Beaker people in Britain: migration, mobility and diet

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The appearance of the distinctive 'Beaker package' marks an important horizon in British prehistory, but was it associated with immigrants to Britain or with indigenous converts? Analysis of the skeletal remains of 264 individuals from the British Chalcolithic–Early Bronze Age is revealing new information about the diet, migration and mobility of those buried with Beaker pottery and related material. Results indicate a considerable degree of mobility between childhood and death, but mostly within Britain rather than from Europe. Both migration and emulation appear to have had an important role in the adoption and spread of the Beaker package.

Keywords: Britain, Bronze Age, Beaker, migration, mobility, diet, Bayesian analysis, isotope analysis, osteology

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Introduction

The 'Bell Beaker folk' have long been considered a prime example of migration in prehistory. During the third millennium BC, new pottery forms, new inhumation rites and unusual skeletal morphology (brachycephalic or broad-headed skulls) appeared across much of Western Europe. In the late 1970s, at the height of processualist reaction against migration-based explanations, this archaeological 'culture' was newly interpreted as the diffusion of a cult package (Burgess & Shennan 1976). Yet the case for migration of Beaker-using people to the British Isles remained firmly supported (e.g. Waddell 1978).

Within continental Europe, recent research into non-metric dental morphological traits (Desideri & Besse 2010) and strontium isotope analysis of tooth enamel (Price *et al.* 2004) has shifted the focus back to Beaker users as migrant groups, demonstrating the arrival of incoming populations at the end of the Neolithic into parts of Switzerland, Bavaria, Austria, the Czech Republic and Hungary. Recent analyses of ancient DNA are providing further support for Bell Beaker migrations within continental Europe (Allentoft *et al.* 2015; Haak *et al.* 2015; Hervella *et al.* 2015).

The debate about the arrival of the Beaker package in Britain was revived in 2002 by the discovery of the Amesbury Archer, buried near Stonehenge in *2380–2290 cal BC* (*95% probability*; OxA-13541; Barclay *et al.* 2011: fig. 58). From the oxygen isotope ratios for his tooth enamel, he was probably a long-distance migrant from continental Europe (Chenery & Evans 2011). But how typical was his pattern of lifetime mobility for the wider population of Britain during the Chalcolithic–Early Bronze Age?

The skeletal remains of 264 individuals buried in Britain (Figure 1) in that period (*c.* 2500 BC–1500 cal BC) have been analysed, as part of the Beaker People Project (BPP), for isotope ratios (strontium, oxygen, sulphur, nitrogen and carbon), radiocarbon dating, osteology and dental microwear (Parker Pearson *et al.* forthcoming). The sample ranged from the north of mainland Scotland to the Wessex heartland of southern England, and included the Beakers & Bodies Project in north-eastern Scotland (Curtis & Wilkin 2012). The BPP is the first large-scale strontium and oxygen isotope investigation of human skeletons excavated from across Britain, aiming to establish whether the Bell Beaker people were immigrant groups (Childe 1929: 194–96) or indigenous converts to a 'Beaker package' of cult practices and prestige goods (Burgess & Shennan 1976).

Chronology

The earliest dates for Bell Beakers, in the second quarter of the third millennium BC, occur in Iberia and southern France (Müller & van Willigen 2001). Yet across much of Europe, the Bell Beaker phenomenon was not present until the middle of that millennium, reaching Britain relatively late, with no cases dateable to before 2500 BC.

For the BPP, a Bayesian approach, using 193 new radiocarbon dates with existing dates from a further 82 burials, was adopted for the interpretation of the period of use of Beakers in graves. This assumes that dates are uniformly distributed across the time period (Buck *et al.* 1992, 1996; Bayliss *et al.* 2007). Although this use of a uniform distribution is far from ideal—especially if Bell Beakers originated at a given time in a given place, were gradually

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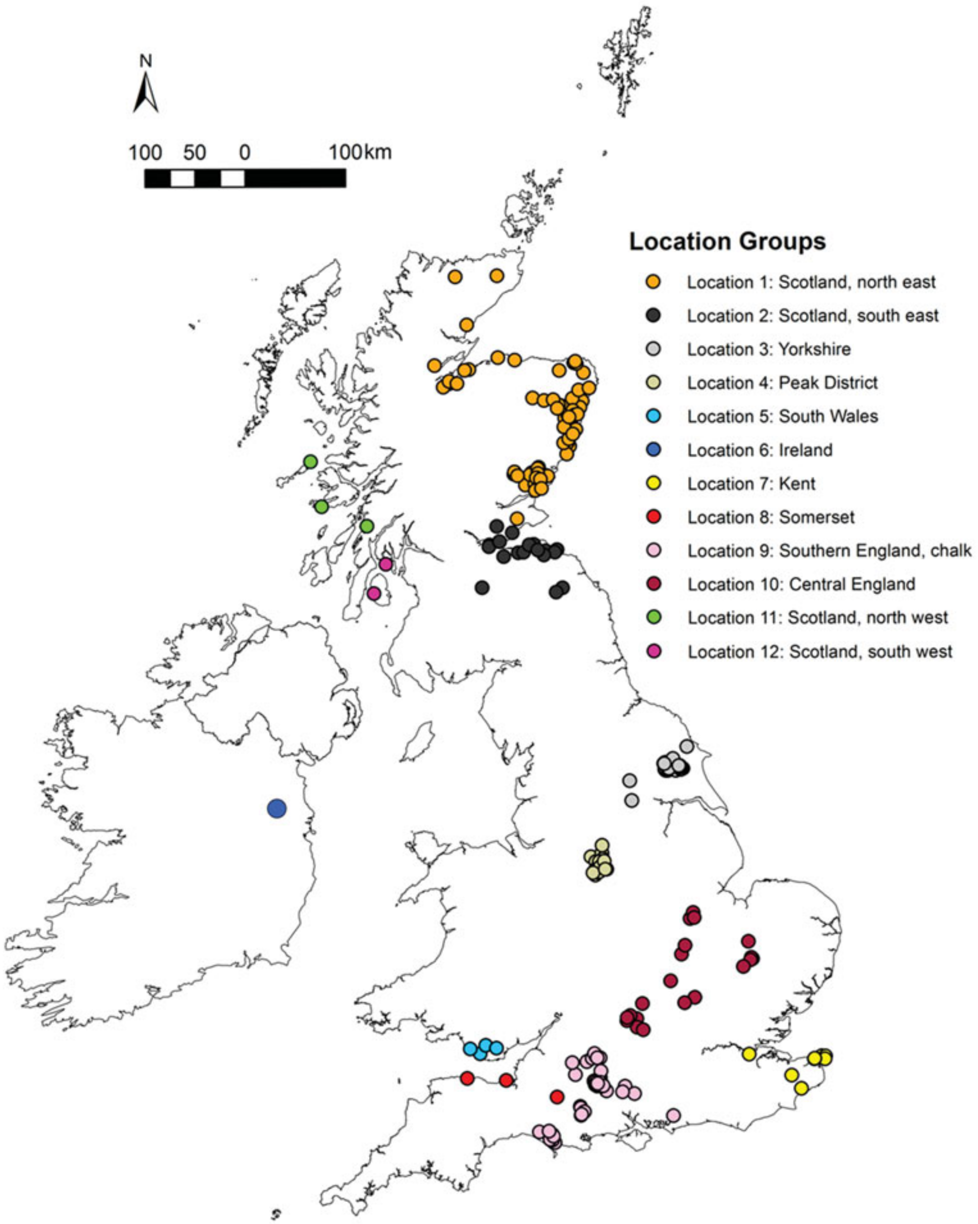

Figure 1. Beaker-period burials in Britain for which isotopic analysis has been undertaken.

produced in greater numbers and then decreased as their popularity waned—it makes the fewest assumptions about the distribution of dates.

The model estimates the first use in Britain of Bell Beakers in burials to have occurred in *2475–2360 cal BC* (*95% probability*) and probably *2450–2385 cal BC* (*68% probability*). Their first use in funerary contexts started in Wessex (84% probability), followed by the Peak

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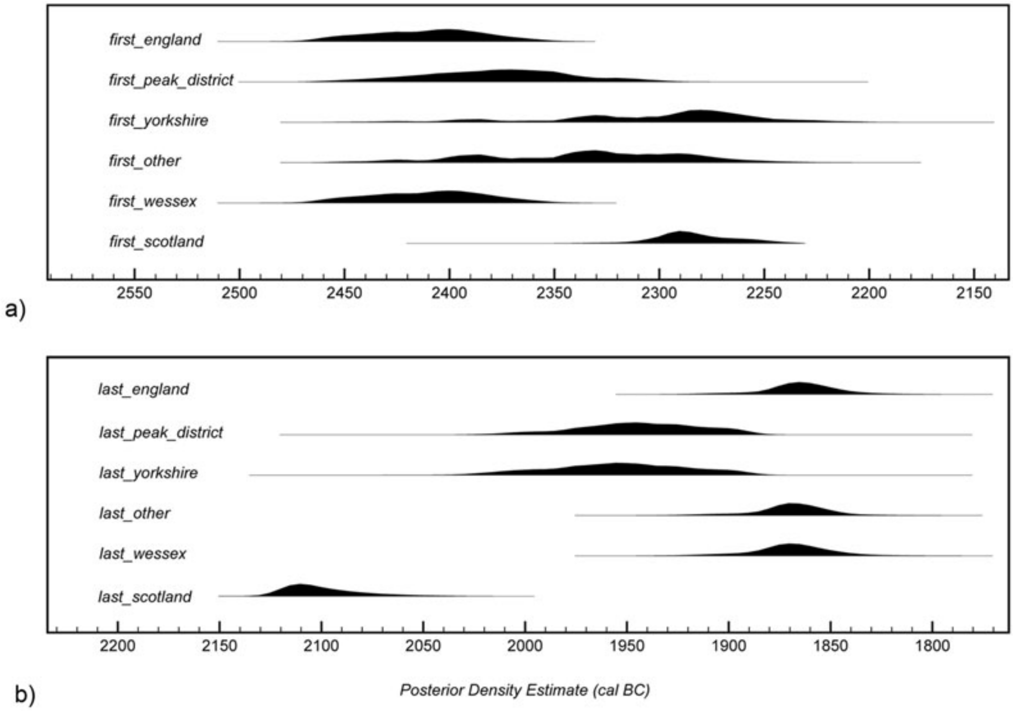

Figure 2. Probability distributions for use of Beakers in burials in geographic regions of Britain: a) beginning of use; b) end of use.

District (61% probability), Scotland (47% probability), other regions (44% probability) and finally Yorkshire (36% probability; Figure 2).

The end of use of Beakers in burials in Britain is estimated to have occurred in *1905–1810 cal BC* (*95% probability*) and probably *1880–1840 cal BC* (*68% probability*). Their last use in graves in Scotland occurred earlier, in *2130–2045 cal BC* (*95% probability*) or *2120–2080 cal BC* (*68% probability*).

Beakers first stopped being placed in burials in Scotland (100% probability), then Yorkshire (58%), the Peak District (58%), other areas (49%) and finally Wessex (49% probability; Figure 2). The overall period of use of Beakers as grave goods is estimated to have been *480–640 years* (*95% probability*) and probably *515–600 years* (*68% probability*). In northern Britain, Food Vessels (a wholly British and Irish style of post- and late-Beaker pottery; Wilkin 2014) replaced Beakers, whereas Beakers continued to be used in Wessex long after the introduction of Food Vessels in that region.

British Beaker burials have been divided into three chronological stages (Figure 3; Needham 2005, 2007, 2012), a scheme supported by the new radiocarbon dates (with two exceptions that could be explained by curated bodies with anachronistic grave goods; see Booth *et al.* 2015). The earliest period (*c.* 2450/2400–2300 cal BC) is characterised by Low-Carinated Bell Beakers, while non-perishable grave goods include copper knives, stone wristguards, barbed-and-tanged flint arrowheads, flint tools and flakes, boars' tusks, bone

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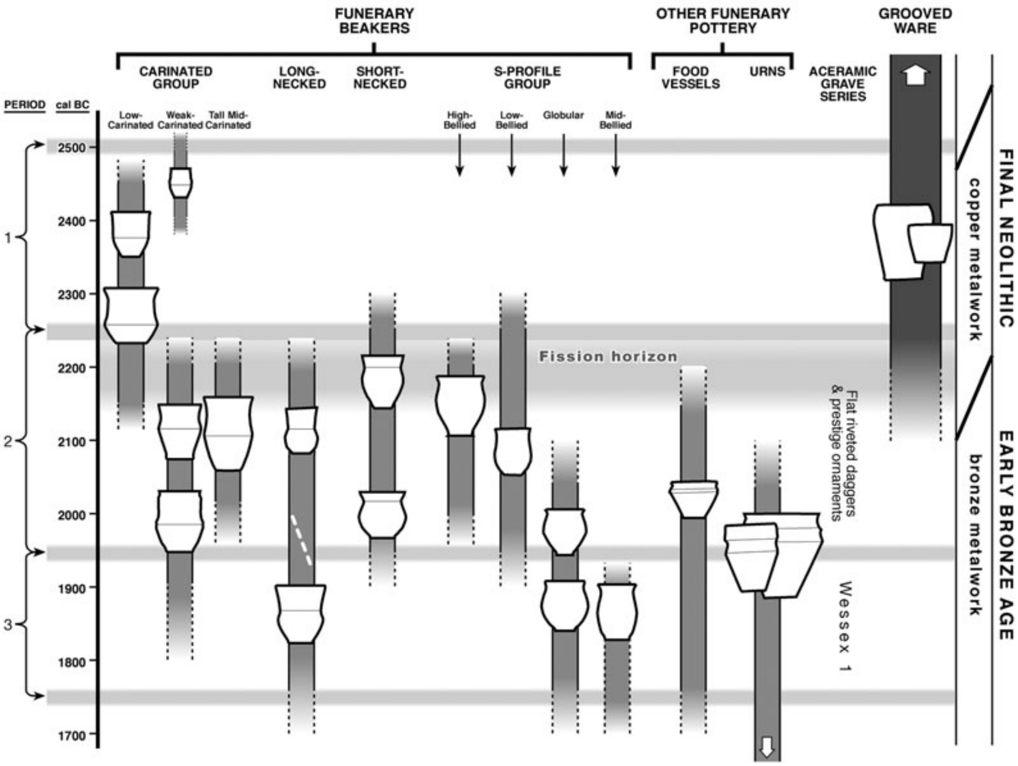

Figure 3. The ceramic chronology for British Beakers.

pins, antler or bone spatulae, belt rings, iron pyrites strike-a-lights, gold hair-tress rings and other ornaments, such as those accompanying the Amesbury Archer (Fitzpatrick 2011).

The second period begins around 2300/2250 cal BC with a 'fission horizon' (Needham 2005), when a wide range of pot styles was adopted for funerary use. From this point onwards, these British pots are known simply as 'Beakers' to distinguish them from the earlier, pan-European style of Bell Beaker. Copper was succeeded around 2200/2150 BC by bronze. Needham's third period (*c*. 1950–1810 cal BC) equates with Wessex I, the horizon of gold-provisioned burials (both inhumations and cremations) of Britain's Early Bronze Age (Piggott 1938; Needham *et al.* 2010).

Human osteology

The selection of skeletal remains was dictated by the presence of suitable dental enamel, so the sample is not entirely representative of the archaeologically retrieved population. There is a deliberate bias in avoiding the very young (whose permanent teeth were insufficiently developed) and the elderly (whose molars were missing or severely worn). Slightly more male skeletons are present than female or those of unknown sex, and there are more middle-aged adults than those of other ages. Examples of trauma were few; none were as dramatic as the chronic infection in the Amesbury Archer's left knee (McKinley 2011: 80–81).

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Statistical analyses of the Peak District sample reveal significant differences in cranial length between Early Neolithic (*c*. 3800–3400 cal BC) and Beaker/Bronze Age (*c*. 2500–1500 cal BC) individuals, confirming the transition from dolichocephalic (long-headed) to brachycephalic cranial forms. Certain individual skulls exhibit occipital flattening, probably caused by infants lying flat on their backs or being secured to a cradle-board. Two Neolithic skulls exhibit artificial cranial deformation resulting from infant head-binding to produce long skulls. This evidence was recognised at the time of excavation (Bateman 1861; Wilson 1863: 273–74) but has been largely forgotten; it goes some way to resolving the debate about 'racial types' of brachycephalic Beaker people and dolichocephalic Neolithic people across Europe (Childe 1925: 90; Gerhardt 1976; Brodie 1994) by introducing a cultural explanation for some of these differences in cranial shape.

Carbon, nitrogen and sulphur isotopes: diet and mobility

Isotope ratios from skeletal collagen provide useful insights into diet but, as part of a multi-isotope study of both bone and dentine to provide evidence for lifetime changes, they can also contribute to investigating mobility. Collagen chemistry reflects dietary protein, ultimately leading back to plants at the base of the food chain, which themselves reflect the isotope ratios found in their natural environment (e.g. atmospheric carbon, soil nitrogen, geological sulphur). This is similar to the way in which strontium and oxygen isotope ratios are used as evidence for mobility, although regional environmental distinctions are less clear.

The carbon isotope ratios reveal a restricted range of values that suggests both a consistent background environmental signal across Britain, and a consistent diet across the entire group, with no noticeable variation from northern Scotland to southern England (Jay & Richards 2007; Jay *et al.* 2012). By contrast, dental microwear analysis (Mahoney 2007) reveals consistent regional differences in the physical properties of the foods consumed. Samples from central and southern England had a harder diet—foods requiring greater compressive forces, such as seeds or nuts—compared with more northern regions in England and Scotland, where a softer but still abrasive diet—consistent with greater dietary emphasis on plants and their contaminants—was consumed.

No individuals from the period *c*. 2500–1500 cal BC had a significant marine component in their diet, despite the fact that many of the burial sites are very close to the coast. In general, Beaker people were omnivores, with a relatively high level of animal protein in their diet.

This is an unprecedented dataset of carbon and nitrogen isotopes at the British scale with a consistent analytical foundation, and no regional distinctions in human diet have been found, suggesting that climate differences within Britain had little effect on regional dietary resource values at this time. Since temperature and rainfall have an effect at the continental scale (e.g. van Klinken *et al.* 1994), the consistency of the δ^{13}C data for both bone and dentine may indicate that mobility revealed by other isotope ratios (see below) relates largely to movement *within* Britain, and not at a continental scale.

The BPP analyses were of collagen from both bone and tooth root dentine for each individual. Bone remodels during life and thus reflects an averaged lifetime dietary input, albeit weighted towards adolescence. The tooth root results reflect only childhood diet

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because primary dentine forms early and is not remodelled. Although secondary and tertiary dentine can form during life in the pulp chamber, the amounts involved are slight. Given that the BPP processed entire roots (in order to produce enough collagen for sulphur analysis) the homogenised bulk product from each tooth is unlikely to have produced an isotope ratio significantly affected by dentine that formed after childhood. All collagen data retained for interpretation, from both bone and dentine, fell within the quality parameters that are usually considered indicative of samples free from contamination or diagenetic alteration (van Klinken 1999).

The average carbon isotope values are $-21.2\pm0.3‰$ for bone, and $-21.0\pm0.4‰$ for dentine. The $\delta^{15}N$ ratios show more variation than the carbon isotope ratios ($10.2\pm0.6‰$ for bone; $10.3\pm0.7‰$ for dentine), most probably reflecting local environments rather than differences in diet; there is a broad distinction between those individuals buried on chalk bedrock and those buried west of the chalk ($\delta^{15}N$ ratios of $10.0\pm0.7‰$ for Cretaceous and young terrains to the east *versus* $10.4\pm0.5‰$ for older terrains to the west). This distinction is also present for domesticated herbivores ($5.6\pm0.6‰$, $n = 58$, as opposed to $6.2\pm0.5‰$, $n = 32$). Among those individuals with unusual $\delta^{13}C$ and $\delta^{15}N$ values are two from Kent (Figure 4); these values may indicate migration from outside Britain or merely non-normative dietary histories.

Across the dataset, $\delta^{13}C$ and $\delta^{15}N$ values are slightly higher for dentine than for bone (by $0.2\pm0.3‰$ for carbon and $0.2\pm0.5‰$ for nitrogen). The majority of teeth analysed were second molars or premolars, chosen specifically to avoid the probable period for breastfeeding, so the difference is unlikely to have been caused by breastmilk. It is possible that there is a physiological cause for this systematic difference, but childhood diet in this overall population may have differed from that of adults in a consistent way across Britain at this time.

Extreme (>3 standard deviations (SD) from the mean) carbon and nitrogen isotope ratio differences between bone and dentine in nine individuals, from sites across Britain, may reflect migration between childhood and later-life environments, as supported in several cases by the other isotope data. For example, one of the Boscombe Bowmen from a multiple burial in Wessex (Fitzpatrick 2011) has a $\Delta^{13}C_{(bone\text{-}dentine)}$ value of 0.9‰ (Figure 5). His strontium and oxygen isotope ratios have been interpreted as being indicative of migration, possibly from Wales (Evans *et al.* 2006). The bone–dentine difference may therefore indicate mobility.

Detailed results of the sulphur isotope analysis are presented elsewhere (see Jay *et al.* 2012: 233–34; Parker Pearson *et al.* forthcoming). Regional variation in collagen $\delta^{34}S$ does occur, probably caused mainly by geology and distance from the coast, but also possibly by dietary differences. While carbon and nitrogen isotope ratios reveal no dietary difference between northern and southern Britain of the kind revealed by dental microwear, there are regional $\delta^{34}S$ distinctions. References to $\delta^{34}S$ ratios are made below for cases of interest.

Strontium and oxygen isotopes

Enamel strontium isotope ratios are a weighted average produced from diet over many months (Montgomery *et al.* 2010). It is often impossible, therefore, to identify the different

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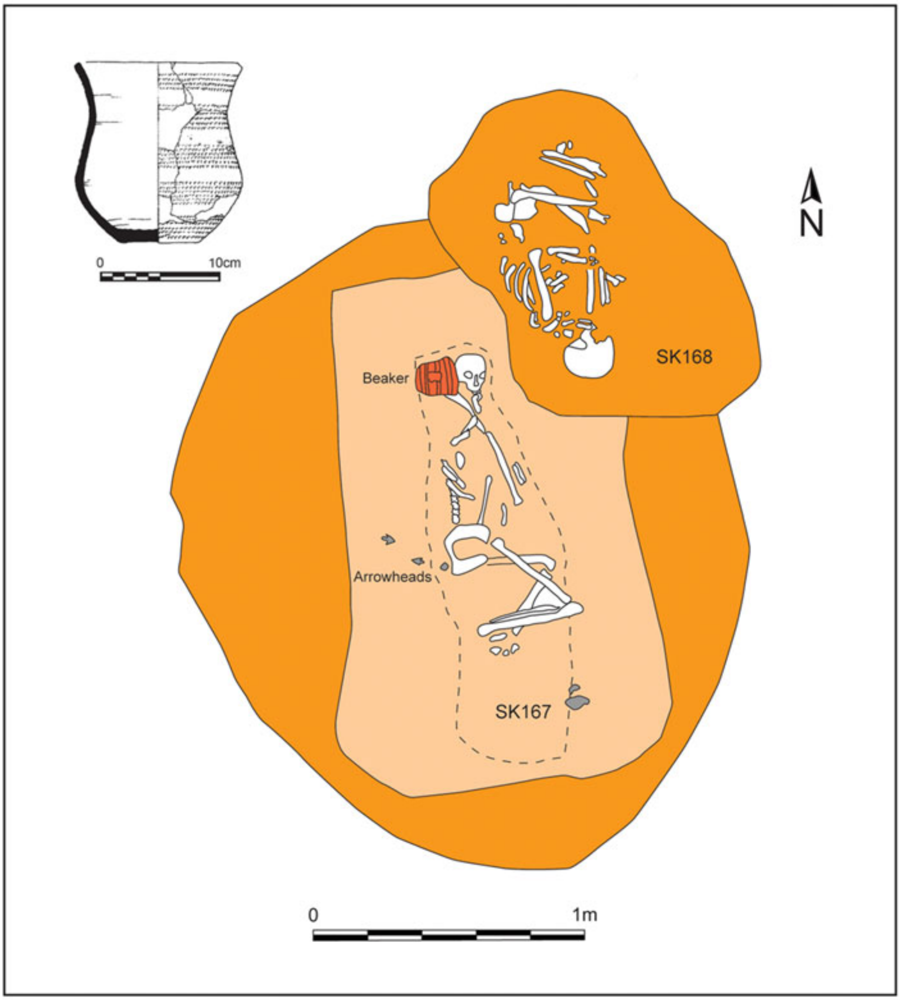

Figure 4. Two burials from the QEQM Hospital site, Margate. The earlier, male burial (SK167 with a Beaker and three arrowheads) has the highest $\delta^{15}N$ ratio (at 11.9‰) within the dataset, and the female burial (SK168 with an arrowhead) has the most negative $\delta^{13}C$ (−22.3‰). SK167 dates to 2330–2195 cal BC (94% probability; Wk-18733) and SK168 to 2140–1955 cal BC (95% probability; OxA-V-2271-37). Drawing by Irene De Luis after Moody (2008).

contributions and, if food is procured locally from two or more rock types, the resulting human isotope ratio may not be characteristic of either (Montgomery 2010). Such difficulties were largely overcome by the BPP because the majority of individuals were excavated from geographically restricted, well-characterised regions of chalk and limestone (Figure 6). For Scotland, however, individuals were sampled from a wide range of geological terrains, many having no comparative data from either the local biosphere or other archaeological skeletons. It has therefore not been possible to constrain local ranges for the Scottish burials as tightly as regions within England.

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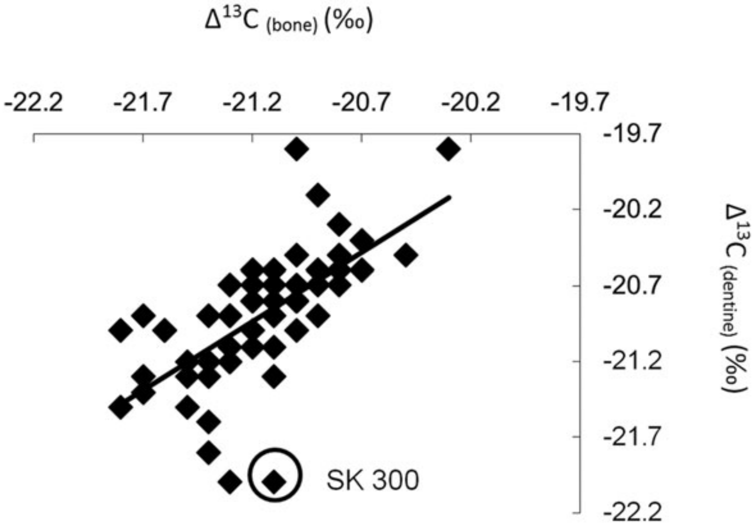

Figure 5. $\delta^{13}C$ values from bone and dentine (x and y axes respectively) for individuals from southern England, with a 'Boscombe Bowman' (SK300) highlighted as having a difference between the values for the two skeletal fractions that is more than 3 SD from the mean of such differences.

Individual mobility has, however, been indicated for many of the individuals from Scotland by analysing dentine mineral (not to be confused with the collagen discussed above), which is not resistant to diagenetic strontium changes caused by the burial environment, as is the enamel. The strontium isotope ratio of the dentine can provide an indication of the trend towards the values of the burial soil and, hence, the local geology (Montgomery *et al.* 2007). The comparison between the unaltered enamel value and that from the dentine, which is equalising with the burial environment, can suggest whether the enamel shows a probable non-local signal even if the geological ranges for Scotland are not tightly constrained.

Few age-related or gender differences in mobility have been revealed by strontium isotope analysis. The proportion of females to males among 'movers' is slightly higher than that in the entire sampled population.

The proportion of detected probable lifetime migrants in the sample is 28% on strontium isotope analysis alone (Table 1). The real figure is probably higher as those who moved between similar geological regions will generally have remained undetected, and this table only includes migrants with a Sr isotope difference of >0.001 between the enamel value and the environmental value, the latter being based either on measured dentine analysis (this study) or taken from Evans *et al.* (2012). The isotope data may even relate to long-distance corpse transport as well as lifetime mobility. On the strontium isotope evidence, the proportion of movers is 28%; this increases to 41% when results from other isotopic analyses are included (Table 1).

There are also considerable differences between regions, with the highest mobility in northern Scotland, Yorkshire and the Peak District. It should be noted, however, that the complex geology of Scotland produces significant changes in biosphere strontium isotopes at a relatively small geographic scale, so, while identified as non-local, movements in those

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Table 1. **Numbers of individuals (*c.* 2500–1500 cal BC) analysed by region and by broad period, showing those detected as probable 'non-locals' by $^{87}Sr/^{86}Sr$ isotope analysis and other isotopic evidence.**

	Total	Sr movers	%	Standard error	Oxygen	Sulphur	C & N	Other isotopes	Total movers	Total %	Standard error
Northern Scotland	27	17	63	9	0	0	0	0	17	63	9
Southern Scotland	13	3	23	12	1	1	0	2	5	38	13
Western Scotland	4	2	50	25	0	0	0	0	2	50	25
Yorkshire	68	13	19	5	2	8	1	11	24	35	6
Peak District	29	15	52	9	1	1	0	2	17	59	9
Wales	5	1	20	18	0	0	0	0	1	20	18
Kent	17	6	35	12	0	1	0	1	7	41	12
Somerset	3	1	33	27	0	0	0	0	1	33	27
Southern England	68	16	23	5	2	4	1	7	23	34	6
Central England	30	1	3	3	0	9	0	9	10	33	9
Total	**264**	**75**	**28**	**3**	**6**	**24**	**2**	**32**	**107**	**41**	**3**
Earlier Chalcolithic *c.* 2450–2300 cal BC	32	10	31	8	0	6	0	6	16	50	9
Later Chalcolithic *c.* 2300–2150 cal BC	59	19	32	6	1	3	0	4	23	39	6
Early Bronze Age *c.* 2150–1500 cal BC	111	37	33	5	4	10	2	16	53	48	5
Undated burials with a Beaker	20	5	25	10	0	2	0	2	7	35	11
Undated burials without a Beaker	42	4	10	5	1	3	0	4	8	19	6

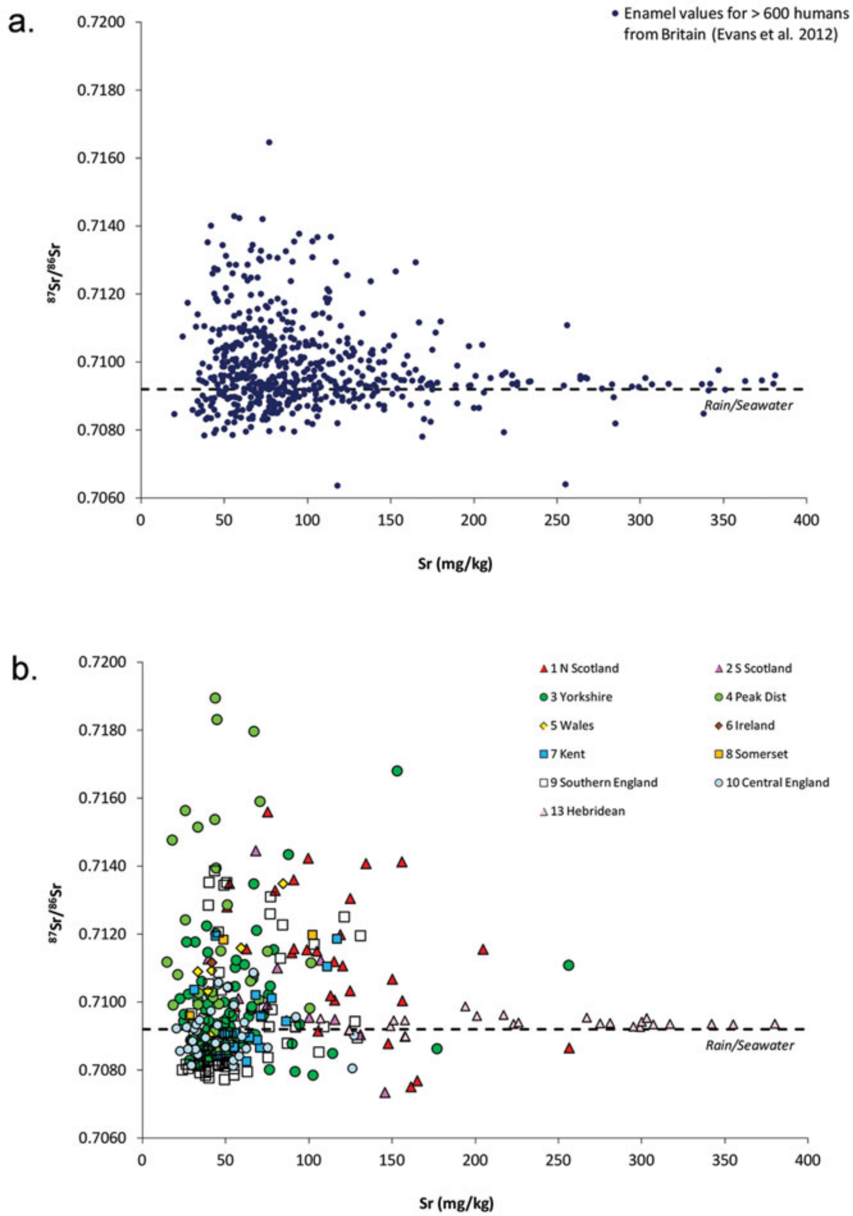

Figure 6. a) All the enamel strontium data for Britain from non-BPP archaeological investigations of all periods ($n > 600$; Evans et al. *2012); b) all the enamel strontium data for Britain from the BPP ($n = 264$), grouped by region.*

instances may not necessarily have covered large distances. The English Midlands displayed the least mobility, with strontium isotope results consistent with the Cretaceous and Jurassic geology of places of burial in all but one instance. As many as nine individuals out of thirty in this region may, however, have been mobile on the basis of $\delta^{34}S$ and other isotopic evidence. One of these, a secondary burial from Irthlingborough, Northamptonshire

(Figure 7), has sufficiently extreme differences between bone and dentine $\delta^{34}S$, $\delta^{15}N$ and $\delta^{15}C$ values to suggest that he grew up some distance from where he was buried.

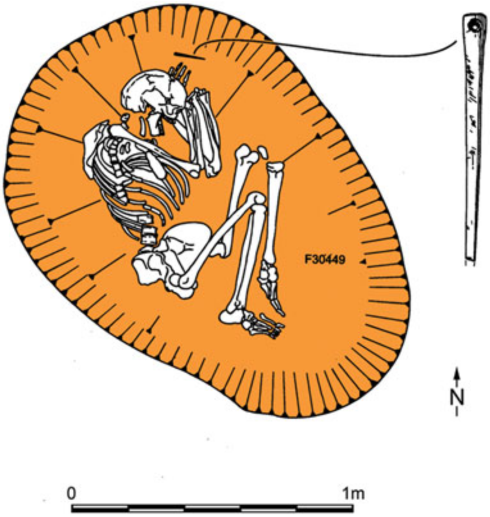

Figure 7. A secondary burial (1945–1730 cal BC [95% probability; UB-3147]) into the top of a round barrow at Irthlingborough, Northamptonshire, is that of a young man with a bone pin. Extreme divergences between bone and dentine $\delta^{34}S$, $\delta^{15}N$ and $\delta^{15}C$ ratios indicate probable migration after childhood. (From Harding & Healy 2007.)

Regional differences: the Peak District and Wessex

The Peak District produced unusually high strontium isotope ratios (>0.7145) for eight individuals, of both sexes. Extremely rare in any European population outside Scandinavia, these high ratios are produced by the consumption of crops grown on ancient or granitic rocks. Another Peak District individual is a middle-aged man with childhood cranial modification from Bee Low (Figure 8), buried in a round barrow with a bronze pin and two possible awls but no pot, in *2200–2030 cal BC* (*95% probability*; SUERC-31855). Although his strontium isotope ratio is not unusual for the Peak District, his extremely low oxygen isotope ($\delta^{18}O$) value of 16.2‰ is equivalent to that of the Amesbury Archer (Chenery & Evans 2011), indicating that the Bee Low man grew up in a cold and 'continental' climate, either in eastern Scotland or outside Britain. His unusually high $\Delta^{34}S_{(bone\text{-}dentine)}$ value (8.5‰) suggests migration from a region farther from the coast than the Peak District, i.e. continental Europe.

Similarly low $\delta^{18}O$ values (16.2‰) were obtained from only two other burials, both from eastern Scotland; overall isotopic results suggest that they are probably indigenous to that region. The long-distance mobility of the Amesbury Archer (and Bee Low man) is the exception rather than the norm.

Ten individuals in Wessex (both male and female, buried with and without Beakers) have strontium isotope ratios between around 0.7120 and 0.7140 (Figure 9). These include three of the 'Boscombe Bowmen' (Evans & Chenery 2011). Such values derive from Palaeozoic rocks (e.g. Devonian sandstone or Silurian mudstones) or from a combination of atmospheric deposition (e.g. rainfall) and granitic or gneissic bedrock; they cannot be obtained from the chalk or from adjacent Mesozoic and Cenozoic sediments. This suggests a migration stream into Wessex from the west or north, or from beyond the shores of Britain (Ireland or the Continent). The wide range of $\delta^{18}O$ values (16.9‰–19.3‰) amongst this group makes it unlikely that they derive from a single place.

Conclusion

Brodie (1994, 2001) proposed that the Beaker way of life spread through exchange of marriage partners. Vander Linden (2006, 2007) emphasises that Bell Beaker migration was

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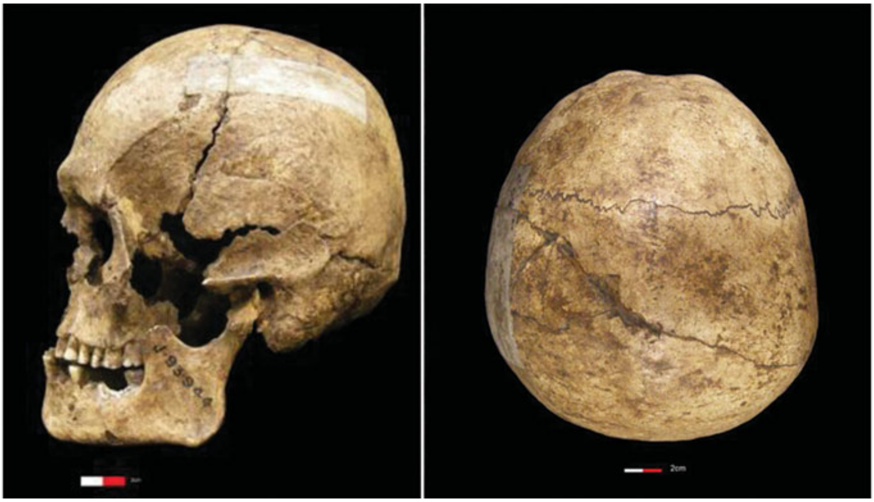

Figure 8. The skull from Bee Low, Derbyshire (SK200; J.93.944), demonstrating occipital flattening in two views: taken in norma lateralis (left) and norma verticalis (right). Image courtesy of Sheffield City Museum.

not an all-pervasive wave of advance. He suggests a generalised marriage exchange model (as opposed to restricted, Lévi-Strauss 1969), in which partners marry out of the group without expectation of counter-marriage; in this way, Beaker know-how and ideas could have moved long distances, producing the characteristic fragmented geographic distributions. Needham (2005, 2007) uses aspects of this approach to explain the pioneering phase of Beaker dispersal but disputes Brodie's proposed mode of inter-marriage. Instead, expansion led to inter-cultural contact in a reinforcing circle: if the indigenous response was favourable, then Beaker groups consolidated and further expanded, with a continuous process of budding-off. Our results show little difference between male and female migration histories across Britain: notions of exogamous exchange of female marriage partners do not explain the observed patterns of movement.

Our research demonstrates a considerable degree of mobility between childhood and death, most of it probably within Britain and persisting over many centuries. The strontium isotope results show that almost a third of the sampled population were buried in a geological region different to that in which they grew up. Some regions, notably the Peak District, show considerable evidence for inward migration, while others, e.g. central England, show virtually none.

For Bell Beaker people in Central Europe, the proportion of migrants into local populations is estimated variously as 62% or 24%, depending on the method of determination (Price *et al.* 2004: 30). These movements are considered to have taken place throughout the Bell Beaker period, and involved either small groups or individuals (Grupe *et al.* 1997, 1999, 2001; Price *et al.* 1994, 1998, 2004). The more conservative estimate of 24% is based on cases where tooth enamel strontium isotope values differ from bone or burial environment by >0.001.

We consider that most lifetime movement during the Chalcolithic–Early Bronze Age was within Britain rather than from Europe into Britain. For a few examples, including

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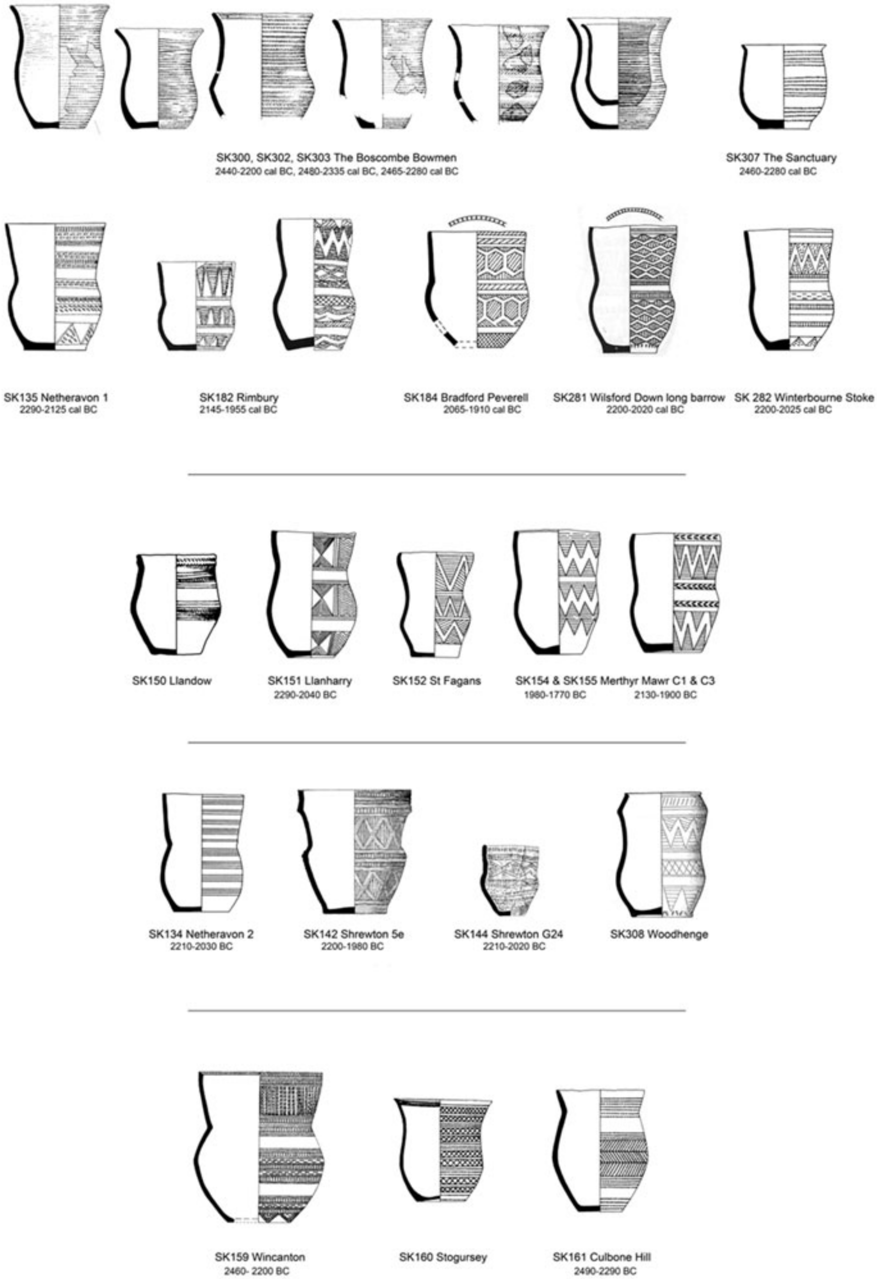

Figure 9. Top two rows: Beakers associated with nine of the ten individuals from Wessex whose strontium isotope ratios indicate that they grew up some distance away from Wessex on Devonian/Silurian geology. Third row: Beakers in burials of non-migrants on South Wales Silurian geology. Fourth row: Beakers in burials of non-migrants on Wessex chalk. Fifth row: Beakers in burials of non-migrants on Devonian geology of south-west England. The second, third and fourth rows include Long-Necked Beakers sharing Clarke's Southern British motif group 4 (1970: 427). (From Clarke 1970; Woodward 1980; Fitzpatrick 2011.)

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the Amesbury Archer, migration from the European Continent is the most probable explanation, and such migrations occurred at different times during the period, not simply at its beginning. Acknowledging that isotopic analyses may identify only first-generation migrants, the consistent proportion of non-locals through time indicates a high, sustained degree of mobility, much of it multi-directional and much of it probably linked to mobile subsistence practices. Rather than positing mass migration as the only process of Beaker expansion, we suspect that cultural transmission (diffusion of a 'Beaker package', as proposed by Burgess & Shennan (1976)) was also significant, especially in regions such as the English Midlands. This process of cultural transmission has been characterised as "emulation of what may increasingly have seemed to be a preferable way of life because of the advantages it brought" (Needham 2007: 44), accompanying the acceleration in growth of Beaker communities in the Later Chalcolithic (Needham 2012: 20–23, fig. 1.3).

The isotopic results provide a further dimension to previous studies of osteology and material culture, indicating that mobility was pervasive, regionally variable and long term during the British Chalcolithic and Early Bronze Age. It is probable that these isotope data will soon be enhanced by those of ancient DNA for Britain, allowing us to assess the strength of our conclusion that both migration and emulation—rather than migration alone—were significant processes behind the Bell Beaker phenomenon in Britain and elsewhere.

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