CHAPTER ONE

IDENTIFYING MIGRATION: THEORY AND METHOD

1.1 Introduction and aims

"Cultures don't migrate; people do" (Anthony 1997, 24)

Faced with two skeletons in an early Anglo-Saxon cemetery, how can an archaeologist separate the invader from the invaded? Moreover, how could they tell if the migrant came alone or in family groups? Traditionally, archaeologists employ a variety of methods to identify migrations. These have ranged from historical records, sudden changes in material culture, grave assemblage, burial style and orientation to more direct studies of skeletal traits such as cranial shape, stature and build. None are wholly objective: historical records are incomplete and often woefully biased; skeletal traits are difficult to interpret and can vary more within than between populations; and how the burial was arranged may say more about the beliefs and needs of the survivors than those of the deceased. Consequently, and perhaps more than most, the scale of the Anglo-Saxon colonisation remains hotly disputed and theories have run the gamut from the arrival of a handful of high-status male warriors to mass invasion and wholesale replacement of the ancient British.

This thesis examines the use of two independent isotope systems, Pb and Sr, which are present as trace elements in bones and teeth, to directly investigate such questions about the geographical origins of archaeological individuals. It compares and contrasts their isotope signatures with those of other individuals in the cemetery and the signatures of the burial locality. The method is based on the principle that Pb and Sr can be used as source-tracers in this way because they retain the isotope ratios characteristic of their geological origin as they move through the geosphere and biosphere. Rocks of different age and type have different Pb and Sr isotope compositions (see Chapter Two) and the resulting geographical variation provides a means to differentiate between inhabitants of different regions on the basis of the local geology (Figure 1.1).

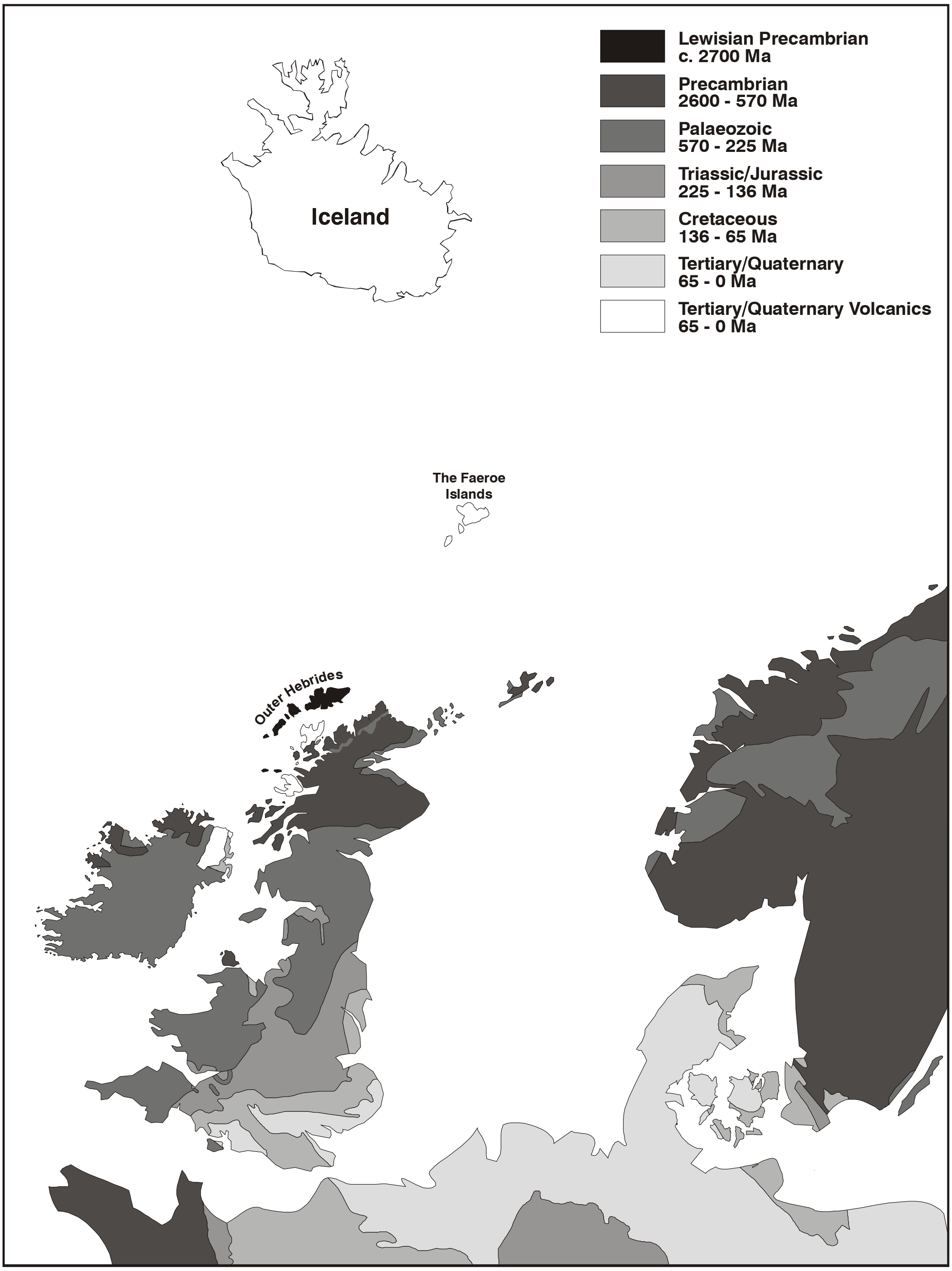

Figure 1.1 Simplified geology map of Northern Europe and the North Atlantic region showing variations in the age of the outcropping rock.
Adapted from Derry 1980.

Specifically, this study analyses teeth and investigates the two main, but very different, dental tissues of enamel and dentine, from their formation *in vivo* through to their eventual excavation and post-mortem analysis. It will be demonstrated that it is of paramount importance to standardise both the sampling methodology, tissue sample, time of formation and assess subsequent alterations either ante- or post-mortem in order to ensure the integrity of the biogenic signal is intact and to enable inter-study comparisons. Only enamel allows these criteria to be fulfilled.

1.2 Migration or just simple mobility?

> **Migration:** *" a simultaneous and permanent movement of substantial numbers of people ….which might be expected to leave measurable traces in the cultural, linguistic and skeletal record"* (Adams *et al.* 1978, 486)

Migration has returned as a serious study. It languished abandoned and unheeded in British archaeological explanations of cultural change during the 1970s and 1980s when processual theories of diffusion, internal differentiation and co-incident evolution of ideas and artefacts were favoured to explain the sharp discontinuities of the archaeological record (Adams *et al.* 1978). Where once the arrival of immigrants was invoked to explain the sudden change from long to round heads or round to square barrows, processual archaeologists discarded such unfashionable traditionalist explanations in favour of an "immobilist" past where travel was severely curtailed and change was stimulated independently on both sides of the North Sea. In the 1990's pleas were made to re-instate migration, in all its guises, to its rightful place as a *bona fide* means by which people, artefacts and ideas could move and to incorporate the long-established and sophisticated migration theories and models from other social sciences (e.g. Anthony 1997, 22; Anthony 1990; Chapman & Hamerow 1997; Härke 1998).

However, migration is not necessarily restricted to the exclusive definition of Adams *et al.* (1978). It does not have to mean a simultaneous, permanent migration of many people from one country to another. It does not have to be a single, inexplicable event or even a one-way process. Neither are warfare and military invasion the sole mechanisms (Chapman & Hamerow 1997, 3), although such events are probably the most visible and best-recorded movements of people. Where, for example, does mobility cease and migration begin? A more inclusive view is expressed by Anthony (1997) using Tilly's (1978) six-fold classification of local, circular, chain, career, colonising and coerced migrations. Here, migration is more akin to mobility in all its forms and includes the more localised social strategies of regular movement within a defined home region, individual migrations and seasonal transhumance. Just as important to archaeology, although perhaps not as glamorous as finding the first Saxon settler to set foot on English soil, is the possibility of identifying mobility between villages, regions or urban and rural environments and it is Anthony's broader definition of mobility that is used in this thesis. Repeated, cyclical mobility within a restricted area is often very difficult to identify archaeologically and chronologically. However, isotope analysis of several teeth with overlapping mineralisation times from a single individual can potentially provide direct, chronologically constrained, evidence for movements of this type (Montgomery *et al.* 2000, and Chapter Six). The direct analysis of skeletal remains can thus highlight crucial differences between the sexes and age groups resulting from such social processes of marriage, trading, slavery, warfare, in fact, any situation where differentiating between groups could be useful. Moreover, major subsistence changes at the Mesolithic-Neolithic or the Neolithic-Early Bronze Age transition are ripe for such study to establish directly how sedentary or wide-ranging people were during these times. It follows that by extending the methodology to animals, information can be obtained about herding practices or the movement, import and export of stock between regions.

1.3 Indirect methods of identifying migrations

1.3.1 Historical evidence

Writers have documented large and small-scale movements of people since Biblical times; warfare, famine, disease, persecution and forced re-settlements have been occurring for millennia. The Roman Army extended its influence through Europe and around the Mediterranean Sea and shortly after, Gildas's *De Excidio*, Bede's *Ecclesiastical History* and the *Anglo-Saxon Chronicles* told of migrations so massive that the region of Angulus was depopulated (Hamerow 1994, 164). The Irish scholar Dicuil, recorded the solitary voyages of Irish hermit monks to the Faeroe Isles and possibly beyond and the *Færeyinga Saga*, *Annals of Ulster*, and the Icelandic *Íslendingabók* and *Landnámabók* recount voyages and settlements during the Viking period (Debes 1993, 455-459). Anthony's (1997, 29) assertion that *"migration is not an exception, but a constant"* appears well-attested in the historical record.

However, the archaeologist's problem resides in directly associating such records, often riddled with inconsistencies and written many years or even centuries after the event, with the archaeological evidence and individual migrants. Not until the start of church burial records and the use of tombstones, does the task become less bleak, e.g. 17th century gravestones in Boston, N. America, frequently record the country and often town of origin (author's own observation). However, even in recent 19th – 20th century cemeteries, major discrepancies can occur between the Church's records and the tombstone (author's unpublished cemetery report of St. Stephen's Church, Copley, Halifax) and gravestones are moved, removed, realigned and "tidied" thus acquiring an uncertain association with the remains beneath. Coffin plates, such as those present in the crypt of Christ Church, Spitalfields (Molleson & Cox 1993), or the decorated skulls of Hallstatt, Austria which were painted with the individual's name (Sjøvold 1995), offer perhaps the only means of categorically assigning migrant status to an individual.

1.3.2 Artefact, settlement and cemetery evidence

In the mid 19th century, it was considered valid to track the historically documented spread of Anglo-Saxon invaders on English soil by mapping distributions of early Germanic pottery and brooches (Lucy 1999, 33). Similarly, the arrival of new styles of housing or a sudden predilection for siting settlements on lighter soils has been interpreted as due to the arrival of settlers with different subsistence practices and building skills. Such endeavours came to be largely scorned by British archaeologists in the second half of the 20th century, leading Hamerow (1994, 165) to point out: *"The observations of a recent writer, who wonders wryly whether these "marching pots wore jackboots" reflects the almost disdainful rejection of many archaeologists over the past 15 years or so of any suggestion of mass migration".* Curiously, migration as an explanatory process has never fallen from favour with German archaeologists (Härke 1998, 19).

No-one disputes that the sudden appearance of Germanic material culture in 5th century England was a very real phenomenon, just as the earlier, Europe-wide appearance of

Beakers was in the Bronze Age. The weak link in the argument is clearly that of assuming that a certain type of Anglo-Saxon artefact (or Beaker) is a valid proxy for determining the presence of people born in Continental Europe. Such pottery traditions could spread by a whole host of mechanisms that do not depend upon every owner and artefact pair making the journey together from Continental Europe. However, whilst it is possible to accept that in Continental Europe, artefact and architecture styles could spread by being passed from village to village with no permanent or large-scale movement of people, at some point, someone must have got in a boat and brought either the artefact or the idea across the North Sea to Britain.

It is this appearance of a new artefact or architectural style at some considerable distance from its source and with no evidence for diffusion in between, that Anthony (1997, 27) believes enables the archaeologist to identify the presence of focussed, chain migration. It is the direction along specific routes rather than all-enveloping diffusion from an original point, that suggests movement of people rather than diffusion is the mechanism: *"Migration therefore, proceeds in streams toward known targets, not in broad waves that wash heedlessly over entire landscapes."* (Anthony 1997, 24). Namely, the movement of people along with their cultural baggage, over long distances is channelled along information networks set up by advanced scouts or kin and thus results in isolated pockets of communities around a "founder" community, often located far from the homeland. Furthermore, he notes that *"pioneer farmers usually leap-frog into new territories through chain migration"* (Anthony 1997, 27). Moreover, he explains that *"because information-exchange networks may be represented archaeologically by shared artefact styles and raw material exchange systems, it may be possible in some cases to reconstruct portions of the prehistoric information networks that constrained and enabled prehistoric migratory behaviour."* Anthony surmises that the absence of "small-group strategies" indicates the Anglo-Saxon settlement involved considerable numbers of people (Anthony 1997, 29). It is interesting to note that they did not appear to "wash heedlessly over the entire landscape" but, in line with chain migration theory, cemetery distribution evidence suggests that they appear to have entirely ignored certain areas of England such as the Weald of Kent and the Sussex Downs (Lucy 2000, 141). Although targeting of specific soils and topography may be suggested, cemeteries are numerous on other southern downlands and many "blank" spots were prime agricultural regions (Lucy 2000, 140).

Burial is an intentional, deliberate action resulting from a set of rituals and is, therefore, meaningful (Ravn 1999, 43). However, it is performed and controlled by the survivors and, thus, illuminates aspects of the deceased which they deemed to be important (Lucy 1999, 37). Variations in burial rites may, therefore, reflect changes in either belief systems or material culture. For example, grave alignment varies considerably through space and time; the variable or consistently N-S alignment in many pagan cemeteries contrasts sharply with the subsequent E-W uniformity and absence of grave goods apparently imposed by the adoption of Christianity (Crawford 1997, 49). Curiously, this is often ascribed to the conversion of the indigenous population, whereas the return to pagan burial observed in Great Britain during the 5th - 10th centuries is usually attributed to the ingress of Norse or Anglo-Saxons from Northern Europe. Likewise, change from interment to cremation and back again and the presence or absence of grave goods is often correlated with fluctuations between Christianity and paganism, although the failure to find grave goods does not mean that none were deposited. Organic goods such as drinking horns, textiles and wooden bowls may not survive except in waterlogged environments. Similarly, penannular brooches and crouched (tightly flexed) burial has been widely used to identify members of the surviving British population (Lucy 1999, 34). The abandonment of Neolithic multiple tombs followed by the appearance of single burials in Bronze Age round barrows has been associated with the arrival of the "Beaker Folk" (Parker Pearson 1993, 91). Many such apparent discontinuities are present in the archaeological record and most have at some stage been explained by the arrival of a new belief system, social hierarchy or organisation and material culture.

In amongst the many that acquired a new material culture or belief system either through necessity or choice, there will be the innovators or people who brought it. People were clearly the agents of artefact movement whether as transient traders, raiders, soldiers, scouts or the subsequent settlers following in their pioneering footsteps. In the absence of any evidence for *in situ* manufacture (Welander *et al.* 1987, 165), it is hard to imagine how Norse brooches arrived on the Isle of Lewis if not by the movement of people. Equally, however, the excavation of a burial with such brooches does not mean that the interred was the first or even last owner of the artefact. Unfortunately, chancing upon a migrant is likely to be, if not the proverbial needle in a haystack, a rare occurrence, and although it can provide pointers, archaeology struggles to provide the resolution necessary to identify a single, founding generation. Dating is often carried out on typological grounds but many artefacts were old when placed in the grave. Moreover, the burials recovered are but a tiny, and not necessarily representative, fraction of the extant population of any period and the more remote the period the smaller, and potentially more biased, the sample becomes. Fortunately, rather than occurring in a single, discrete founding event, chain migration between two places can continue for many years, even perhaps generations, with a concomitant, progressive increase in the status of the founding families. Moreover, once established, migration streams are resistant to change and tend to flow in both directions; migrants have an increased tendency to return to their place of origin (Anthony 1997, 25). These characteristics will considerably improve the chances of locating migrants amongst the native-born population.

1.4 Direct methods of identifying migrants

Migration is rarely indiscriminate: *"even in distress, people do not move about randomly, but follow kin and co-residents to havens that have an attractive reputation"* (Anthony 1997, 27). Chain migration theory predicts that permanent migrants are far more likely to follow family members to known places, or to target places where familiar social systems prevail, than to seek out alternative or new locations. Accordingly, this *"brings migrants from a specific home region to a specific destination over a known route, usually to join kin"* (Anthony 1997, 26; Anthony 1990, 903). This has important implications for studies of aDNA and archaeological skeletal investigations of variation and inherited traits because such kin-focussed migration is recognised as a potential cause of significant variation in allele frequencies between populations (Rogers & Eriksson 1988).

Modern techniques of genetic fingerprinting can assist archaeologists define familial and gene pool relationships amongst archaeological communities (Brown 2000, 465) but it cannot discriminate between the founding population and their subsequent descendants. When coupled with the notoriously poor chronological resolution usually present at most cemetery sites, this makes it difficult to assess the demographic make-up of the original settlers, i.e. whether they were all males, males and females or families of mixed age. However, although skeletal changes resulting from genetic adaptation occur at the population level and are very slow, certain skeletal traits whose phenotypic expression is a combination of genotype and environmental factors may acclimatise rapidly to a new environment at the individual level (Jurmain & Nelson 1994, 141). Consequently, first generation immigrants may be thrown into sharp relief against both their subsequent descendants and the native population.

Skeletal variation between individuals can, therefore, arise through the agency of many factors ranging from the genotype to deliberately altered teeth or skulls. For many of these variables, however, it is the intricate and life-long interplay between the genes and the environment that produce the visible traits in archaeological skeletal remains.

1.4.1 Non-metric traits

Non-metric traits are normal skeletal markers, usually recorded as absent or present and used to classify individual skeletal variation (for list see Buikstra & Ubelaker 1994). They can arise from an inherited genotype, during development or subsequent behaviour or, more probably, an interplay between all three. Generally, they can be divided into four forms (Buikstra & Ubelaker 1994, 85):

1. ossicles or small bones that occur within cranial sutures
2. abnormal proliferative ossifications such as bony spurs or bridges
3. ossification failure leading to defects
4. variation in foramen number and location

Their significance is derived from the observed familial heritability of non-metric traits in both humans and animals (Buikstra & Ubelaker 1994, 85). The precise embryology of most traits is poorly understood but the expression of certain cranial and dental traits is considered to be unaffected by function and relatively immune to non-genetic developmental factors both *in utero* and *in vivo* (Scott & Turner 1997, 131; Tyrrell 2000, 294).

Cranial ossicles (or wormian bones) (Figure 1.2) have no known functional purpose or environmental expression and are, therefore, considered to be one of the few developmental non-metric traits which have an undisputed genetic expression (Tyrrell 2000, 294). Härke (1990, 42) concluded that wormian bones were negatively correlated with Migration Period male weapon burials. Although little can be concluded from their absence at the level of the individual, they are one of the few non-metric traits that have been shown to have significant heritability through the male line (Sjøvold 1995, 250) although they do not necessarily obey Mendel's laws for simple dominant-recessive inheritance.

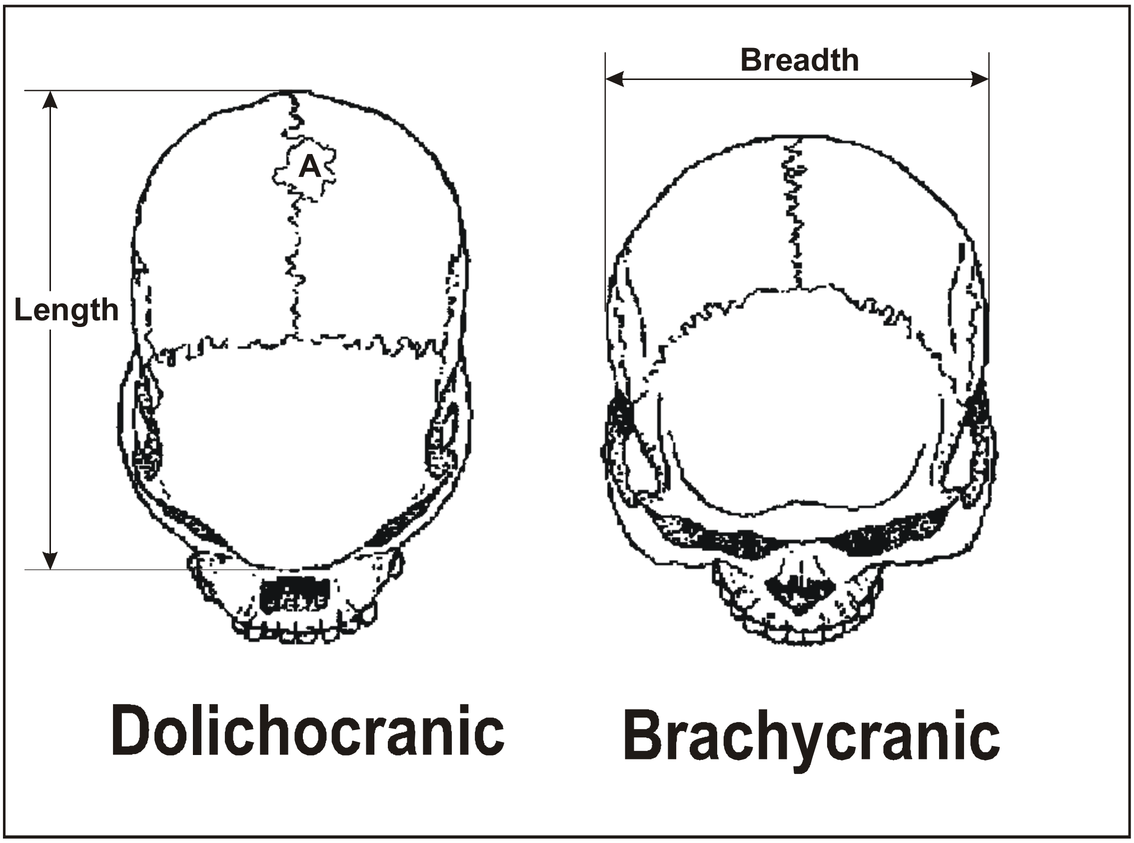

Figure 1.2 Illustration of cranial morphology. The two measurements that produce the cranial index are shown. A cranial ossicle (or wormian bone) is present at 'A'.
Adapted from Marks 1995.

Other non-metric traits may indicate an individual undertook a specific, prolonged and repetitive activity. This may be manifest in enthesopathies (musculo-skeletal markers of stress) at the attachment of tendons and ligaments on bones and, as would be expected, their presence usually increases with age (Knüsel 2000, 387). For example, the widespread presence amongst a population of traits such as squatting facets or the cortical hypertrophy of the third trochanter of the femur, can be compared with their absence in another spatially or temporally distant population to investigate whether different activity patterns were being undertaken.

Skeletal variation can also arise as a result of activity-related pathological change and is frequently found amongst archaeological populations where it can indicate long-standing, strenuous activity patterns. Moreover, a high prevalence rate of a certain trait amongst a skeletal population indicates that certain activities were widespread, and possibly characteristic of the prevailing culture, whereas the trait may be entirely absent in other populations. Spondylolysis, for example, is usually an asymptomatic traumatic fracture of the neural arch of the vertebral body; it is most frequently seen in the fifth lumbar vertebra (Roberts & Manchester 1995, 78). It has a high incidence in Inuit populations where it is attributed to kayaking and is also present in modern athletes, such as female gymnasts and male cricketers who repeatedly rotate and flex the upper body, especially from an early age (Knüsel 2000, 391). Although some individuals may be congenitally predisposed to the condition, the aetiology is considered to be largely traumatic (Roberts & Manchester 1995, 78). "Clay-shoveller's" fracture, is considered to be caused by a repeated, strenuous shovelling action and is characterised by the fracture of the seventh cervical or first thoracic vertebral spinous process (Knüsel 2000, 391; Roberts & Manchester 1995, 8). Non-fusion of the acromial process of the scapula (os acromiale) is found amongst archaeological populations and usually attributed to continued and heavy loading of the arm from an early age which prevents the epiphysis fusing (Roberts & Manchester 1995, 76/77). A high prevalence rate of 13.6% was recorded amongst the crew of the Mary Rose and was attributed to the commencement of longbow practice at an early age (Stirland 1986).

Although rare in British skeletal populations, examples of deliberate mutilation, decoration and deformation of both the dentition and the skeleton are known and have been reported in purported first generation immigrants (Corruccini *et al.* 1987, 236; Cox *et al.* 2001, 89; Cox & Sealy 1997, 210; Ezzo *et al.* 1997, 450; Ortner & Putschar 1985, 90). Such skeletal modifications may not persist amongst subsequent generations of immigrants because the idea of what is socially acceptable or culturally defined aspirations to beauty or status may change. For example, "s*implification occurs during migration because the migrants may be derived only from a specific class or subregion,* *and it occurs again at the destination because the migrants select only those aspects of their culture that seem relevant in their new situation"* (Comments by D. Anthony in Härke 1998, 26). Conversely, the appearance of non-participants amongst a population who carry out a distinctive skeletal modification, may indicate the presence of immigrants to the area.

1.4.2 Metric traits

1.4.2.1 Craniometry

Natural cranial variation has enjoyed little favour in recent British osteoarchaeological investigations but there have been calls for its return to respectability as it has much to offer migration and biodistance studies (Brodie 1994, 80; Mays 2000). Although there are many complex measurements that can be taken on the cranium, it appears that the majority of the observed variation can be summed up by the cranial index which *"embodies a large amount of real, morphological information and is not to be viewed merely as a random combination of two, readily available, measurements"* (Brodie 1994, 70). The terms used in this thesis follow the terminology recommended by Bass (1987, 69) where the Cephalic Index refers to measurements on the living whilst the Cranial Index indicates measurement of skeletal crania. This index is obtained as follows, where the cranial breadth is the measurement from side to side (euryon to euryon) and the length from front to back (glabella to opisthocranion) (Figure 1.2):

$$\text{Cranial Index} = \frac{\text{maximum cranial breadth x 100}}{\text{maximum cranial length}}$$

It is important to note that cranial vault height is not taken into account in this index. This results in the following classifications (Bass 1987, 69):

Dolichocrany	=	≤ 74.99
Mesocrany	=	75.00 - 79.99
Brachycrany	=	80.00 – 84.99
Hyperbrachycrany	=	≥ 85.00

From a long-term evolutionary viewpoint the crania of early Homo were dolichocranic and humans have become progressively more brachycranic (Bass 1987, 70). The predominant cranial shape in Britain during the Neolithic appears, from the available evidence, to have been exclusively dolichocranic coupled with average calvarial height, whilst Bronze Age crania were almost exclusively brachycranic and often hyperbrachycranic (Figure 1.2) (Brodie 1994, 71; Brothwell & Krzanowski 1974, 255; Howells 1937; Morant 1926, 57). Crania in the Iron Age were more variable, if anything tending towards dolichocrany but lacking the extremes observed in earlier periods. Their most notable and consistent characteristic was a low calvarial height. Like the indigenous Iron Age Britons, the incoming Anglo-Saxon population, both male and female, were moderately dolichocranic but form *"a perfectly homogeneous population, and the type is clearly distinguished from that of the British Iron Age by its greater calvarial height, though the lengths, breadths and cephalic indices of the two are almost identical"* (Morant 1926, 57). This was followed by a general trend towards increased brachycrany during the mediaeval period which peaked during the later Middle Ages when it equalled, or even exceeded that of the Bronze Age before reverting to dolichocrany by the 17th century (Brodie 1994, 71). Such classifications of cranial morphology have been used to identify the supposedly intrusive, brachycephalic Bronze Age "Beaker Folk" and in the early Mediaeval period, invading "Germans" from "Romans" (Halsall 1995, 60). Cranial index and cranial capacity are significantly correlated between father and son pairs where no correlations exist between mothers and daughters or between parents, suggesting a high degree of heritability rather than environmental factors are involved (Sjøvold 1995, 277). However, cranial index is no longer accepted as a valid, immutable indicator of race or nationality as it is apparent that genes, environment and even exercise can affect cranial shape (Knüsel 2000, 392).

Brodie (1994, 77) has pointed to the similar spatial and temporal fluctuations of cranial morphology and climate and suggests a correlation between dolichocrany and a wet climate and brachycrany and a drier, continental climate regime. Consequently, he theorises that both changing subsistence practices and an ameliorating climate, rather than the arrival of immigrants, may have produced the marked change from dolichocrany to brachycrany at the Neolithic-Bronze Age transition (Brodie 1994, 80). Modern populations display different cephalic indices through space and time: in modern and historic central Europe for example, people are predominantly brachycephalic (Sjøvold 1995, 256/7), whereas in northern or southern Europe and in Britain, dolichocephaly is the dominant form (Marks 1995, 121/2). However, such differences may derive from acclimatisation rather than genetic adaptation as the plasticity of the skull under different environmental conditions has been demonstrated. Research has shown that radical skull morphological change can take place between an immigrant parent and their offspring and the child's skull shape will be more like the indigenous population (Marks 1995, 125). Moreover, it appears that cranial bone thickness and shape can change in response to both general and specific (e.g. chewing) sustained exercise in the same way as the long bones, suggesting that both facial and cranial vault morphology may change in tandem with major subsistence transitions (Knüsel 2000, 392). Brachycephalisation is also strongly associated with low social or economic status (Cox 1999, 179). It appears, therefore, that rather than being a racially defined, hereditary trait, cranial shape is affected by environmental causes. The underlying stimulus, however, is not known and likely to be multi-factorial.

1.4.2.2 Stature and robusticity

Body size and shape are quantitative traits that have a relatively high polygenic heritability but their phenotypic expression is clearly alterable by intrinsic and extrinsic environmental factors such as health and nutrition (Scott & Turner 1997, 159). Generally, in warm-blooded species, there is also a proportionate increase in body size (height and robusticity) and reduction in limb length with distance from the equator (Jurmain & Nelson 1994, 148). Biological adaptation may account for these differences but there is evidence to suggest that, as with cranial shape, quite marked changes can occur between first generation migrants and their offspring (Jurmain & Nelson 1994, 147). This suggests that acclimatisation rather than evolutionary genetic adaptation is responsible and that stature is sensitive to a host of factors. Male stature appears more susceptible to stunted growth due to poor conditions (nutrition, health etc.) than females (Dunwell *et al.* 1996a, 740; Ubelaker 1995, 235).

For example, Welch (1992, 60) has summarised the traditional view of two different skeletal types in Migration Period cemeteries: *"many of the weapon burials in early cemeteries belong to well-built, strong men either side of six foot in height and the accompanying women are often near or only slightly below modern heights. It is* *tempting to contrast these individuals with the slighter-built skeletons recovered from Late Roman cemeteries in Britain and label them as Anglo-Saxon immigrants".* Extensive data collected recently by Roberts and Cox (in review) gives a mean stature for males in the Anglo-Saxon period as 172cm (n = 996) and for females 161cm (n = 751). These results demonstrate an increased stature when compared to both the preceding Romano-British period and the later mediaeval period. Moreover, 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). 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 population.

1.5 How useful are traditional methods?

Skeletal variation offers a direct method of differentiating between first generation immigrants and their offspring providing there is sufficient separation between the immigrant and indigenous populations. Clearly, any trait that positively identifies first generation immigrants would prove to be very complementary to isotope analysis attempting to do the same thing. Whether the variation is the expression of a different genotype or a phenotypic trait obtained through life-long biomechanical loading or because an individual originates from a region where tooth decoration is practised, it will provide information about difference. Obviously, such studies are based on variation within a population, and variation between two individuals is not the same thing. There will always be within-population variation and the "native" and the "immigrant" may just represent opposite extremes of the population variation, i.e. they may appear to be from two different populations but are actually from the same one.

The aetiology of many skeletal traits is multi-factorial and still poorly understood. However, they offer the means to differentiate between individuals and populations whether the trait is inherited or arises because one population spends a lot of time rowing or throwing, or because of the way they chew their food. Genes and genetically determined traits could separate the population descended from natives from the population of immigrants and their descendants but, in the absence of extremely good burial chronology, it cannot be used to identify the people who participated in the original migration. Clearly, it can be useful to identify a sample pool from which to select a purported immigrant and indigenous population but the immigrant group would include first and subsequent generations. However, if a skeletal trait is environmentally determined and plastic or even entirely culturally created, then the first generation only is likely to show it. If a trait can be shown to be a reliable differentiator on even this transitory basis, then it has utility to complement isotope studies of migration.

If, as Anthony (1997, 24) maintains, *"Cultures don't migrate; people do",* then it is to them rather then the remnants of their archaeological material culture that we must look for direct evidence of migrations. Nevertheless, it would be foolish to discount or ignore material culture, particularly when it is as rich and omnipresent as that of the Anglo-Saxon period. It is unlikely that the whole, complex Anglo-Saxon cultural package was transplanted unaltered on English soil but rather a simplified version originating from a specific region (Comments by D. Anthony in Härke 1998, 26). Such archaeological considerations are vital to guide and constrain attempts to provenance individuals back to their land of origin because isotope analysis can *exclude* places of origin but may be unable to discriminate between many *possible* homelands. Even analysing individuals buried at the suspected homeland will not *prove* that it is so. Clearly, isotope migration studies that are carried out in tandem with traditional archaeological lines of evidence can also assist in assessing which, if any, of those archaeological methods stand up to direct scrutiny.

1.6 Identifying migrants using skeletal isotope signatures: the hypothesis

Provenancing studies have harnessed many stable and radiogenic isotope systems that have been used for several decades in a wide range of disciplines and applications. The fundamental concept for their use in archaeological skeletal remains is that they reflect the diet, either directly or indirectly and this can be used to differentiate between groups of people. However, different diets stem from many causes such as differences in status, subsistence, trade and origins. Diet can change over time and space.

Specifically, Pb and Sr derive from rocks and move through weathering and dissolution processes isotopically unfractionated into soil, plants and ultimately animals where they are principally found in the skeleton. They act, therefore, as a marker linking the skeleton with the locality where food was obtained (Figure 1.3).

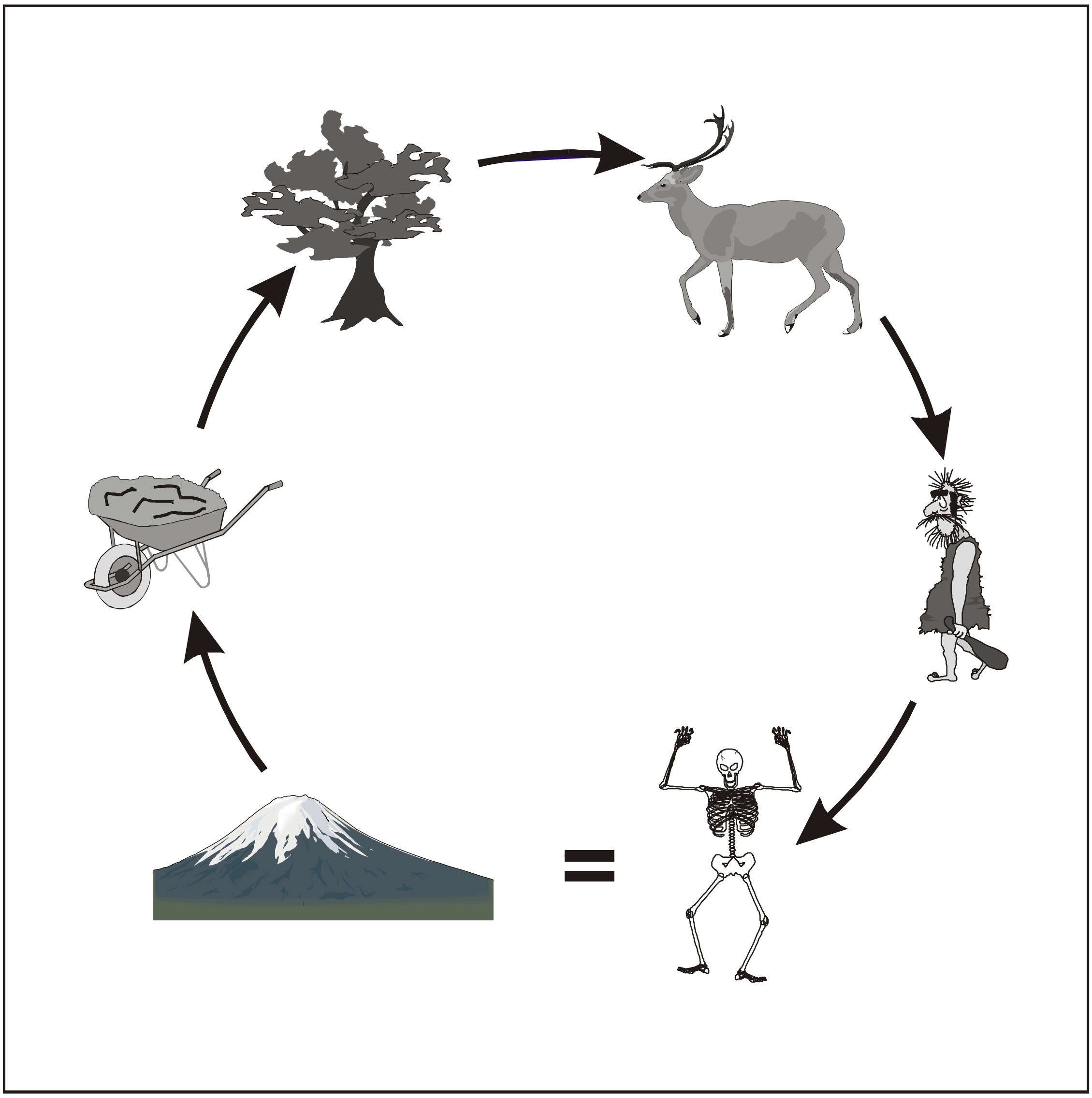

Figure 1.3 The movement of Pb and Sr through the biogeosphere. Pb and Sr move from their geological source into soil, plants and animals and retain isotope ratios that reflect, but may not be exactly the same as, the source rocks. This provides a mechanism for linking individuals to the region where they obtained their food.
Source: Author.

Geographical regions have rocks of different ages (Figure 1.1) and elemental concentrations, and thus, different Sr and Pb isotope ratios. However, the analysis of archaeological skeletal remains is at a turning point. It is no longer viable to indiscriminately analyse any skeletal element, although studies continue apace standardising neither the element nor type of skeletal tissue (Chapter Four). Furthermore, it may be stating the obvious, but skeletal remains were once part of a living, dynamic organism and many factors, intrinsic and extrinsic, can affect their elemental make-up both ante- and post-mortem (Chapters Two and Three). In this respect, bone is the most dynamic of the skeletal tissues ante-mortem and there is considerable evidence that this is the case in the post-mortem environment also. This raises questions about the validity of analysing archaeological remains when even the fundamental basics of ante-mortem uptake are not understood, and with regard to the particular samples under investigation, cannot now be known. Moreover, how certain can investigators be that they are indeed recovering ante-mortem signatures as opposed to information about the post-mortem burial environment?

Teeth do not remodel or re-grow *in vivo* and offer a means to constrain formation times and ante-mortem change. Yet even here, the literature is awash with fundamental misunderstandings and genuine unknowns about their biomineralisation and physiology (Chapter Three). How resistant to ante-mortem and post-mortem change is enamel? Dentine? How homogeneous is enamel? Dentine? In permanent and deciduous teeth? Is it the same for Pb and Sr? What is the isotope variation between enamel samples from the same tooth? Between antimeres? Within a dentition? Answers to even these apparently fundamental questions are difficult to find in the dental or archaeological literature. For studies of migration it is also necessary to address the variation that can exist between siblings, families and discrete communities. Such variation is not well studied in modern teeth (although see the extensive work of Gulson *et al.* on Pb) and such studies of archaeological remains are virtually non-existent. Two problems serve to compound the problem. The cost of the analysis both in labour and machine time tends to make Pb and Sr measurements expensive and consequently reserved for specific, high-profile studies. Secondly, the technique is a destructive one and, particularly in its infancy, it was difficult to obtain permission to destroy archaeological teeth. Both problems may be solved by the new generation of mass spectrometers. Teeth can now be sampled by laser ablation thus reducing time, cost and the amount of sample required as it can be ablated directly from the tooth surface without destroying the tooth crown. It is vital that this background data is produced to provide a framework in which future archaeological work can be placed and more needs to be done.

1.7 Structure of the thesis

The following three chapters deal with the relevant background to the technique and its application. Chapter Two reviews the systematics of Pb and Sr in the geosphere and biosphere and raises important points about their differences and similarities. Chapter Three discusses their uptake in teeth in particular, how teeth are formed and what problems and advantages are posed by using them as analytical samples both ante- and post-mortem. It highlights the frequently misunderstood processes of enamel formation and mineralisation, and developing the argument from Chapter Two, questions the assumption that Pb and Sr behave identically in skeletal tissue. Previous Sr and Pb isotope ratio migration studies, both modern and archaeological, are reviewed in Chapter Four to set the thesis in its academic context. Chapter Five focuses in on this thesis specifically, presenting all the samples, the sampling strategy and sample preparation method and the principal analytical method used (TIMS - thermal ionisation mass spectrometry).

The results of several small pilot studies of modern and archaeological teeth are presented in Chapter Six (for locations see Figure 1.4). These explore the observable variation in both isotope ratios and elemental concentrations, within a single tooth, within dentitions, between siblings, a mother and child and within a cemetery. Conclusions drawn about diagenesis and the utility of soil leach analyses confirm the greater resistance of enamel to post-mortem change and the tendency for dentine to equilibrate with the burial soil. The Neolithic Monkton study has already been published (Montgomery *et al.* 2000) but is included in Chapter Six as it was carried out as part of the thesis and the data contributes much to the overall chronological picture. The Pb isotope data for the Monkton tooth samples were obtained by magnetic-sector multi-collector inductively coupled plasma mass spectrometry rather than TIMS and the reader is referred to the aforementioned publication for the analytical methodology.

The two main case studies are presented in Chapters Seven and Eight. The first, West Heslerton in Yorkshire (Figure 1.4), is an early Anglo-Saxon cemetery with associated settlement site where archaeological evidence exists for Scandinavian migrants. The second is a two-part study on the Isle of Lewis where two unique cemeteries, one Iron Age from Galson and one Norse from Cnip, are investigated (Figure 1.4).

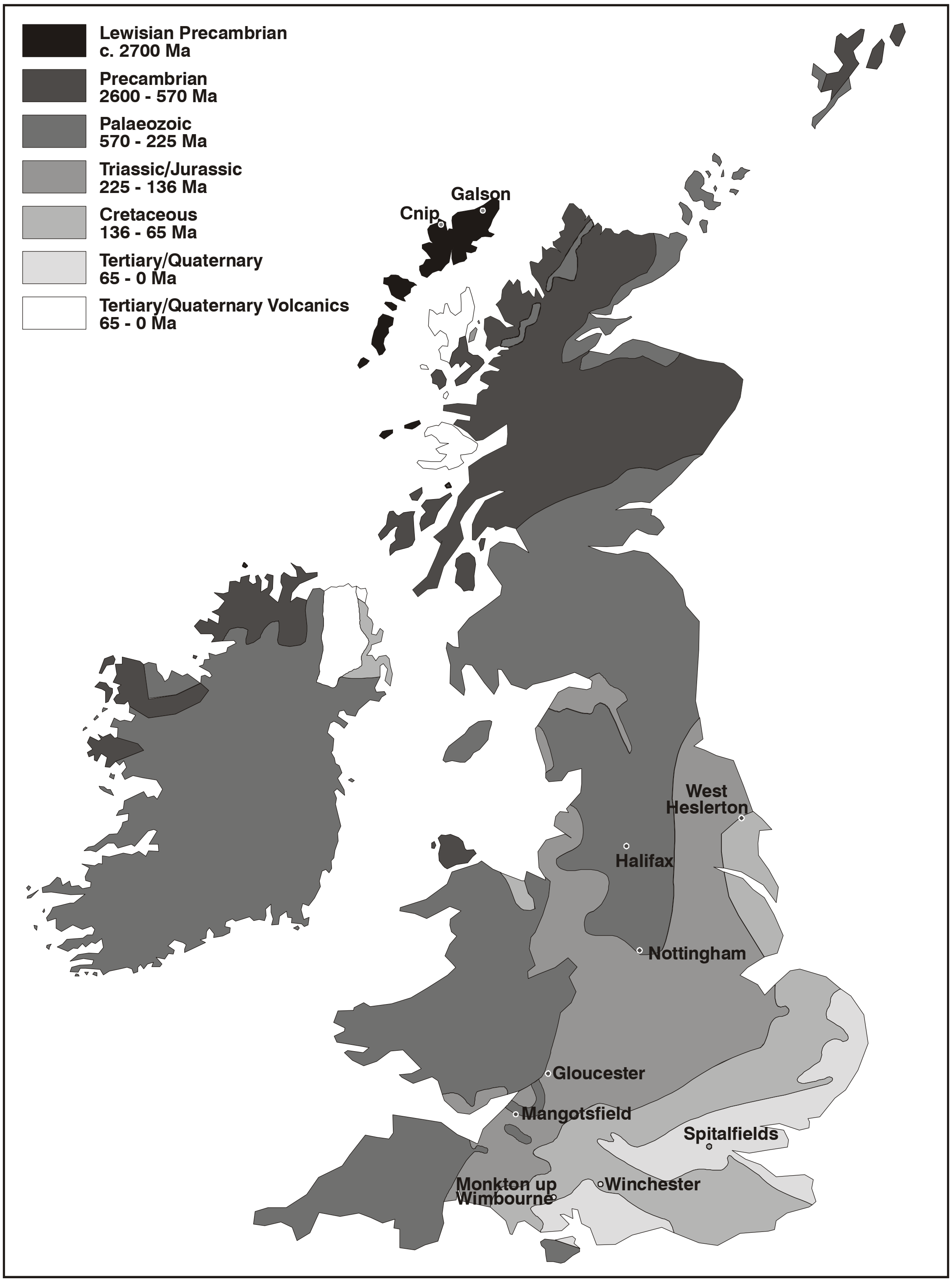

Figure 1.4 Simplified geology map of Great Britain and Ireland showing sample and site locations.
Adapted from Derry 1980.

The geological and environmental habitats of inland Yorkshire and coastal Lewis are very different and both studies illustrate the complexities of interpretation and the specificity required in each project design. The identification of migrants and their place of origin is somewhat contentious in the case of West Heslerton whereas clear evidence was obtained for at least two migrants to Lewis and the geological signatures coupled with the archaeological evidence enabled the place of origin to be constrained. The archaeological outcomes of each individual study are presented within these chapters whilst the overarching conclusions relevant to the technique and to future applications are gathered together in the final Chapter Nine. These cover the use of Sr and Pb isotope ratios for migration studies and to assess changes in exposure levels and sources, particularly of Pb, through time. It is concluded that Pb and Sr are very different, but highly complementary, isotope systems both in their behaviour in skeletal tissue and the amount of useful information they yield. How informative each system is, is highly specific to the environmental habitat, culture and time period under investigation.

The dental notation system used in this thesis is that given in Table 3.1 (Chapter Three). All sites and samples are listed in Tables A5 – A9 (Appendix II) and their geographical locations presented in Figure 1.4. Data Tables A1 – A4, the detailed laboratory chemical separation method and a glossary of terms used in this thesis can be found in the Appendices.