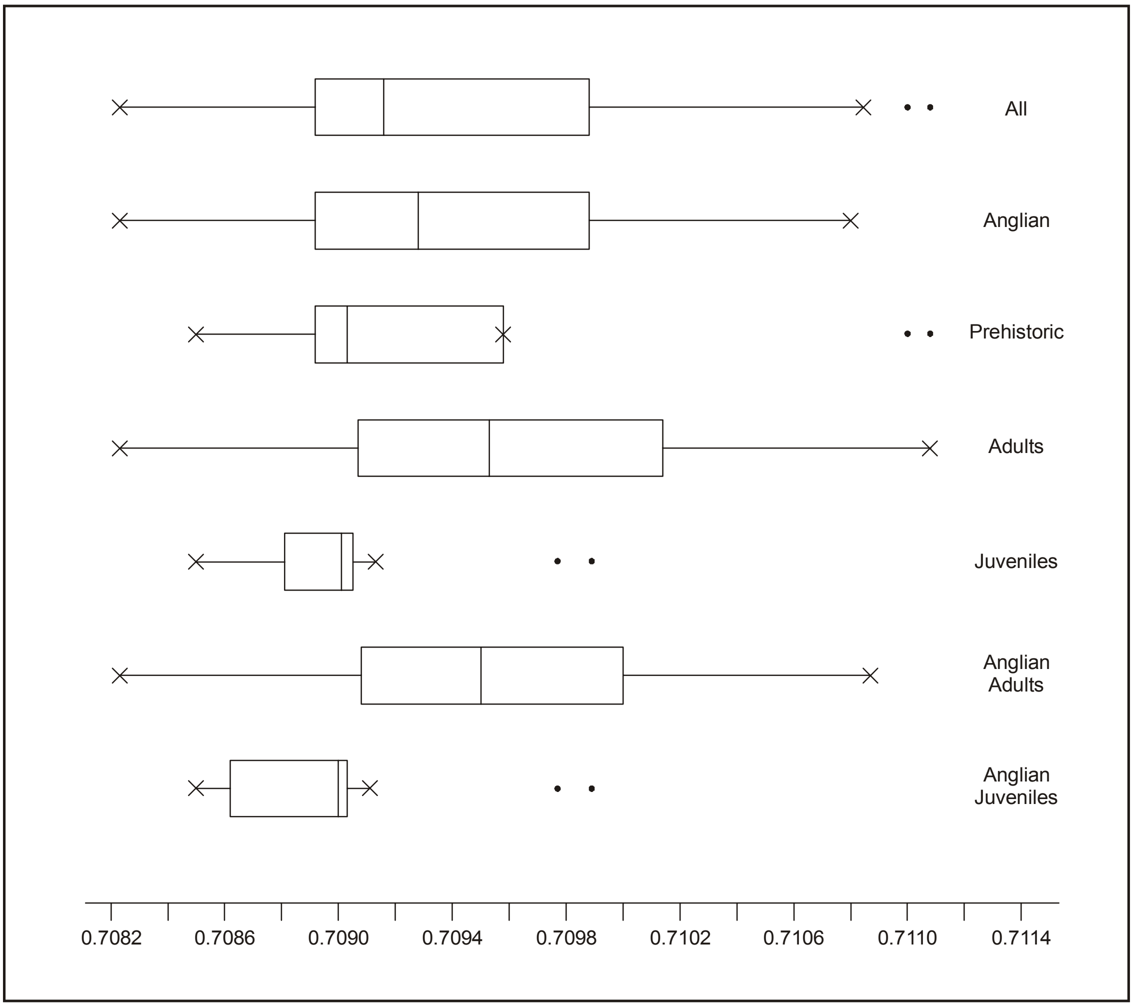


Figure 7.7 Box and whisker plots of the $^{87}Sr/^{86}Sr$ data for West Heslerton enamel samples. Note that both prehistoric individuals and all juveniles have a distribution tending toward lower $^{87}Sr/^{86}Sr$ ratios.

Two outliers appear to be present in both the prehistoric (n = 8) distribution and that of the children (n = 13). Both groups are relatively small sample sets. Parametric statistical tests for outliers, such as the Dixon's *Q*-test, should not be used if, as in the case of this whole data set, there is doubt about the population distribution (Miller & Miller 1993, 65). However, if the prehistoric sample and that of the children are taken as separate populations the Dixon's *Q*-test would allow all four points to be excluded as outliers at the 95% confidence interval.

In their study of Bell Beaker burials from the predominantly Tertiary and Jurassic deposits of Bavaria, which had a very similar range of skeletal Sr isotope ratios to West Heslerton, Grupe *et al.* (1997) discussed two methods of identifying immigrants in their sample of over 60 individuals. One criterion required a minimum difference of 0.001 between the Sr isotope ratio of the enamel and the bone from each individual, and the second more cautious estimate, a ratio greater than $\bar{x} + 2\sigma$ of all bone isotope ratios. The cut-off identified by the second method also coincided with a gap in the spread of enamel ratios. Their analysis was criticised by Horn and Müller-Sohnius (1999) for the use of bone samples in this way as they believe they are heavily and irrevocably contaminated with Sr from the burial environment. Moreover, they questioned the validity of treating data from eight different burial sites, which appeared to have different diagenetic Sr signatures, as one statistical population. Horn and Müller-Sohnius (1999) recommend using $\bar{x} \pm 4\sigma$ of the enamel ratios to establish a cut-off where $n \geq 10$. This, of course, assumes that the data are normally distributed and the seven individual immigrants they identify using this method are, nonetheless, all clearly visible as outliers when plotted by graphical means. It is not possible to replicate these three approaches at West Heslerton; no bone analyses were undertaken due to concerns regarding diagenetic alteration raised by the paired enamel/dentine analyses carried out in the pilot studies (Chapter Six) and the inability of Sr solubility profiling to rectify this reported in Trickett's subsequent study (1999).

If all the juveniles at West Heslerton ($n = 13$, $\bar{x} = 0.709027$, $\sigma = 0.000411$) are taken as the best estimate of local tooth enamel values, the three methods above would give the cut-off for immigrants as:

1. $\bar{x} + 0.001 = 0.710027$ producing 8 adult immigrants
2. $\bar{x} + 2\sigma = 0.709849$ producing 1 juvenile and 10 adult immigrants
3. $\bar{x} + 4\sigma = 0.710671$ producing 3 adult immigrants

The magnitude of the required cut-off will be very specific to the local area and its geology, rendering each site different. A fixed value of 0.001 may be applicable to an area of Bavaria but may not be so at West Heslerton, although both are located on lithologies <190Ma old. Using the mean plus multiple standard deviations is also problematic because enamel ratios higher or lower than the local range, intra-tooth variability or measurement error do not arise from random experimental error. They can only be obtained if the individual had a different diet whilst the analysed tooth was forming. Alternatively, retrospective characterisation of the local food chain, i.e. soil, water, plants and animals (although one or more may exert a disproportionate affect the resulting Sr isotope ratio) may be attempted. Such parameters along with nutritional guidelines and archaeological evidence for trade, subsistence and the extent of food importation from outside the locality, could be used to define the extremities of the local signature.

Consequently, four hypotheses can be made to explain the distribution of the Anglian Sr isotope ratio data at West Heslerton:

1. The chalk, sand and rainwater ratios are insufficient to fully characterise the range of environmental parameters and a more radiogenic Sr food source exists nearby.
2. The Anglian inhabitants were importing a large amount of food (or conversely a smaller amount of Sr rich food) from a region with a more radiogenic Sr signature.
3. The West Heslerton dietary Sr signature lies within the measured environmental parameters and individuals falling outside this have moved to the area from elsewhere.
4. Some or all of the enamel Sr isotope ratios were considerably more or less radiogenic prior to burial and have since equilibrated with the burial soil to a greater or lesser degree.

Can a case be made, therefore, that the sample of individuals taken from West Heslerton consists of an immigrant and an indigenous population? It is clearly more difficult to identify two populations rather than individual outliers, and particularly so if some degree of overlap between the two is present (Price *et al.* 2002, 129). If the two outliers present in both the juvenile and the prehistoric sample set are deemed non-local and removed, then both sample sets seem to derive from a different and much more constrained population than the Anglian adults, despite all enamel signatures deriving from childhood. The Anglian adult distribution appears to be at least bi-modal and this may be evidence for the presence of a local and one, or more, non-local groups in the cemetery, e.g. northern Europe and western Norway.

To investigate whether any archaeological criteria can be used to support the isotope interpretation, the sample data have been grouped according to Sr isotope ratios into the following two groups (Table 7.3):

1. The local population with Sr isotope ratios ≤0.7092
2. A putative non-local population with Sr isotope ratios >0.7092

Table 7.3 Anglian burials separated into Local and Non-local groups using $^{87}Sr/^{86}Sr$ ratios

1. Local $^{87}Sr/^{86}Sr$ ratios ≤0.7092					**2. Non-local $^{87}Sr/^{86}Sr$ ratios >0.7092**				
Skeleton code	**Sex**	**Grave goods**	**Position**	**Side**	**Skeleton code**	**Sex**	**Grave goods**	**Position**	**Side**
G73	U	W	Fl	Su	**G74**	U	W	Fl	Rt
G98	Juv	W	Fl	Lt	**G75**	U	W	Ex	Su
G100*	Juv	J	Cr	Rt	**G78**	F	J	Ex	Su
G101*	Juv	N	Cr	Lt	**G84**	F	J	n/k	Rt
G113*	F	J	Fl	Pr	**G89**	?F	J	Ex	Pr
G115	?M	W	Fl	Lt	**G97***	Juv	J	Ex	Su
G117	Juv	O	Cr	Lt	**G102***	F	J	Cr	Rt
G132	Juv	J	Bn	Pr	**G109**	M	O	Fl	Su
G139	F	J	Cr	Su	**G114**	F	J	Bn	Pr
G144	F	W	Ex	Su	**G122**	Juv	J	Fl	Su
G151	U	W	Ex	Su	**G133**	F	N	Ex	Su
G154	Juv	J	Cr	Rt	**G145**	M	N	Fl	Su
G159	F	O	Ex	Su	**G149**	M	N	Cr	Rt
G162	Juv	N	Fl	Lt	**G158***	M	W	Ex	Su
G166	F	N	Fl	Pr	**G164**	F	W	Fl	Su
G169*	Juv	N	n/k	n/k	**G173**	U	J	Fl	Lt

Key to groups
Sex (osteological or DNA): M = male, F = female, U = undetermined, Juv = juvenile
Grave goods: W = weapons, J = jewellery, O = other, N = none
Position: Ex = extended, Fl = flexed, Cr = crouched, Bn = bound
Side: Su = supine, Pr = prone, Lt = left, Rt = right
* indicates burials made directly into chalk

7.5 Discussion of archaeological indicators of migration

7.5.1 Cemetery development and grave location

Twenty-two of the 32 Anglian individuals analysed could be assigned to a development phase of the cemetery (Haughton & Powlesland 1999b, 82). Precise dating and chronology is problematic in Anglian cemeteries and many burials had a wide date range that encompassed 100 to 200 years. Only five burials were constrained to a single phase (i.e. 50 years), two in phase II (non-local: G122 and local: G159) and three in phase III (non-local: G113 and G132 and local: G114). As can be seen in Table 7.4 early burials were not confined to the non-local group nor were late burials confined to the local group, although non-local burials tend to have earlier possible phase dates. The presence of non-locals in all phases is consistent with a migration stream which can continue for many years between the place of origin and settlement (Anthony 1990, 903). Neither does the observed distribution provide evidence for the *absence* of migration at West Heslerton.

Table 7.4 Distribution of dated burials between local and non-local groups

Earliest possible phase	Local group	Non-local group
I (450-500AD)	4	7
II (500-550AD)	5	3
III (550-600AD)	2	1
Latest possible phase		
II (500-550AD)	2	3
III (550-600AD)	6	5
IV (600-650AD)	3	3

The burials in the two defined groups are located throughout area 2BA and follow no discernible cluster or pattern (Figure 7.8). This supports the excavator's interpretation of polyfocal cemetery development, i.e. burial in household groups rather than spreading out chronologically from a single origin. Arranging burials in household groups will cause second and subsequent generations to be buried amongst the initial founding burials. Neither is there any evidence for the clustering of local individuals, which might have indicated the presence of "British" households at West Heslerton.

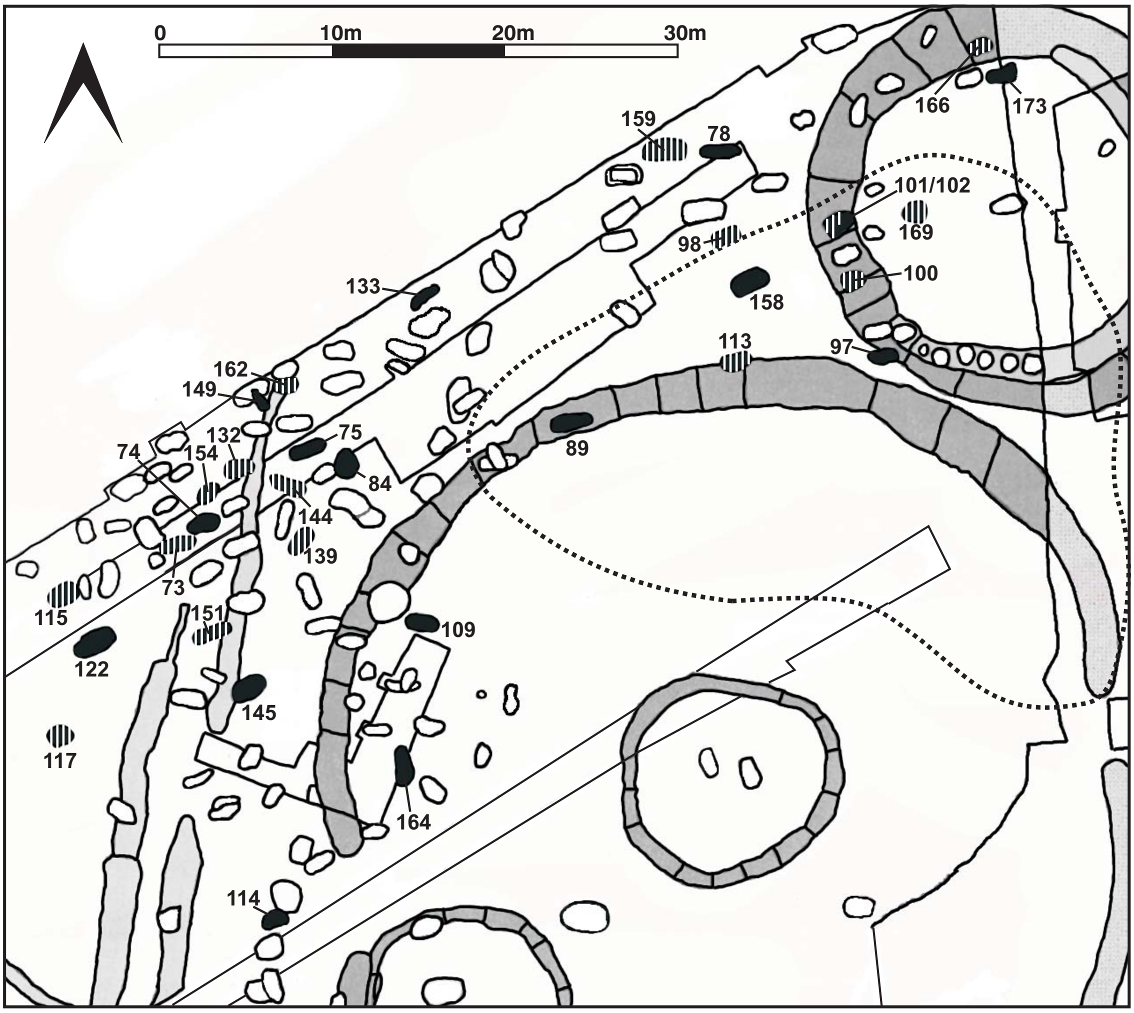


Figure 7.8 Plan showing the locations of "local" (hatched) and "non-local" (black) burials at West Heslerton. Note that in the mother (102) and child (101) double burial the mother is in the "non-local" group and the child is in the "local" group.
Adapted from Haughton and Powlesland 1999.

7.5.2 Skeletal

Females are evenly distributed in both residence groups whereas all the males that were securely sexed by osteological methods fall into the non-local group (Table 7.3). There is, however, no statistically significant correlation between sex and Sr isotope ratio (r_2 = -0.02, P = 0.05) nor between sex and group. One ?male and two unsexed adult weapon burials fall into the local group. However, as there are three known female weapon burials at West Heslerton it cannot be assumed that these are male burials. Of the two elderly, female weapon burials analysed, G164 has the most radiogenic Sr of all the Anglian burials, i.e. the "most" non-local, whereas G144 has a local signature.

Although the few juveniles that were accorded burial in the cemetery were clearly special in some way and cannot therefore be regarded as representative of West Heslerton juveniles as a whole, 8 of the 10 analysed fall into the local group. The two non-local juveniles, a child of 8-9years (G97) and an adolescent of 12-15years (G122) were both buried with jewellery.

Adult weapon burials are present in both local and non-local groups suggesting that it was not just the first generation settlers who were accorded this rite, which provides support for Härke's (1990) suggestion that it was reserved for individuals of Germanic descent. In six burials the later forming M3's were analysed: G115, G132, G151 fell into the local group whilst G84, G102 and G173 were non-locals. These last three must have moved after the formation of the third molar, i.e. during or after adolescence or early adulthood. As two were females and the third a jewellery burial where sex was undetermined, this would suggest that the non-local group included adult females of marriageable age. This evidence does not support the settlement at West Heslerton of an elite band of exclusively male warriors but suggests that some were present and made the journey accompanied by females, children and males who were not accorded burial with weapons.

G144, a local burial, had an unusual deformity of the tooth root, noticed during sample preparation which bore a remarkable similarity to the malformations seen in the Early Bronze Age teeth from 2BA283 and 2BA589. Extra cusps were noted on the teeth of four Anglian individuals (Cox 1999, 182), three of these were analysed (G98, G113 and G166) and all three fell into the local group, the latter two being adult female prone burials. Thirteen burials at West Heslerton had congenitally absent M3's (Cox 1990, 27; Cox 1999, 182). Seven Anglian and one Early Bronze Age burial (2BA283) were analysed from this group. All but one fell into the non-local group although unfortunately, this was not the Early Bronze Age burial but an Anglian one (G139). The majority of individuals at West Heslerton had an edge to edge bite. G78 was unusual, however, for a marked overbite (Cox 1999, 181) and fell into the non-local group.

G164 was a non-local burial displaying unusual cranial sutures: an inca bone and 3 large ossicles at lambda (Cox 1999, 179). If the weaponry buried with this adult female indicates Germanic origin, it would contradict the conclusions reached by Härke (1990, 42) that wormian bones were negatively correlated with weapon burials and hence, Germanic descent. G158, a weapon burial was a robust male and the tallest recorded individual, he falls into the non-local category. However, not all non-local males were tall: G145, a burial with no extant grave goods, was of short stature at 163.3cm (Cox 1999, 178).

7.5.3 Burial practice

There is no significant correlation between Sr isotope ratio and either burial position (e.g. crouched, extended), burial side (e.g. prone, supine) or grave alignment (e.g. north, south). Crouched and prone burials appear in both the local and the non-local groups. The majority of crouched burials are those of juveniles and this is equally likely to be explained by the fact that it was a favoured burial rite for children rather than that they were native Britons. However, all crouched juvenile burials did fall within the local group whereas of the two juveniles who did not, one was flexed and one was extended. The two adult crouched burials in the non-local group are those of an adult male (G149), aligned NW-SE with no extant burial goods and an adult female (G102) buried with her 6-year-old son (G101) (result of aDNA analysis, C. Flaherty pers. comm.). It is very likely that the crouched position of G102 resulted from being curled around the body of her child when the double interment took place. Furthermore, the child has a local and consequently different Sr isotope ratio to his mother. This indicates that the source of his dietary-Sr at the time of crown mineralisation was different to his mother's (P_2L crown mineralisation occurs between ~2-8 years), and constitutes evidence for a move by the mother from more radiogenic (e.g. older) to the less radiogenic substrates found at West Heslerton after mineralisation of her M3 crown (approx. >12 years).

G149 is a crouched burial with no Anglian grave goods that, according to Faull (1977), is indicative of a native British burial. However, his Sr isotope ratio is one of the highest found at West Heslerton and indicates an origin on more radiogenic and perhaps older geology which, in England, is found to the north or west of the site. It raises the possibility, therefore, that he could have moved to West Heslerton from surrounding non-Anglian areas. Nevertheless, his Pb isotope ratio and concentration does not distinguish him from other individuals at the site and his position is not that of the traditional tightly crouched posture. Rather, with the femora at ~90º to the torso, he seems to have been fitted into a too-small grave cut. The third crouched adult burial analysed (G139), is a local female, aligned NE-SW but buried with Anglian jewellery. Once again, the angle of the femora is ~90º and appears to have occurred as a result of the knees being drawn up against the grave wall to accommodate the body in a too-small grave.

Of the prone burials, three are designated as locals and two as non-locals. Four were furnished with jewellery and therefore, unlikely to represent the burials of British slaves. The female without burial goods (G166) is in the local group and is a strange burial where the body was twisted awkwardly to fit a too-small grave and the spine broken. However, the shape of her cranium was dolichocranic, the predominant cranial index at West Heslerton, and did not mark her out as different. Also in the local group are the two prone and possibly live burials (Haughton & Powlesland 1999b, 92), that contained amongst the jewellery assemblage the walnut amulets that appear to be unique to this site. Their significance is uncertain but it has been suggested they may have been fertility charms or religious amulets (Haughton & Powlesland 1999b, 119). Both were young individuals: G113 a female aged ~20 years old and G132 an adolescent male (result of aDNA analysis, C. Flaherty pers. comm.).

7.5.4 Grave goods

There is no correlation between Sr isotope ratio and the type of grave goods (weapons, jewellery, other and none). All four categories are found in both local and non-local groups, thus indicating social status is not associated with a presumed local or non-local origin. Males with and without weapons are found in the non-local group. However, G74, the only sword burial and thus a possible contender for a founder burial, which also contained fabric reminiscent of examples found in southern Schleswig and northern Germany, is in the non-local group.

All three analysed burials containing wristclasps (G89, G97 and G173) amongst the grave assemblage fall into the non-local group. As Hines (1984, 109) regarded this artefact as the most diagnostic of the presence of immigrants from Norway in the population, this is particularly interesting. The wristclasps in G173 are amongst the earliest in the cemetery (late 5th to mid-6th centuries) and this individual has one of the most radiogenic Sr signatures amongst the Anglian population. The other juvenile in the non-local group (G122) is an early Phase II jewellery burial containing a mid-5th century equal armed brooch, the only one found at West Heslerton. The distribution of this brooch is restricted to Norway and Sweden and this example is believed by Hines (1984, 259) to be from a Norwegian source. Moreover, G78 and G84 both in the non-local group, contained the earliest cruciform brooches (early 6th century) found at West Heslerton as well as early 6th century Scandinavian style small-long brooches.

Table 7.5 Distribution of grave goods in jewellery burials

Skeleton code	Annular brooch	Cruciform brooch	Small Long brooch	Equal Armed brooch	Wristclasp	Girdle-hanger	Latch- lifter	Purse & Walnut amulet	Vessel
1. Local $^{87}Sr/^{86}Sr$ ratios ≤0.7092									
G100	✓								Pottery
G113	✓					✓	✓	✓	
G132	✓						✓	✓	
G139	✓					✓	✓		Pottery
G154			✓						
2. Non-local $^{87}Sr/^{86}Sr$ ratios >0.7092									
G78	✓	✓	✓						
G84		✓	✓						
G89	✓				✓				
G97	✓		✓		✓				
G102	✓								Wood
G114	✓								
G122				✓					Wood
G173	✓	✓			✓		✓		

All three burials containing cruciform brooches (G78, G84 and G173) were in the non-local group. In the local group were G159 a burial accompanied by a single amber bead and therefore thought to be an early burial, as is the child buried in G154 which also contains an early copper alloy disc brooch. G139 is in the local group and contained a scutiform pendant dating from the beginning of the 5th century. Table 7.5 suggests other possible divisions of grave good types between the local and non-local group, such as the type of vessel, girdle-hangers, purses and walnut amulets but the distribution may be a product of too small a sample size. Clearly, the ubiquitous annular brooch occurs in both groups and does not appear to be indicative of origin. However, this result may be simply a matter of their greater frequency and the same situation may result if burials containing other brooch types could be analysed in similar numbers.

7.5.5 Provenancing – possible origins

Attempting to provenance the individuals in the non-local group is highly problematic. The Sr isotope ratios are not particularly diagnostic, e.g. not sufficiently radiogenic or unradiogenic to rule out the majority of possible sources. Nor is the total range at West Heslerton particularly large when compared to that found for example at Blackfriars or Lewis. However, although all the Sr isotope ratios obtained at West Heslerton are in no way unusual for England, they do require a more radiogenic source than appears to be present locally. A further difficulty results from the uncertainty surrounding whether the putative Anglian settlers came from Norway, Sweden, Denmark or northern Germany, or indeed from more than one place. There is a big difference in geological age and lithology between Norway and Denmark. The outcropping geology of Denmark and northwest Europe dates from the Tertiary and Quaternary periods with Cretaceous chalk outcropping in the north and east of Denmark and the southern tip of Sweden. It is, therefore, geologically younger than northeast England. Moreover, the Danish chalk is younger than English chalk, which has been subjected to extensive erosion of these younger beds so that none outcrop in England today (Ager 1961, 178). Norway and most of Sweden would be a source of considerably more radiogenic Sr. An origin in Denmark, which has extensive deposits of chalk, should produce Sr isotope ratios of <0.7092, whereas a coastal Norwegian origin should produce Sr isotope ratios

>0.7092. Moreover, a Danish origin would overlap with the "local" range at West Heslerton. However, the non-local group is not sufficiently radiogenic to place it with certainty in Norway or central Sweden or to rule out an English origin.

There is little directly comparative data but amongst the small number of Norwegian mediaeval teeth analysed by Åberg (1998, 113), Sr isotope ratios ranged from 0.71087-0.73232. Samples excavated from inland sites had higher ratios, whereas the individual from the coastal port of Bergen was the lowest of the sample and this probably indicated the increased contribution of seawater-Sr (0.7092) to the diet. Inland fish samples from southern and central Sweden also have Sr isotope ratios > 0.713 (Åberg 1995, 311). The Sr isotope ratio of 0.71087 is very similar to that of 0.71081 obtained for G164. Nevertheless, the two prehistoric individuals WHAI-2 and EBA229 had ratios >0.7110 and highlight the degree of overlap that may exist between coastal Scandinavian sites and signatures obtained in England. Clearly, a radiogenic Sr signature could indicate an origin in an area of Britain such as Wales, Scotland or Cornwall, or a foreign origin somewhere like Scandinavia where older lithologies exist.

It is possible that immigrants to West Heslerton from both western Scandinavia and northern Europe are represented in the non-local group and this may account for the spread of ratios and the multi-modality suggested by the data. It is worth noting, however, that the general direction of migration in England during this period is normally understood to be from east to west or south to north and not the other way around. This raises the possibility that British individuals may have moved towards areas of Anglian occupation either voluntarily or forcibly. The technique is still relatively new and as a consequence, there is no data currently available to show what Sr isotope ratios contemporary individuals who remained behind in the putative homelands of the Anglian immigrants, such as Schleswig-Holstein and Denmark, actually had. As a result, it is presently only possible to say that the non-local group do not appear to have isotope signatures that would indicate a childhood origin at West Heslerton but not possible to provenance them with any degree of certainty.

7.6 Conclusions

The first aim of this case study was to investigate whether Sr and Pb isotope analysis could identify the presence of two distinct groups within the cemetery. This objective was achieved but the two isotope systems split the sample population on different lines. Pb isotope and concentration data produced two clearly identifiable groups: Anglian and prehistoric. This grouping resulted from the change from predominantly geological to predominantly anthropogenic Pb sources between these periods and the concomitant severing of the link between geology and origins, which is present in the prehistoric individuals. Pb isotopes, therefore, gave no clear information about the geographical origins of the Anglian individuals but rather an indication of status and access to metal products. It is not known whether this cultural Pb isotope sphere extended to the Anglian homelands also, or is unique to England during this period. Pb exposure is an order of magnitude greater in the Anglian population than the preceding Iron Age and Early Bronze Age whilst Anglian exposure is an order of magnitude lower than individuals investigated from the Roman and later Mediaeval periods. This rise in exposure appears to reflect metal use and circulation and is accompanied by a progressive "cultural focussing" (J. Evans pers. comm.) of the Pb isotope ratios towards the centre of the English ore field (Figure 9.2).

The Sr isotope data points to at least two Sr groups, a local and a non-local group, at West Heslerton. One group falls within the environmental end-members for the site and includes most of the juveniles and prehistoric individuals, which supports the suggestion that it represents the local variation. The other group is more radiogenic and suggests a greater contribution from older or more rubidium-rich lithologies. Unfortunately, no individuals are sufficiently radiogenic to point irrefutably to a Norwegian or Swedish origin or rule out an English origin. Individuals have either moved to the site from such an area or were importing or producing considerable amounts of food from such an area. The second observation is not consistent with the hypothesis that crops and livestock were being grown and grazed in the immediate locality of the site and may point to larger-scale trading in foodstuffs. This would seem to be inconsistent with a small, self-sufficient farming community but may confirm the observation that West Heslerton was a proto-urban settlement (Powlesland 1998, 2.1). Further analysis of animal teeth and preserved food remains from the settlement may help to clarify this issue. It was, however, certainly not the case that everyone in this sedentary farming settlement was consuming the same childhood diet.

The observed difference in Sr isotope ratios is not one of differing status between adults and children as all enamel ratios derive from childhood diet. Neither is it likely that it is one of differing social status between two groups. Males and females are found equally in both groups and the Anglian children in either group cannot be deemed of low social status, firstly because they were accorded burial in the cemetery, which is unusual, and secondly because the majority were buried with jewellery or weapons. This would also be supported by the settlement evidence, which provides little support for two different status groups at the site. Individuals from both groups were spread throughout the cemetery supporting the hypothesis that the cemetery developed polyfocally rather than from a single origin. Furthermore, the Sr isotope ratio difference between the two groups does not appear to be one of changing subsistence practices with time, as individuals from all phases of cemetery development occur in both groups. Accordingly, the study's second aim, to use geological and archaeological evidence to determine whether such groups were consistent with a local and an immigrant contingent, has been successfully addressed but the origin, or origins, of the immigrant population is still uncertain.

The third aim of the study, to assess the traditional archaeological methods of identifying native Britons and Anglian immigrant burials against the isotope results to see which, if any, supported or refuted such methods is more problematic. When combined with archaeological indicators traditionally used to identify Anglo-Saxon immigrants there are suggestions that some may hold more promise as indicators of first generation Anglian settlers but the sample numbers are too small to enable firm conclusions to be reached. They may, however, provide a guide for future sampling strategies at sites from this period. All burials analysed that contained wristclasps (n = 3) or cruciform brooches (n = 3) fell into the non-local group as did the only burial found at West Heslerton containing an equal-armed brooch. Of the small-long brooches (n = 4), three were found in non-local burials and one, belonging to a 9 year old child, in an early local burial. Burials analysed containing girdle-hangers (n = 2), purses (n = 2), walnut amulets and pottery vessels (n = 2) all fell into the local group whereas wooden vessels (n = 2) were only found in non-local burials. Annular brooches (n = 10) were found across both groups and whilst this may be due to their greater numbers, it confirms they are not diagnostic. Weapon burials, both male and female, and those from the series of tall, gracile individuals occurred in both groups, as did burials with none and other types of goods. The tallest male and the shortest male were found in the non-local group. This is evidence that the non-local group was not composed exclusively of males bearing arms but that females, children and males of other status were settling here also. There was no correlation between the side, position or alignment of the body within the grave and Sr isotope ratio group, which might have provided indications of a surviving British contingent.

The results of the Sr and Pb isotope study to investigate the *adventus Saxonum* at West Heslerton are, therefore, somewhat inconclusive. There is evidence for the presence of two groups in the cemetery, whose differences are not explicable in terms of status or changes over time. However, further work is required to more fully characterise the local environment and diet and investigate the promising lines of enquiry raised by the presence of particular grave goods. Nevertheless, the following general conclusions relevant to future studies can be drawn:

1. Pb isotopes produce a clear trend between geologically related prehistoric groups and the later Anglian inhabitants, i.e. from less to more like English ore.
2. This cultural focussing (J. Evans pers. comm.) of the enamel-Pb isotope ratios towards the centre of the Pb ore field is accompanied by a rise in enamel-Pb concentration sometime between the Iron Age and the Roman period. However, Anglian Pb signatures at West Heslerton are considerably more diffuse than individuals from the preceding Roman period or the late Mediaeval period which may be due to lower exposure or lower bioavailability resulting from a hard water source.
3. If this Pb isotope focussing proves to be a distinctive characteristic of English or British population during certain periods, it would provide a means for identifying immigrant populations who are focussed on a different ore source.
4. Sr isotope ratios remain indicative of geological origins in all periods so far investigated.
5. There is a clear need to define the "local" environmental Sr signature before conclusions can be drawn between immigrant and local populations beyond the

immediate burial ground. Juvenile burials are likely to produce the most "locals". Utilising preserved plant remains and animal teeth from the settlement sites, along with soils and water samples would be another way forward.

6. Despite what is undoubtedly the most poorly preserved skeletal remains so far analysed, it is encouraging that enamel of fully mineralised and erupted teeth retains an *in vivo* signature: in fact, the evidence suggests that gross preservation provides no indication of the isotopic integrity of the enamel. The integrity of incompletely mineralised permanent enamel and resorbing deciduous teeth is less certain however, and requires more study on the timing of mineralisation and the susceptibility of such teeth to ante-mortem and post-mortem change. Tooth maturation appears to be a more important consideration for predicting the integrity of the biogenic Pb and Sr isotope signature than the gross morphological preservation of the remains.

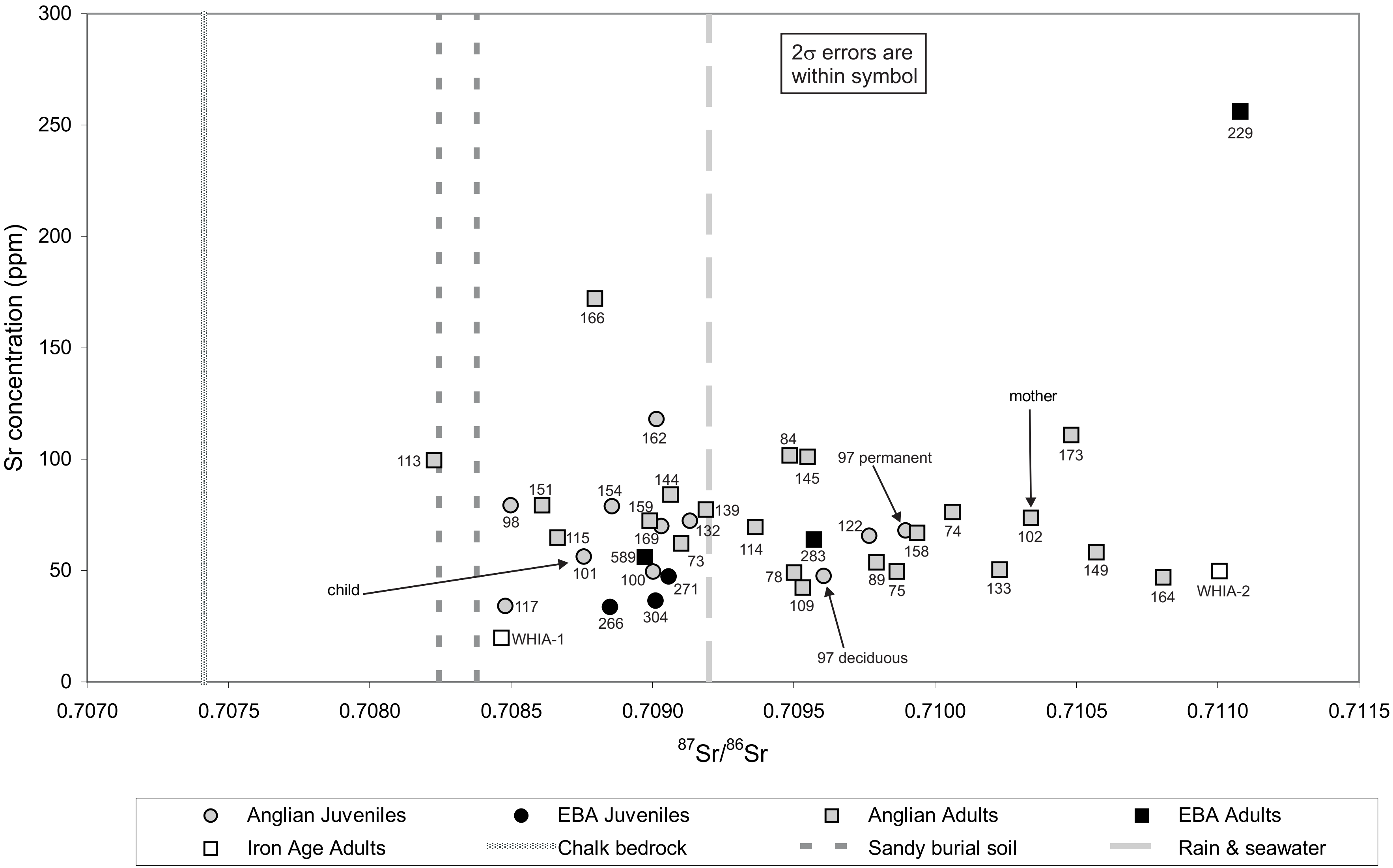


Figure 7.9 Plot of $^{87}Sr/^{86}Sr$ ratios versus Sr concentration (ppm) for enamel samples from West Heslerton. Note the absence of points between G139 and G114, to the right of the rain/seawater ratio of 0.7092 and all three Neolithic/Early Bronze Age juveniles and eight out of ten Anglian juveniles fall to the left of this ratio.

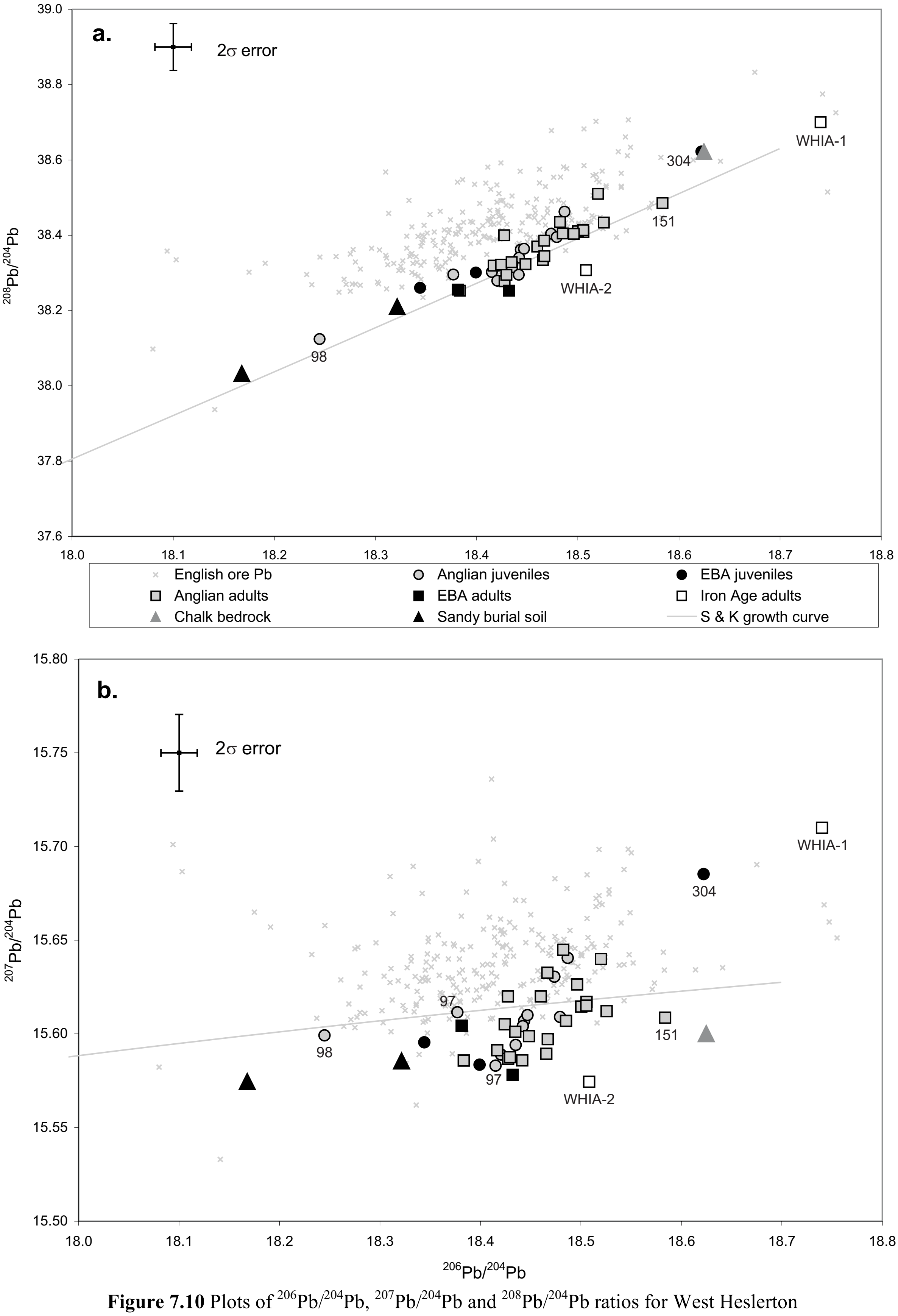


Figure 7.10 Plots of $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios for West Heslerton enamel samples. Note that the majority of Anglian samples cluster around the growth curve and in the lower centre of the English ore Pb field but also fall between the two local soil end members of the chalk and the sand.

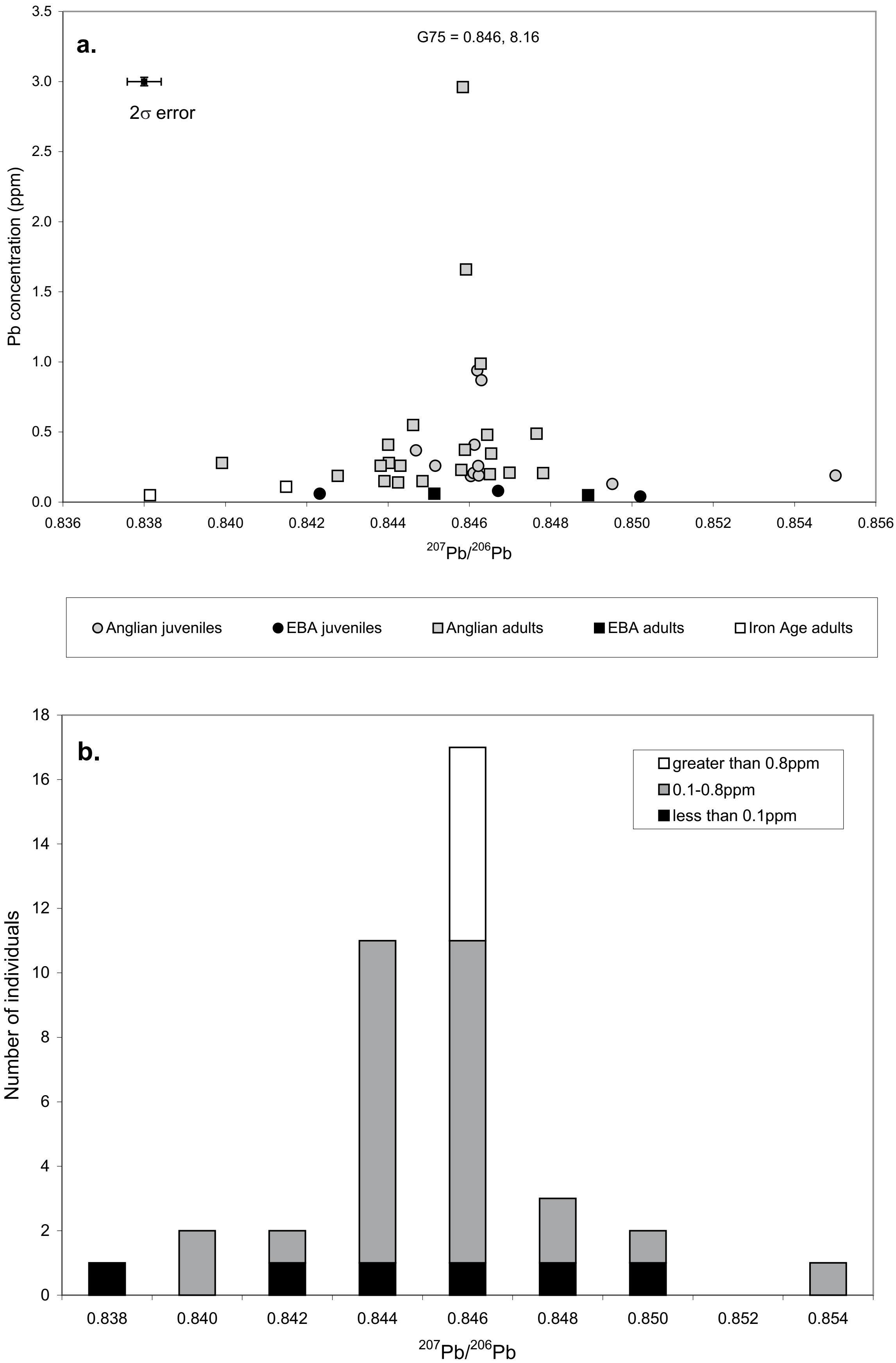
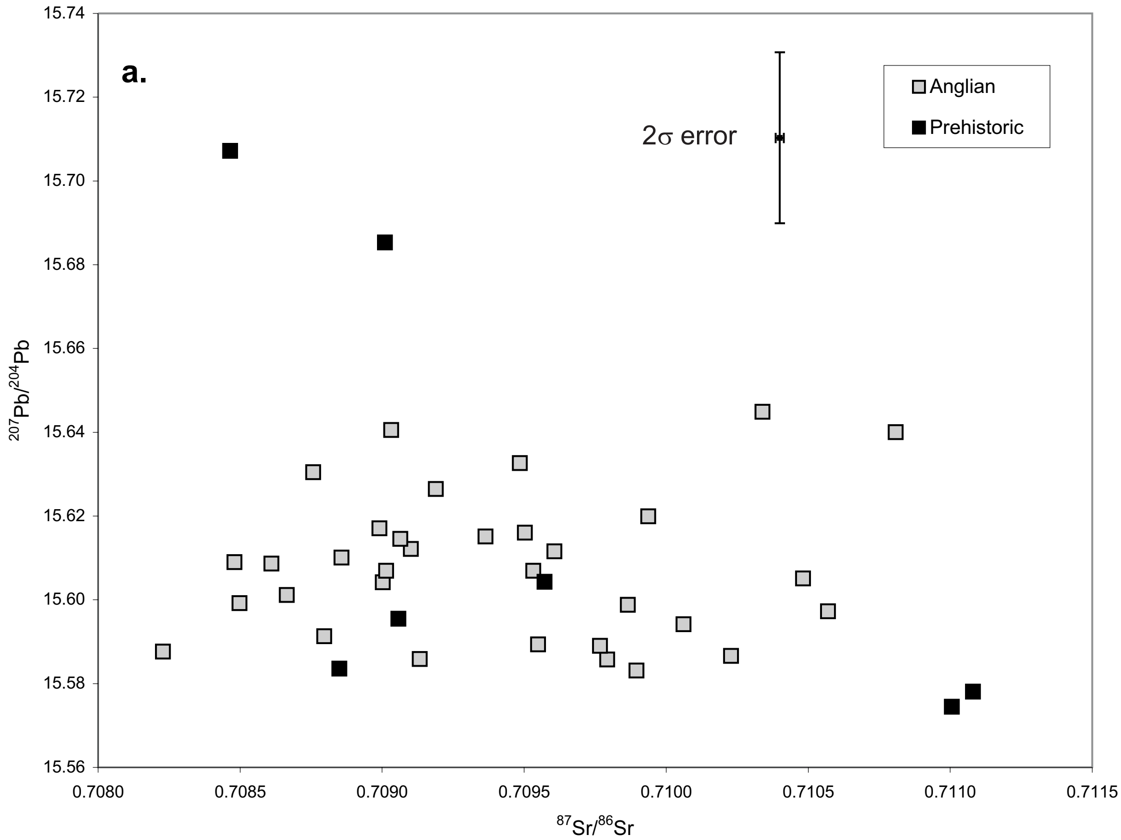


Figure 7.11 Plot (a.) and histogram (b.) of $^{207}Pb/^{206}Pb$ v Pb concentration for West Heslerton enamel samples. Note that all enamel samples with Pb concentrations >0.8ppm are from the Anglian population and have $^{207}Pb/^{206}Pb$ ratios of 0.846.



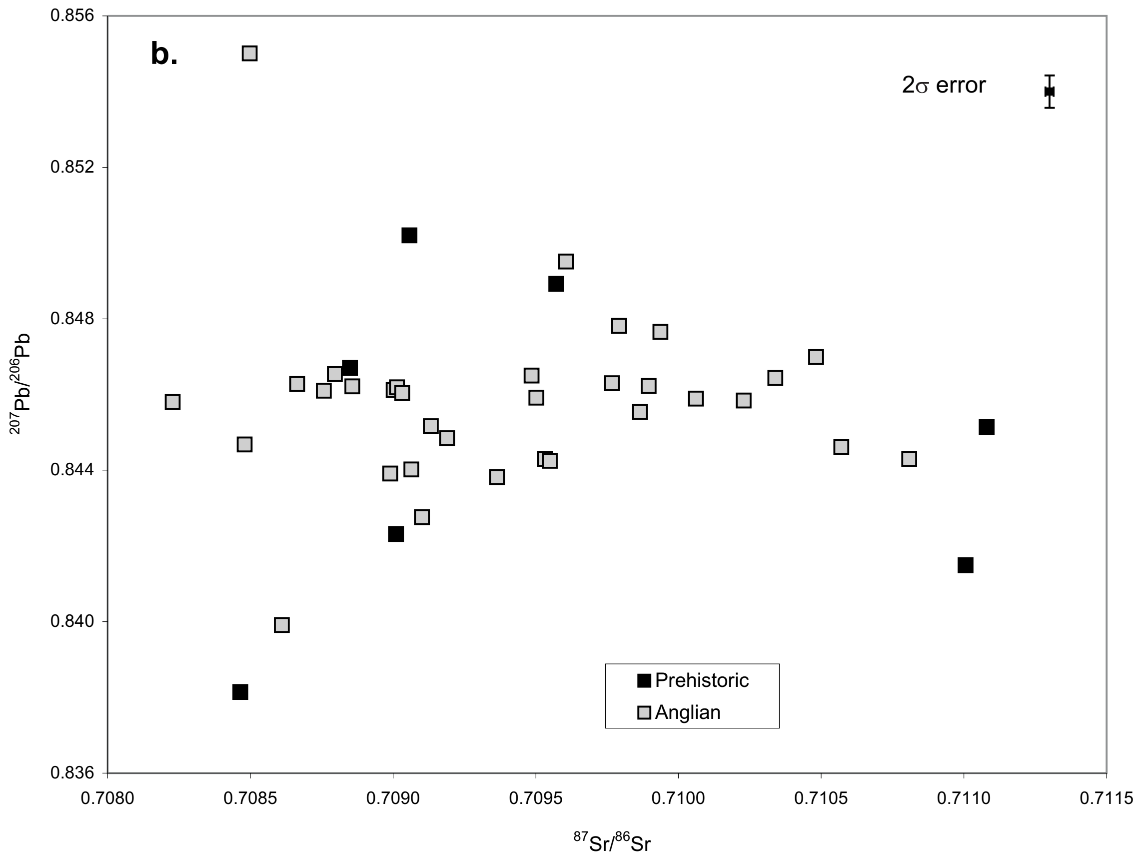


Figure 7.12 Plots of $^{87}Sr/^{86}Sr$ v $^{207}Pb/^{204}Pb$ (a.) and $^{207}Pb/^{206}Pb$ (b.) ratios for West Heslerton enamel samples. There is no statistical correlation between Sr and any of the Pb isotope ratios in the Anglian population. Amongst the prehistoric individuals the correlations fall just short of being statistically significant (see discussion in text). Note, however, the absence of data points in the lower centre of plot b.

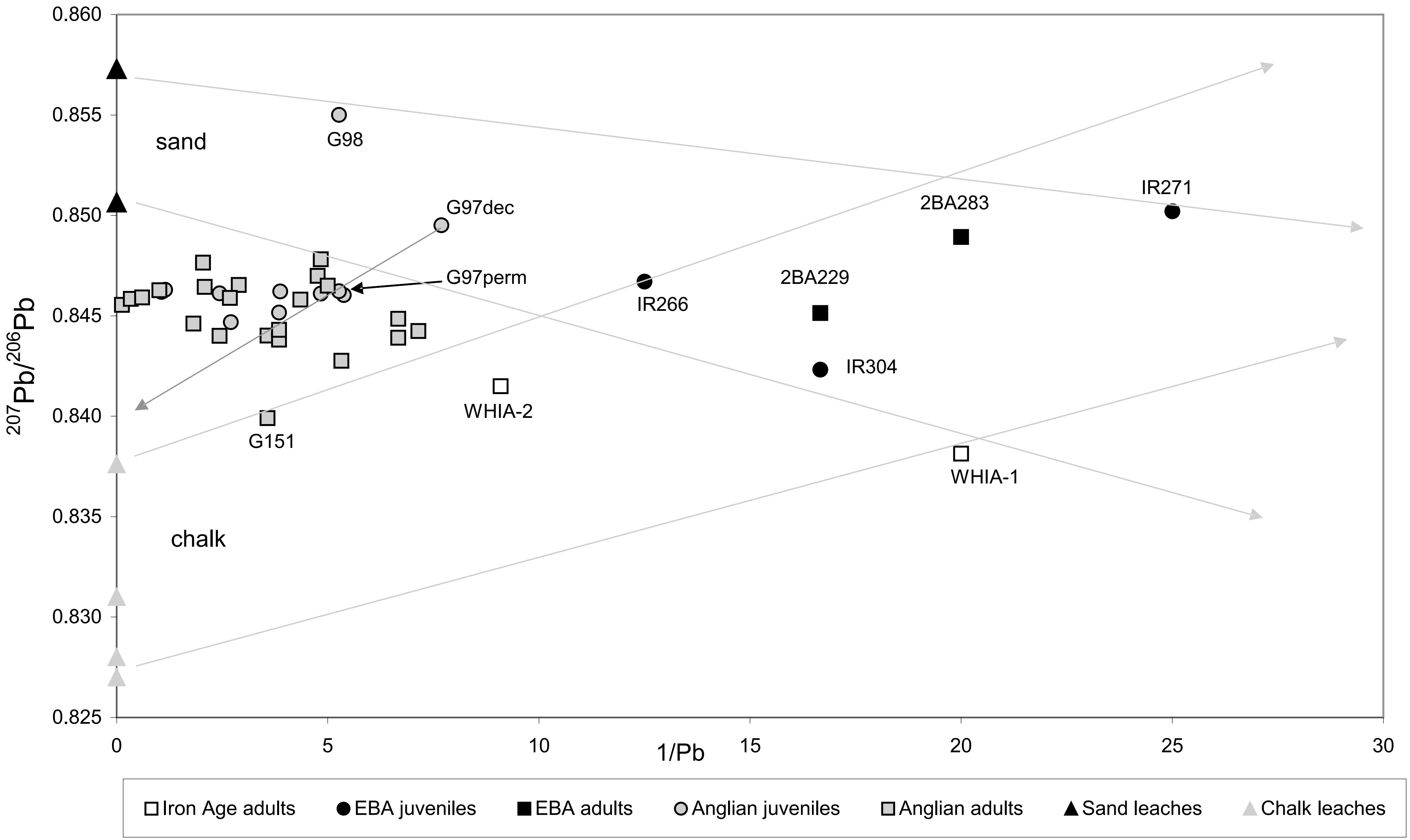


Figure 7.13 Pb isotope mixing diagram for West Heslerton enamel samples. Note that the Anglian samples are located centrally between the sand and the chalk and there appears to be no relationship between the burial soil leach and samples with progressively increasing Pb concentrations. Although there is a focussing of the Pb isotope ratio with increasing Pb concentrations, it appears to be related to Pb ore sources rather than locally available country rock ratios.