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**'Ava': a Beaker-associated woman from a cist at Achavanich, Highland, and the story of her (re-)discovery and subsequent study**

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# ‘Ava’: a Beaker-associated woman from a cist at Achavanich, Highland, and the story of her (re-)discovery and subsequent study*

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ABSTRACT

*This contribution describes the discovery and subsequent investigation of a cist in a rock-cut pit at Achavanich, Highland. Discovered and excavated in 1987, the cist was found to contain the tightly contracted skeletal remains of a young woman, accompanied by a Beaker, three flint artefacts and a cattle scapula. Initial post-excavation work established a date for the skeleton together with details of her age and sex, and preliminary pollen analysis of sediments attaching to the Beaker was undertaken. The findings were never fully published and, upon the death of the excavator, Robert Gourlay, the documentary archive was left in the Highland Council Archaeology Unit. Fresh research in 2014–17, initiated and co-ordinated by the first-named author and funded by the Society of Antiquaries of Scotland with assistance from National Museums Scotland, the Natural History Museum and Harvard Medical School, has produced a significant amount of new information on the individual and on some of the items with which she was buried. This new information includes two further radiocarbon dates, a more detailed osteological report, isotopic information pertaining to the place where she had been raised and to her diet, histological information on the decomposition of her body, and genetic information that sheds light on her ancestry, her hair, eye and skin colour and her intolerance of lactose. (This is the first time that an ancient DNA report has been published in the* Proceedings*.) Moreover, a facial reconstruction adds virtual flesh to her bones. The significance of this discovery within the Chalcolithic to Early Bronze Age of this part of Scotland is discussed, along with the many and innovative ways in which information on this individual, dubbed ‘Ava’, has been disseminated around the world.*

## INTRODUCTION: DISCOVERY AND EXCAVATION OF THE CIST

Maya Hoole

In February 1987, William and Graham Ganson were quarrying rock for use in road improvements at the side of the main A895 road (now the A9) at Craig-na-Feich near Achavanich, in the former county of Caithness, when their digger dislodged the capstone of a prehistoric short cist and pulled apart its south corner, exposing human remains and a Beaker. Having removed

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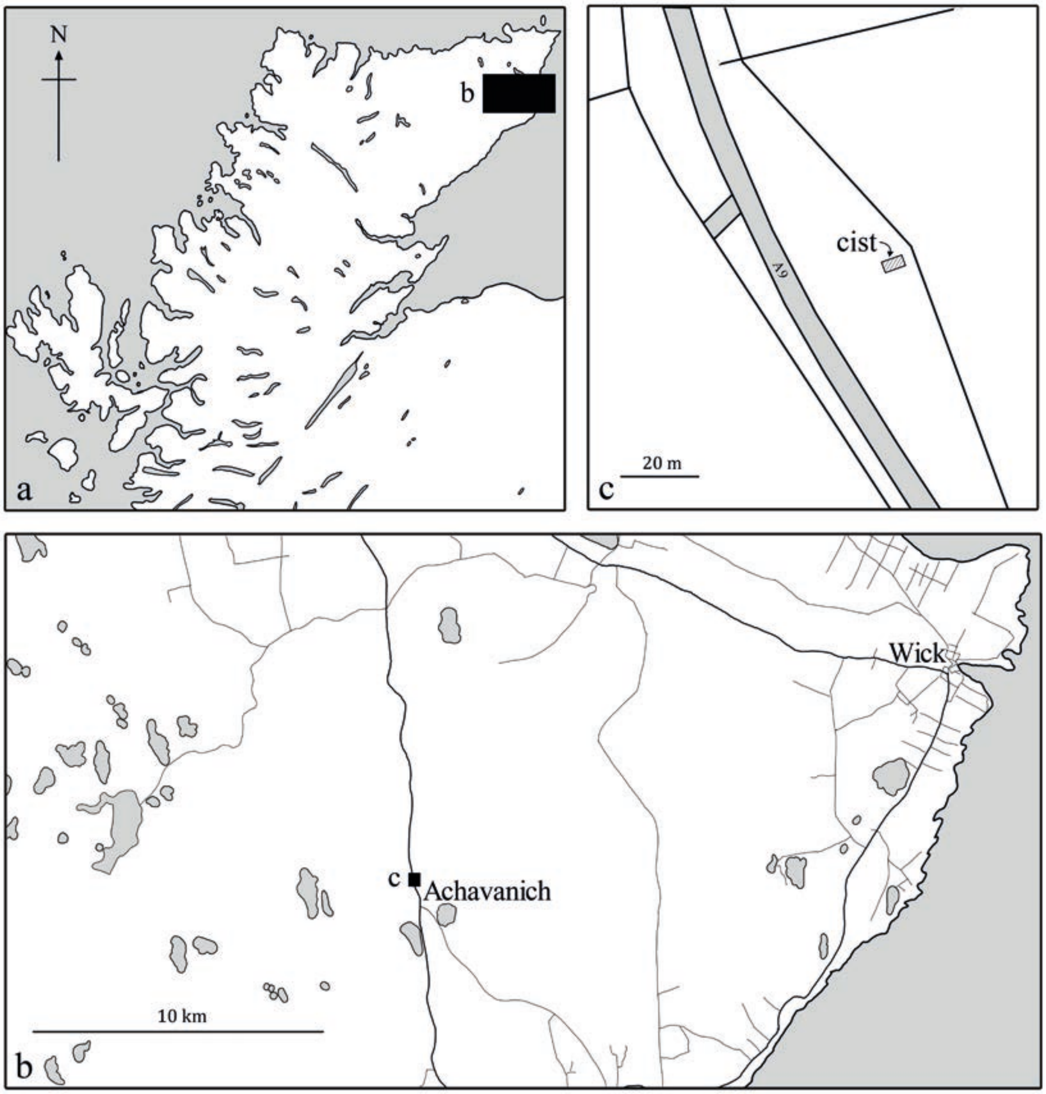
the pot to the nearby farmhouse to prevent it from being damaged by unstable material above, they contacted the Thurso Northern Constabulary, and the cist was inspected by Officer Neil Sutherland (Sutherland 2016: 1). Robert Gourlay – the Highland Regional Archaeologist – was then contacted and having advised them to 'wrap [the pot] in wet newspaper as the change of atmosphere could have a serious effect on it' (ibid: 2), he excavated the cist shortly thereafter.

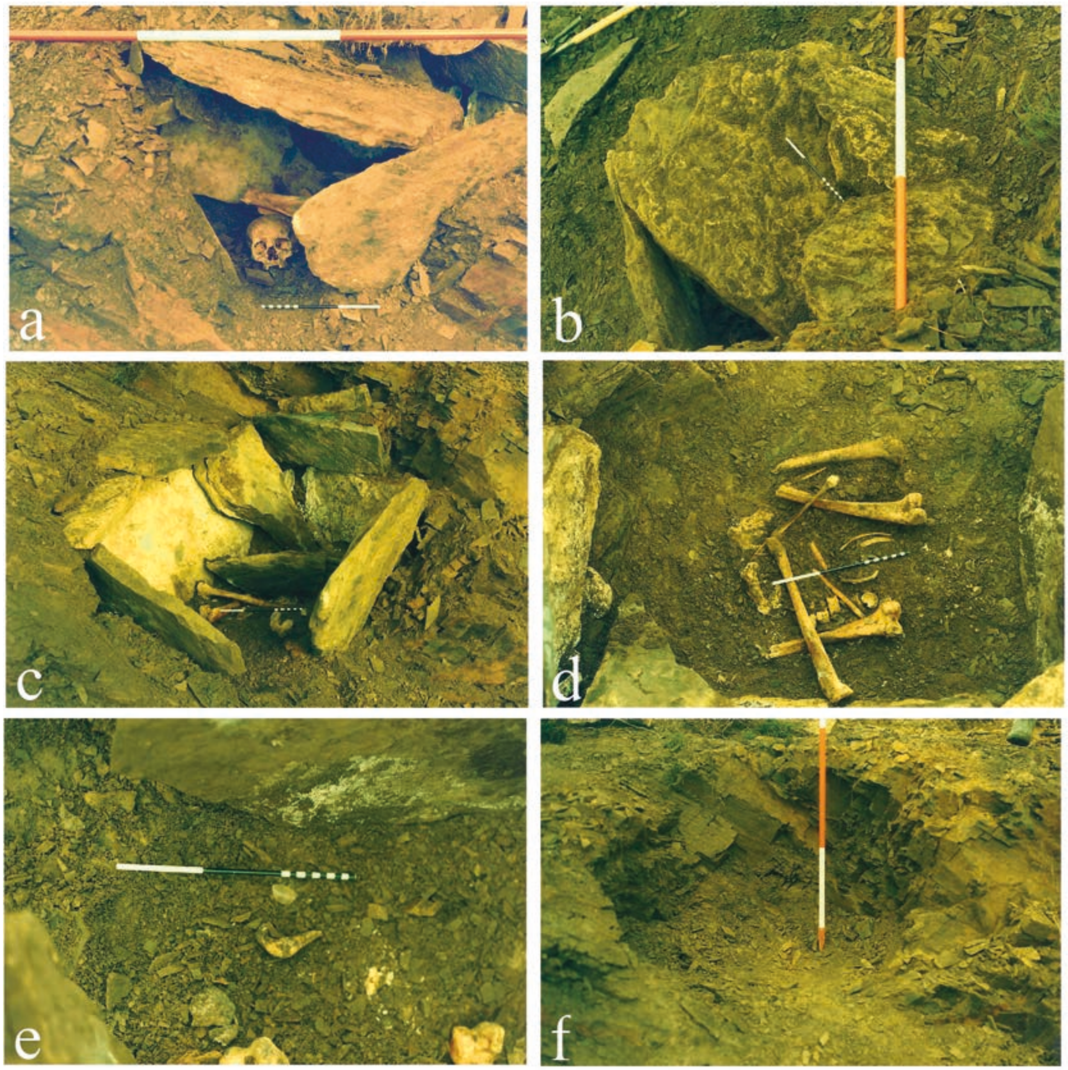
The cist (Canmore ID 317871; Highland HER ID MHG 13613) was located at NGR: ND 1783 4333 atop a low ridge at 150m OD (Illus 1). It had been set into a rock-cut pit and was orientated south-west to north-east along its longer axis. It was rectangular and constructed using four principal slabs and a large ovoid capstone, with additional slabs supporting and giving height to the north-east end slab and others supporting the capstone; its floor was formed by the base of the




Illus 1 Location plan by Maya Hoole

pit. No evidence was found above ground of a cairn or surface marker and no other graves were discovered in the immediate vicinity, although an exhaustive search was not undertaken.

The contents comprised the remains of a single person accompanied by a Beaker, three pieces of struck flint (namely one small 'thumbnail' scraper and two flakes), and a cattle scapula (Gourlay 1988: 2). The individual's head was to the south-west and feet to the north-east, and although there had been decomposition of the skeleton and some post-depositional movement of certain bones, the clustering and partial articulation of the bones suggested that the deceased had been buried in a tightly contracted position. The flint items were positioned in front of the cranium near the south-west end of the cist. The cattle scapula was placed behind the

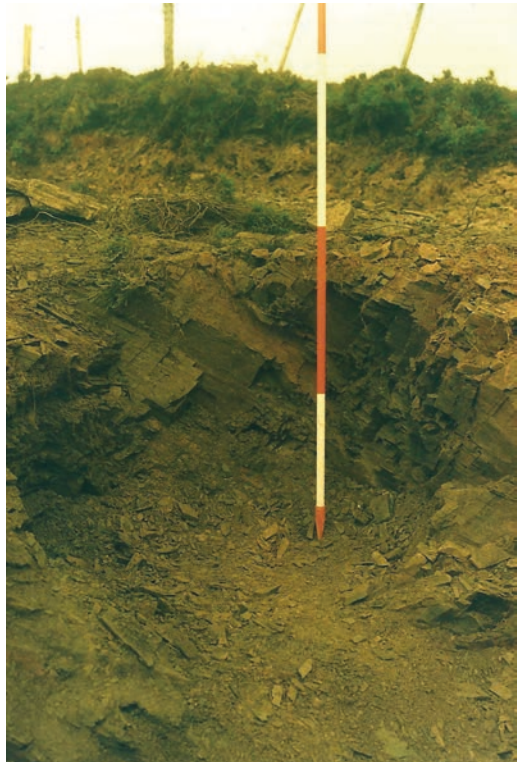



Illus 2 Selection of Robert Gourlay's 1987 excavation photographs (discoloured over time): (a) prior to excavation with skull probably set upright by the finders; (b) capstone from above; (c) cist shape after removal of capstone; (d) interior showing layout of human bones; (e) interior showing flint location (beside scale) and right human scapula; (f) rock-cut pit after removal of cist. Copyright © Highland Council

cranium between the west corner and the centre of the cist. It rested horizontally on top of the human bones and extended from the left knee to the left shoulder.

Unfortunately, the exact position of the Beaker is unknown as it had been removed by the finder as soon as the cist was uncovered, but Officer Sutherland recalled that the Gansons had reported that it had been positioned beside the skull (Sutherland 2016: 2). They also reported seeing the skull 'peeping out of the rock' and therefore facing south on discovery (although it should be noted that in the photograph (Illus 2a), the skull is likely to have been tilted upright for visual effect. Indeed, the skull might well have been taken out of the cist and then put back by the finders when they removed the Beaker). The cist was partially opened in the south corner, where the skull was located. Since there was no space for the Beaker to rest between the skull and the cist's south-west end slab, it is most likely that it had been positioned between the skull and the cattle scapula in the north corner of the cist (Illus 2a and 5).

The cist was recorded and excavated by Gourlay on 19 February 1987. No drawings or detailed notes of the excavation have been found, but a thorough photographic record was made, so the various stages of its excavation can be traced. Illus 2a shows the cist with its contents (except for the Beaker) intact; the gap in the cist's south corner where the digger had hit the cist is clearly visible. Behind the cranium it is possible to see the cattle scapula and the long bones extending into the cist's interior. The cranium and cattle bone were then removed, followed by the capstone, which had been balancing precariously above it (Illus 2b), along with loose rock. Close-up shots were taken showing the flint thumbnail scraper, the right human scapula, the ends of two long bones in situ, and fragments of the cranium at the south-west end of the cist prior to their removal (Illus 2d and e). The cist was photographed from the south, showing that one stone slab had collapsed inwards (Illus 2c). This and the south-east side-slab were removed and the rest of the skeletal material was revealed. The tightly contracted arrangement of the body was photographed from above (Illus 2d) before the bones were removed. The remaining stone slabs were photographed before they, too, were lifted. Lastly, the shape of the surviving northern section of the rock-cut pit was recorded (Illus 2f); the southern side had been destroyed during quarrying work. A final post-excavation photograph (Illus 3) suggests that there had been around 0.5–1m of overburden above the capstone covering the grave.



ILLUS 3 Excavation photograph showing an approximate 0.5–1m overburden above the grave. Copyright © Highland Council

## POST-EXCAVATION WORK, 1987–8

Gourlay returned to Inverness with the assemblage and set about organising preliminary post-excavation work. He secured some funding from Caithness District Council, which was keen to acquire the finds for display in the John

Nicolson Museum in Auckengill. Mary Harman produced an osteological report on the skeletal material, concluding that the remains were those of a young adult woman (Harman 1987), while radiocarbon dating of the right femur was undertaken at the British Museum at no cost, as part of a project to date British Beaker pottery, led by Dr Ian Kinnes. The result – 3700 ± 50 BP (BM-2590, 2280–1940 cal BC at 95.4% probability) – confirmed a date within the late Chalcolithic/Early Bronze Age (Ambers et al 1991). The Beaker was taken to Edinburgh for analysis, by Brian Moffat, of pollen trapped in sediments attaching to the inside and outside of the pot. Moffat concluded, from a preliminary examination, that pollen of barley and oats was present, along with that of 'major or minor honey plants' (heather type, ling, thyme family, scabious, clover, buttercups, composites and umbellifers); meadowsweet, bramble and wood sage; and birch and alder (Moffat 1988). From this he concluded that the pot had contained a thin alcoholic porridge or gruel, sweetened with honey and flavoured with meadowsweet and other flower heads or fruit, with birch and alder sap added: he referred to it as 'an alcoholic hotch-potch' (ibid). Moffat's request for additional funds for more detailed analysis could not be granted, so no further palynological investigation took place.

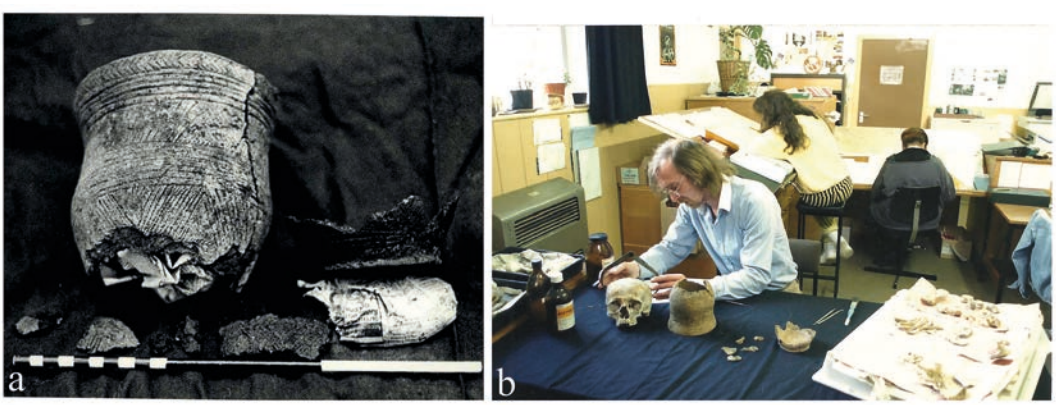
The Beaker had developed a large vertical crack and had fallen apart, around its lower belly, into seven pieces shortly after its discovery (Illus 4a). Following Moffat's examination it was returned to Inverness and repaired by Gourlay (Illus 4b), before being sent north, along with the rest of the assemblage, to the John Nicolson Museum. (It had not, however, passed through the Treasure Trove system.)

While Gourlay was able to produce a short public information leaflet about the find, he was unable to work on a definitive publication owing to competing demands on his time, and upon his death in 2007 the documentary archive remained in the Highland Council Historic Environment Record.

## THE 2014–17 RESEARCH PROJECT

### Maya Hoole

In 2014, the Highland Council's record of the Achavanich cist was discovered by the lead author, who decided to find out more about the site and its finds, and to disseminate information about it as widely as possible. Time was spent on analysing the paper archive and recreating plans of the site from the photographs, as well as tracking down information and people who were connected to the cist and its contents. Most individuals were untraceable, deceased or had no recollection of the burial. As the John Nicolson Museum had closed long before, the location of the assemblage was unknown. A fortunate




Illus 4 (a) The Beaker after it cracked and separated into seven pieces; (b) Robert Gourlay repairing the Beaker before it was sent north to the John Nicolson Museum. Copyright © Highland Council internet search revealed that the Beaker and the bone assemblage were at Caithness Horizons Museum in Thurso. In February 2015, the author visited the site and the museum, photographing and recording the Beaker and the skeletal assemblage. Unfortunately, the location of the flint was no longer known.

An appeal for information was published by the *Caithness Courier* newspaper in 2016. The former police officer Neil Sutherland and his daughter Kathleen Macdonald were among those who responded, with a report of his memories of the discovery. Alan McIvor, former curator of the Thurso Heritage Museum, also responded with photographs of the assemblage on display in the museum before it was redeveloped. (These confirm that the flint thumbnail scraper was still present at this stage.) Numerous other individuals responded, with photographs and recollections of the discovery.

On the advice of the second-named author, collaborations were established with a number of researchers to carry out further post-excavation work, much of which was kindly funded by a research grant from the Society of Antiquaries of Scotland. The reports that follow are the results of the wide-ranging specialist research undertaken on the assemblage since 2016.

## A NOTE ON THE USE OF THE TERM 'AVA'

Maya Hoole

Throughout this contribution the young woman discovered in the Achavanich cist will be referred to as 'Ava'. Initially this abbreviation (the central three letters of the place-name) was used as a name for the research project, but when the media took an interest in February 2016, the name was used interchangeably for the project and for the individual. Henceforth the term will be used to refer to the individual, rather than the overall project.

While there is room for discussion about the ethics of assigning a name to an individual from the past, we must not forget that the subject of our research is people, not inanimate objects: it is all too easy for archaeologists to become detached from the human nature of their discoveries. Numerous other famous human remains have been assigned names by archaeologists over time, including 'Lucy', an Australopithecus Afarensis recovered in the 1970s in Ethiopia, and 'Ginger', a naturally mummified Late Predynastic Egyptian man on display in the British Museum. Kirk and Start (1999) have advocated that archaeologists assign names to skeletons, not only as a memorable means of identification but also as a way to recognise the individuality of the deceased. The young woman from Achavanich would have had a name and an identity within her community, and assigning her a name helps draw attention to her individuality during life.

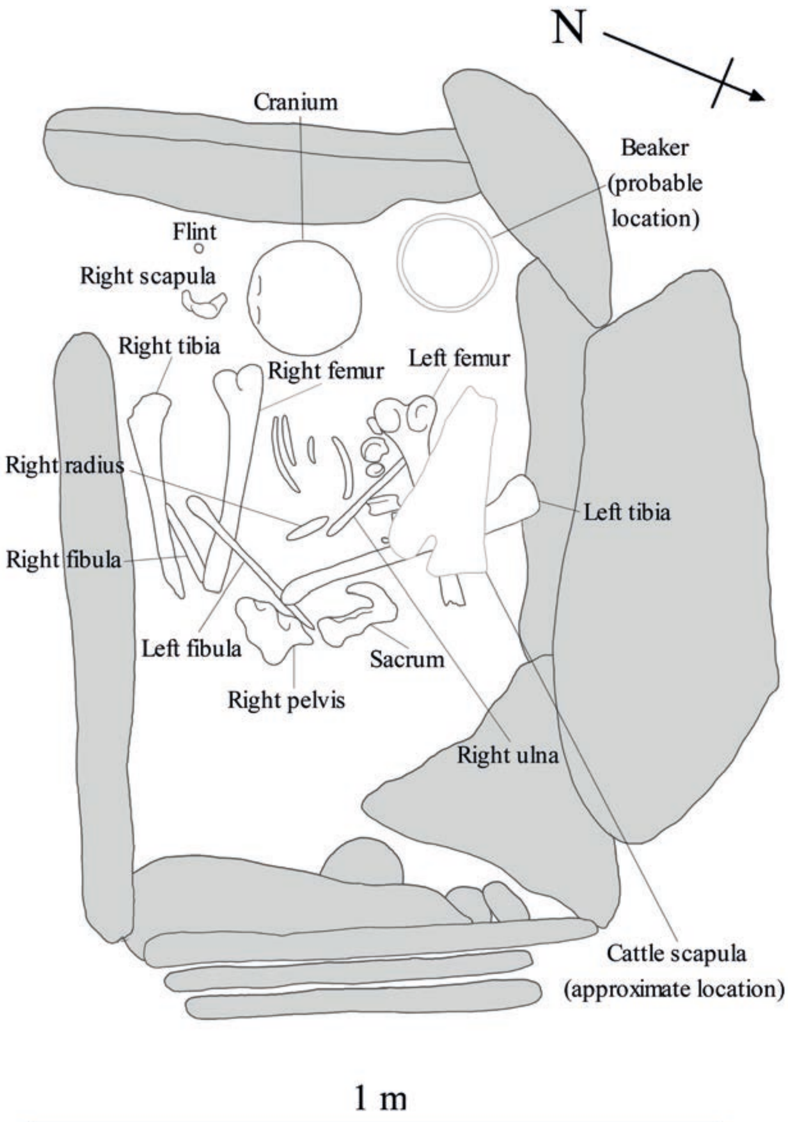
In 2006, Brooks and Rumsey highlighted how the practice of assigning nicknames can make human remains feel less alien and more human to museum audiences. This has, undoubtedly, also proven to be the case for Ava. As will be discussed in the final section, the naming of Ava and the fleshing-out of details about her proved to be a way of engaging millions of people across the world, and of encouraging their interest in Scottish prehistory.

Moreover, Giles and Williams (2016) recently noted how a well-publicised individual burial can often become an effective representative of a specific type of burial and can, by humanising the archaeological subject, engage the media and capture the imagination of the wider public audience. However, this approach must be taken with caution as such an intensive gaze on a single individual can create an over-exaggerated depiction of one identity, which may limit the visibility of the other rich and diverse personalities represented within the same burial tradition. This is especially problematic when a particularly unorthodox or wealthy example takes centre stage as its unique traits may become viewed as the norm. However, Ava's burial – and associated grave goods – could be considered relatively modest and (in terms of gender) under-represented within the wider setting of other equally well-publicised contemporary Beaker burials, making it an arguably favourable candidate for capturing the public's imagination.

## LABOUR ESTIMATE FOR THE DIGGING OF THE ROCK-CUT PIT

Maya Hoole

Unusually for a Beaker-associated grave, the cist had been inserted into a pit excavated into the Caithness flagstone bedrock. Its dimensions of 1000mm wide, 1380mm long and 940mm deep indicate that around 1.3m$^3$ of rock was removed to create the pit (Illus 2f, 3). Nineteenth-century statistics for quarrying stone by hand provide some assistance in estimating the labour requirements of the task: if shale can be used as a very rough comparator for Caithness




Illus 5 Recreated site plan (based on excavation photographs), showing probable location of Beaker and approximate location of cattle scapula. Note: see text regarding the probable original disposition of the cranium. Plan by Maya Hoole

flagstone, then given that $0.39m^3$ of shale weighs 1.01 tonne (McConnell 1883: 92), the weight of the flagstone extracted at Achavanich can be estimated at 3.38 tonnes or thereabouts. Using 19th-century metal quarrying tools, one man could extract and shift $3m^3$ of 'soft easily parted stone' and $1.5m^3$ of 'hard stone' per day (ibid: 91). Based on these calculations, it might have taken one 19th-century quarryman roughly half a day to extract approximately 3.38 tonnes of stone from the pit. If we assume that Chalcolithic/Early Bronze Age tools were half as efficient, the time doubles, and if conditions were poor (eg rainy), the time required would be longer. However, if more than one person was involved – as seems likely, given that funerary rites are believed to have been a community matter – then the pit could have been excavated in less time. Overall, it appears likely that the task could well have been achieved within a day or so.

## RESEARCH ON THE HUMAN REMAINS

### POSITION OF THE BODY WITHIN THE CIST

Maya Hoole and Angela Boyle

As noted above, the body seems to have been buried in the cist in a tightly contracted position. Illustration 5 presents a plan of the bones that are visible in the excavation photograph (Illus 2d), annotated to identify the individual bones. The surviving bones of the left leg – which had been moved out of their original anatomical relationships, probably by a combination of the decomposition process and the actions of burrowing animals – were found above all the other bones. Despite the incompleteness of the skeleton (as detailed below), the position and partial articulation of the bones shown in Illus 2d and 5 suggest that Ava had been buried on her right side (but perhaps not completely turned to her right), with her legs tightly drawn up so that her knees would almost have reached her shoulders, and with her right arm across her chest, under her legs. The position of the skull as shown in the plan (Illus 5) is based on the photograph Illus 2a and, as noted above, it is most unlikely that it would originally have lain on its chin like this, twisted at 90° to the rest of the body; it seems far more likely that it would have been in line with the body, facing approximately south-east. It is not known whether the body had been bound, to achieve the tightness of its contraction, but the position of the partly articulated bones suggests that some springing apart of the body occurred as part of the decomposition process: the surviving lumbar vertebrae, for example, had come away from the sacrum, to which they had originally been attached.

There remains the question of why nearly half the bones of the body, particularly those of the left (ie upper) side, were missing (as recorded below). Where natural decomposition in a cist occurs, it is normally the side in contact with the cist floor that suffers the most (Hutchison in press), but that appears not to be the case here. There was no obvious evidence of the cist having been reopened in antiquity and bones removed by humans, although given the circumstances of the cist's discovery (with the dislodging of the capstone by the digger), it is impossible to prove whether or not any ancient reopening had taken place.

It should be noted at this point that a north arrow was not included in any of the excavation photographs. The orientation of the cist has been calculated using the fence line adjacent to the cist (visible to the east in the background of several photographs), combined with study of aerial photographs and a site visit. The fence line runs NNW as it approaches the site from the south and alters course to the north-west directly to the east of the cist's location (Illus 1c). In the excavation photographs the cist appears to be perpendicular to the section of fence line which runs NNW. The orientation of the cist has therefore been calculated as running south-west to north-east along the longer axis, but this is inevitably an approximation. Although numerous site visits have been carried out, no further graves have been identified. However, an exhaustive survey has not been carried out and there is potential for further future investigation of the surrounding area, using non-invasive techniques.

## OSTEOLOGICAL ANALYSIS

Angela Boyle

The aims of the osteological analysis were to explore the health and physical attributes of the skeletal remains. The primary objectives were to determine the age, sex and stature of the individual; to undertake metric analysis; to record the presence of cranial and post-cranial non-metric traits and to record all evidence for skeletal and dental pathology. The skeletal material was examined in accordance with national guidelines (Brickley & McKinley 2004; Mays et al 2004; McKinley 2004).

Illus 6 The cranium: (a) profile; (b) left side showing damage to zygomatic bone; (c) from above; (d) from below; (e) right side; (f) back. Scale: 10 cm. Copyright © Michael Sharpe

*Surface preservation, fragmentation and completeness*

Surface preservation of the skeleton was scored as 3, which indicates that most of the bone surface was affected by some degree of erosion with general maintenance of morphology, although the details of parts of the surface are masked by erosive action. Fragmentation of this skeleton was moderate. Recent breaks were observed.

Completeness of the skeleton was scored as 41–60%. Missing skeletal elements comprised most of the occipital, part of the left and right temporal bones (including the mastoid processes), the mandible, most of the ribs, the sternum, all cervical vertebrae, the upper eight thoracic vertebrae, the left clavicle, left scapula, left humerus, left radius, left ulna, the hands (apart from the proximal shafts of the right third and fourth metacarpals), the left pelvis, the patellae, the ankles and the feet. Many teeth are missing. Only four survive intact; of the others, four have some dentine remaining and six survive only as crowns. Also absent from the skeletal remains, when they were examined in 2017, was the right femur, but this was because it had been used up in the radiocarbon dating undertaken in the 1990s.

*Assessment of sex, age and stature*

Sex determination was carried out using standard osteological techniques for assessment of the skull (Buikstra & Ubelaker 1994) as none of the sexually dimorphic characteristics of the pelvis had survived. Metric measurements were used where possible to supplement assessment of the skull (Bass 1987). The skeleton was identified as female based on three sexually dimorphic characteristics of the skull and three metric measurements.

Age estimation was based exclusively on dental attrition (Miles 1962; Brothwell 1981) and the final stages of skeletal fusion, in this case the first and second sacral bodies (Scheuer & Black 2000a, 2000b). The skeleton was identified as a young adult (18–25 years).

Stature was calculated using the regression formula developed by reference to adults of known stature (Trotter 1970: 77). In the original report, stature was calculated using the maximum length of the left tibia which now has damage to its proximal end; the resulting estimate was 166.5cm (65.55in). For the purposes of this report, a calculation of stature has been based on the maximum length of the right ulna and the resulting estimate was 171.34cm (67.45in).

*Cranial indices*

The cranial index of 88.88 falls within the hyperbrachycranial range, which is indicative of a very broad-headed skull (Illus 6). The brachycranial range was most frequently recorded by Brothwell in his study of Bronze Age populations (Brothwell 1973: 65), where he demonstrated a shift from dolichocranial (narrow or long-headed) skulls in the Neolithic to brachycranial skulls in the Bronze Age. The Achavanich skull appeared slightly asymmetrical, with a slight bulge on the right side at the back (Illus 6c, f). The sutures appeared normal and there was no identifiable pathology.

Comparable examples of hyperbrachycranic skulls from short cist burials were identified at nearby Acharole, Cnoc Sgadain (Bryce & Low 1905), where the cranial index was 85.8, and farther afield, at Piekie Farm, Boarshill, Fife (Waterston 1927), where a much higher cranial index of 91.9 was recorded. An example from Strathnaver (Low 1933) had a cranial index of 89.2. The author has not carried out an exhaustive search and the necessary information is not always readily available but there are likely to be further examples.

It was also possible to calculate the fronto-parietal index which was metriometopic (average or medium). The nasal index was platyrrhinic (broad or wide nasal aperture). The maxillo-alveolar index was brachyuranic (broad palate) while the orbital index was chamaeochonic (wide orbits).

*Meric and cnemic indices*

Leg measurements taken from the femora and tibiae were used to calculate the platymeric index (degree of flattening of the femur shaft front to back) and the platycnemic index (degree of medio-lateral flattening of the tibia shaft). The right femur was platymeric (broad or flat from front to back) while the tibiae were eurymeric (broad). Generally speaking, femur and tibia shafts have become rounded (meric and cnemic) over time, possibly due to an increasingly sedentary lifestyle (Wells 1964: 32; Brothwell 1981). However, the relationship between mechanical stress and flattening is far from clear and there could be other causes, such as mineral and vitamin deficiency (Waldron 2007).

*Non-metric traits*

Non-metric traits occur in a minority of skeletons and may suggest hereditary affiliation (Saunders 1989). The heritability of some is open to question (Tyrell 2000) and other factors – such as mechanical stress (Kennedy 1989) and environment (Trinkhaus 1978) – have also been implicated.

Lambdoid and coronal ossicles were both present. These are the small irregular bones which often occur along the cranial sutures. Bennett (1965) has suggested that the formation of ossicles in these sutures may be related to stresses placed on the growing cranium during foetal life and early infancy. Lambdoid ossicles were observed in 37% of the Bronze Age skulls studied in Brothwell's survey (1973: 152).

A septal aperture is a foramen located just above the trochlea of the humerus which extends into the olecranon fossa. A medium-sized septal aperture was observed on the right distal humerus of the Achavanich skeleton. These traits are relatively common and it has been observed that they occur in females more frequently than males (Hrdlička 1932).

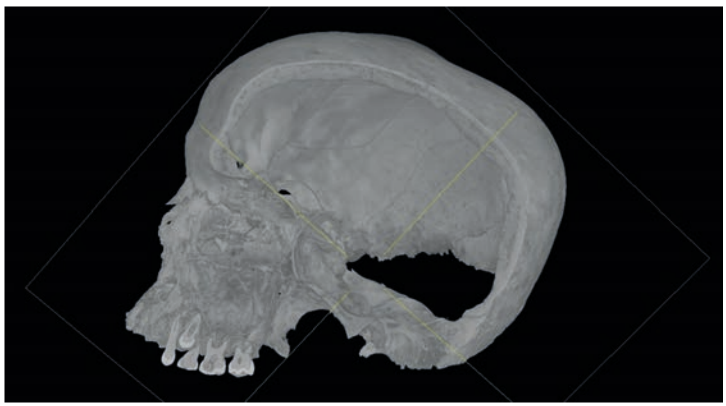
A foramen of Huschke is a foramen occurring in the floor of the external auditory meatus. It is always present in young children but only occasionally persists after the fifth year (Berry & Berry 1967). An example was observed on the left side only.

*Skeletal pathology*

Schmorl's nodes appear as indentations in the upper and lower surfaces of the vertebral bodies caused by the pressure of herniated vertebral discs (Aufderheide & Rodriguez-Martin 1998: 97). Stress-related trauma is implicated as a major cause (Roberts & Manchester 1997: 107). They are most commonly seen in the lower thoracic and lumbar vertebrae and, unlike many of the other joint diseases, this condition commonly develops in young adults (McKinley 2011). All four surviving lumbar bodies had mild to moderate Schmorl's nodes. The three surviving thoracic vertebrae were unaffected.

*Dental pathology*

Dental enamel hypoplasia (DEH) was the only condition affecting the teeth of this skeleton. DEH is demonstrated by developmental defects in tooth enamel which are formed in response to growth arrest in the non-adult and are believed to be caused mainly by increasing periods of illness or nutritional stress (Hillson 1979). Both maxillary first molars, and a retained deciduous left molar, exhibited enamel defects.



Illus 7 CT Scan of cranium showing that the left maxillary permanent second premolar had not erupted, as well as the congenital absence of the maxillary third molars. This image was produced using facilities at the Natural History Museum Image Analysis Centre, by Thomas Booth

Calculus (calcified plaque) tends to dislodge during excavation and post-excavation processing. Its absence here, however, along with a lack of caries, abscess and ante-mortem tooth loss is suggestive of a high-protein meat-rich diet which was low in carbohydrates and generally self-cleaning (Hillson 1986: 286–99). This type of diet was presented as an explanation of the low rates of dental pathology among the Bell Beaker group excavated at Boscombe Down, Amesbury, Wiltshire (McKinley 2011).

The left maxillary deciduous molar had been retained. A CT scan, produced at the Natural History Museum Image Analysis Centre for Thomas Booth, shows that the left maxillary permanent second premolar had not erupted (Illus 7). Congenital absence of the maxillary third molars was also demonstrated by this CT scan. It was not possible to determine whether this was also the case for the mandibular third molars as the mandible did not survive. The third molar is the most commonly absent tooth (Hillson 1986: 269).

### *Osteology: discussion and conclusions*

The skeleton recovered from the cist at Achavanich was a young adult female aged approximately 18–25 years. She achieved a stature in life of 171.34cm (67.45in). Her dental health was good at the time of her death, although early in life some disruption to enamel development had occurred, probably due to prolonged illness or nutritional deficiency. The absence of dental pathologies is suggestive of a diet that was high in protein and low in carbohydrates. Schmorl's nodes were the only evidence of skeletal pathology. These are commonly seen in young adults and are thought to be strongly linked to stress-induced trauma.

Metric analysis has demonstrated that her skull was hyperbrachycranic. Although the cranial index is high, examples in this range are not unknown. She also had a wide nasal aperture, wide orbits and a broad palate. Congenital absence of the maxillary third molars and retention of a deciduous molar were observed.

The nearby individual from Acharole, Cnoc Sgadain (Bryce & Low 1905), has some features in common with the young female from Achavanich. Their skull shapes both fell into the hyperbrachycranic range and both had wide nasal apertures which fell into the platyrrhinic range. Both skeletons also had femora which fell into the platymeric range. The young adult male from Acharole exhibited congenital absence of third molars although his dental health was worse with caries and ante-mortem tooth loss. This skeleton was also slightly shorter at 169cm (65in).

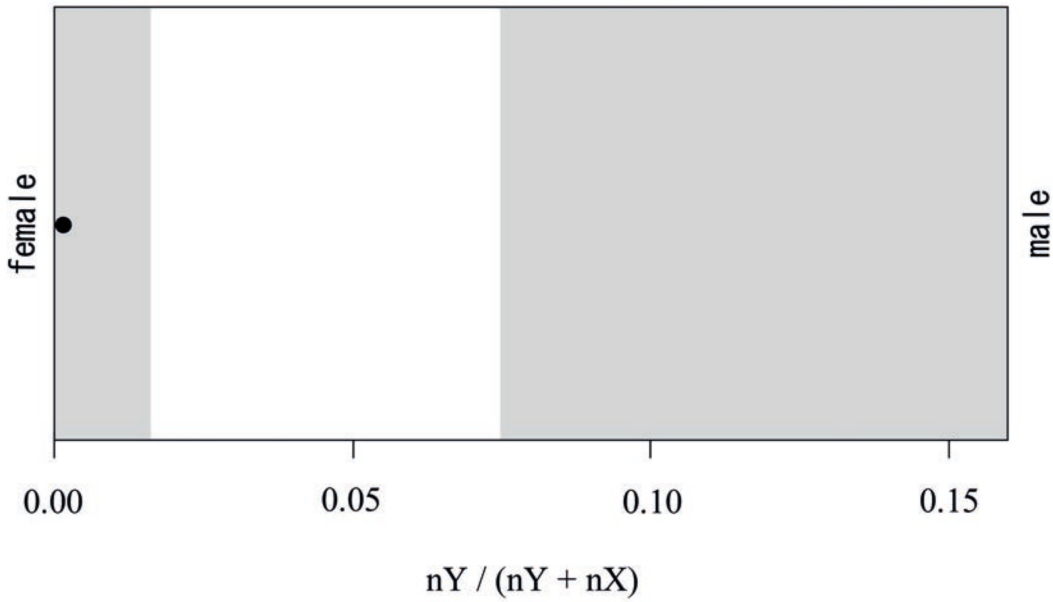
## ANCIENT DNA ANALYSIS

Thomas Booth, Selina Brace, Yoan Diekmann, Iñigo Olalde, Mark G Thomas and Ian Barnes

The Achavanich cranium was sampled for DNA as part of a Wellcome Trust-funded project at the Natural History Museum, investigating natural selection and population change in Britain over the last 10,000 years. Around 30 milligrams of bone powder were drilled from the petrous portion of the temporal bone – the inner part of the skull, housing the inner ear – in the dedicated ancient DNA laboratory at the Natural History Museum (NHM). This area was targeted specifically because this dense element can have exceptional DNA preservation (Pinhasi et al 2015). DNA was extracted from this sample using a modified version of the Dabney et al (2013) protocol and built into partial-UDG treated Next Generation Sequencing (NGS) libraries using

Table 1
Summary of DNA results from the Ava petrous sample

| *Sample* | *Lab no.* | *Coverage NUC* | *Coverage MT* | *Endogenous content* | *ContamMix* | *MT HG* | *Sex* |
|---|---|---|---|---|---|---|---|
| Ava | SB 343 | 0.06× | 7.30× | 40% | 1<br>[0.99, 1] | H5 | XX |




Illus 8 Results of the sex estimation from Ava’s DNA using criteria from Skoglund et al (2013), by Thomas Booth and Yoan Diekmann

a modified Meyer & Kircher (2010) protocol (Rohland et al 2015). One of these libraries was enriched for target DNA sequences using in-solution hybridisation capture synthesised by Mycroarray. Capture arrays enrich DNA libraries for particular parts of the genome that are known to be useful for addressing certain questions (eg population differences, physical characteristics and disease resistance). DNA libraries were also shotgun-sequenced on the NHM’s Ilumina NextSeq to produce whole genome data at low (0.06×) coverage. A sample of the DNA library was also sent to Professor David Reich at the Harvard Medical School for additional enrichment and analysis.

*Results and discussion*

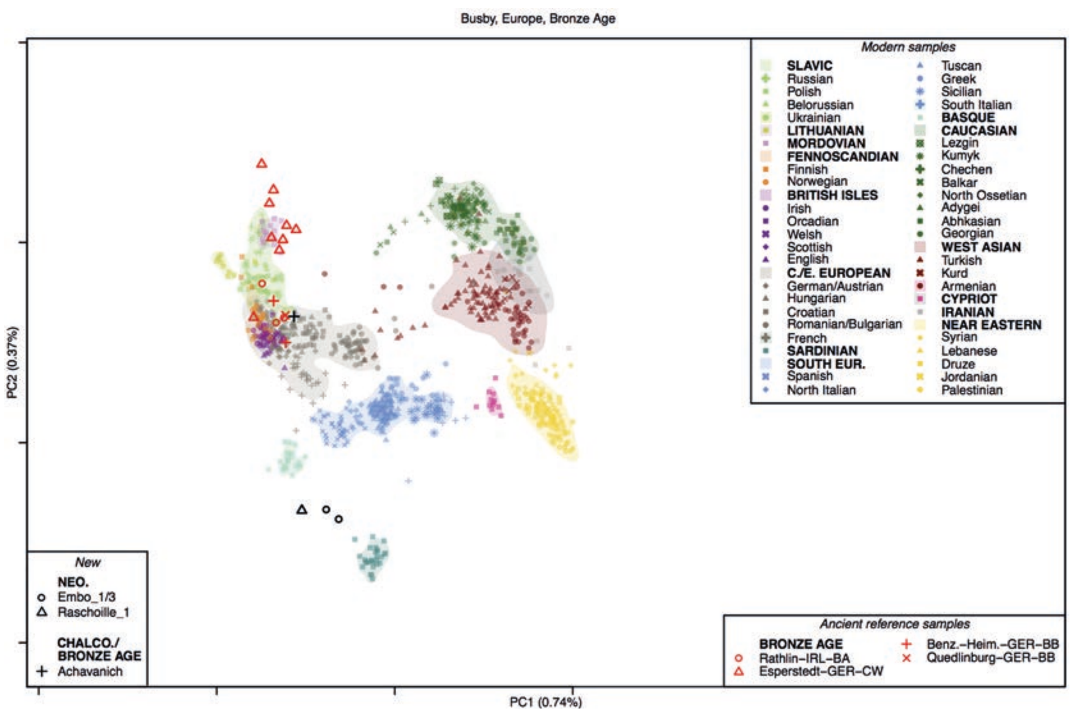
Around 40% of the DNA sequences obtained from Ava’s petrous aligned with the human genome, suggesting that DNA preservation was quite good (Table 1). The possibility of contamination from modern human DNA has been a persistent issue in analyses of archaeological human remains (Llamas et al 2017). However, the advent of NGS sequencing has facilitated the development of several tools for assessing modern contamination (Key et al 2017). Application of these tools to ancient remains analysed using NGS methods have found that modern human contamination, whilst still a problem, is not as big an issue as was once envisioned (Fu et al 2013; Allentoft et al 2015; Haak et al 2015; Lazaridis et al 2016; Olalde et al 2018).

The human DNA sequences obtained from Ava were authenticated using several analyses including MapDamage, a program that identifies patterns of DNA damage that are characteristic of ancient DNA sequences (Jónsson et al 2013). The data were also analysed using ContamMix, which estimates the likelihood that a sample contains DNA from more than one individual and quantifies the level of any related contamination (Fu et al 2013). The level of contamination in the data from Ava is less than 1%.

We calculated Ava’s genetic sex using Skoglund et al’s method (2013). This method compares the number of DNA reads which align with the Y chromosome against the number which align with the X. As females have two X chromosomes and males have an X and a Y, the ratio between DNA sequences aligning to these chromosomes can be used to determine sex. This analysis suggests that Ava is female (XX), consistent with the osteological evidence (Illus 8).

Ava's maternally inherited, mitochondrial haplogroup was determined using Phy-Mer (Navarro-Gomez et al 2015) in verbose mode (including ranking output and diagnostic sites) at read depth threshold 3 (–min-DoC = 3). Ava belongs to the H5 mitochondrial haplogroup which is estimated to have originated around 12,000 years ago among human populations in the Near East (Brotherton et al 2013). The first evidence of the H5 haplogroup in Europe is around 6000 BC and is associated with a migration of Neolithic farmers from Anatolia (Allentoft et al 2015; Haak et al 2015; Lazaridis et al 2016).

We also explored Ava's ancestry using information from across her whole genome, employing Principal Components Analysis (PCA) of Single Nucleotide Polymorphisms (SNPs). The data were plotted against published modern and ancient populations, including Neolithic populations from Scotland (from Raschoille Cave and Embo chamber tomb: see Olalde et al 2018: fig 2) using the method of Hofmanova et al (2016). Ava plots with Bell Beaker-associated populations in mainland Europe and, notably, away from the Scottish Neolithic samples. This result is consistent with recent palaeogenetic analysis of individuals associated with the Bell Beaker complex across Europe that found that its appearance in Britain around 2500 BC coincides with a migration of people from continental Europe, with some probably coming from the Netherlands (Olalde et al 2018). A large proportion of the ancestry of these Beaker-associated populations had




ILLUS 9 PCA of whole genome SNP data from Ava projected into a selection of available ancient and modern genomes (Busby et al 2015; Haak et al 2015) based on 32,279 SNPs, yielding a high confidence projection (LASER t-statistic (Wang et al 2015) is 0.96). Key to ancient samples: (red) IRL-BA = Bronze Age Ireland, GER-CW = Germany Corded Ware, Ger-BB = Germany Bell Beaker. Ancient British samples are shown in black, by Thomas Booth and Yoan Diekmann

originated in the Pontic steppe region, and the spread of these steppe groups into central and Western Europe around 3000 BC had produced a significant genetic shift there. Within Britain, the appearance of Beaker-using migrants seems to have had a profound impact: over the space of a few hundred years, this migration seems to have resulted in a genetic turnover of the local British Neolithic population in excess of 90%.

We explored the question of what proportion of Ava's ancestry could be explained by British Neolithic and Beaker-associated populations from continental Europe using qpAdm (Haak et al 2015). We used this program to model Ava's genome as a combination of Neolithic British populations and Beaker-associated populations from Oostwoud in the Netherlands. This Oostwoud Beaker population was chosen because, out of all ancient populations for whom we have data, it is genetically the most closely related to many British Beaker-associated individuals. The results of this genome-wide analysis suggest that all of Ava's ancestry could be attributed to continental Beaker populations, and that she had few or no ancestors from earlier British Neolithic populations (Illus 9) (Olalde et al 2018).

The results from the strontium and oxygen stable isotopic analysis of Ava's skeleton (as reported on below) indicate that she probably grew up within the Caithness region. Therefore Ava was probably a descendent of Beaker-using migrants, rather than being an immigrant herself. The radiocarbon dates from her skeleton and from the associated cattle scapula, and the lack of any detectable British Neolithic ancestry in her overall genome, suggests that her ancestors had arrived in Britain only a few generations before she was born. This result is unsurprising given Ava's associations with Beaker pottery, although some early British Beaker-associated skeletons show mixed British Neolithic/continental Beaker genetic signatures, suggesting some initial mixing with local populations. The small levels of British Neolithic ancestry in later British genomes suggests that, for whatever reason, this mixing had only a small long-term genetic legacy (Olalde et al 2018). The result from the whole genome analysis and the lack of any detectable British Neolithic ancestry in Ava's genome suggests that Ava's ancestry probably had a recent origin in continental Europe.

*Physical characteristics and lactose intolerance*

Ava's genomic data were inputted into the Hirisplex DNA phenotyping web tool using the Harvard Medical School capture array to produce predictions of her hair and eye pigmentation (Walsh et al 2014). This tool uses genetic associations with physical traits in modern individuals to make predictions about appearance. The reliability of the prediction depends on the representation of relevant positions on ancient genomes. The absence of particular positions does not necessarily preclude prediction, although confidence is lowered. Each position has a variable influence on relevant phenotypes, therefore the absence of certain positions will have a larger effect on predictive power than the absence of others. The results suggested that Ava probably had brown eyes and black hair.

Two positions of the genome (SLC24A5 and SLC45A2) are the main determinants of reduced skin pigmentation (ie light skin) in Europeans. Almost all present-day Europeans have two copies of the reduced pigmentation version. However, these positions are more variable in ancient Europeans. We could not discern the status of one of these positions (SLC24A5) in the Achavanich DNA sample, as it was not sufficiently preserved in the data. However, all ancient European individuals from this period have two copies of the light pigmentation version, therefore we can assume that this was the same for Ava. For the other position, the Achavanich sample is heterozygous, ie there is one copy of the light pigmentation version and one copy of the dark pigmentation version. This result suggests that Ava probably had a somewhat intermediate level of skin pigmentation, darker than what is normally observed in most modern British individuals, and possibly something more like modern individuals from southern Europe.

The Achavanich sample has one DNA sequence overlapping the LCT (rs4988235) position that is responsible for lactose tolerance in European populations. The lack of the lactase persistence version of the gene suggests that Ava was lactose intolerant, like most of her contemporaries (Olalde et al 2018) and unlike most present-day British individuals.

*Ancient DNA results: conclusions*

Analysis of whole genome data from the Achavanich skeleton confirms that Ava was female and a relatively recent descendant of a population of Beaker users who migrated into Britain from continental Europe around 2500 BC (Olalde et al 2018). This population movement represents the westward extension of an earlier migration originating in the Pontic steppe region of Russia (Allentoft et al 2015; Haak et al 2015). Ava is genetically discontinuous with preceding Scottish Neolithic populations. Analysis of parts of the genome associated with physical characteristics suggests that Ava probably had brown eyes, black hair and intermediate skin pigmentation.

## HISTOLOGICAL ASSESSMENT OF BONE BY MICRO-CT TO DETERMINE AVA'S DECOMPOSITION PROCESS

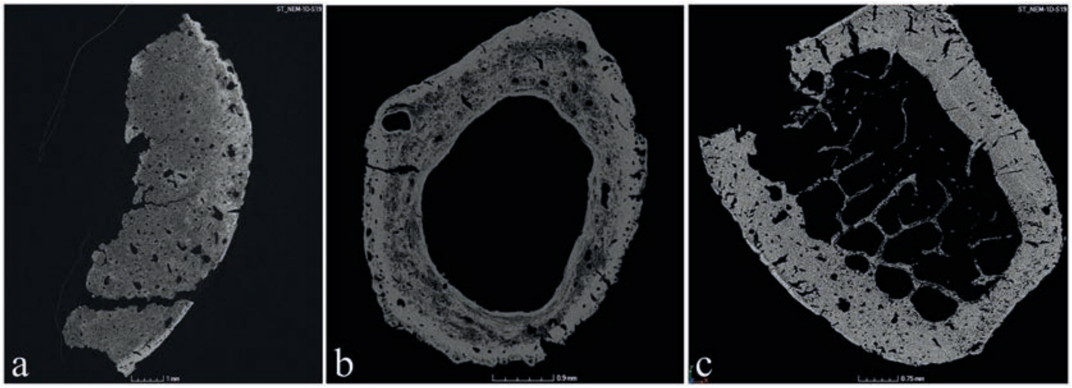
Thomas Booth

In order to determine whether Ava had been buried soon after death, or else treated in some other way (eg exposure, dismemberment, primary burial or even mummification – all rites that have been inferred to have taken place at other Bronze Age funerary sites in Britain: Barrett 1990; Brück 1995, 2004; Fowler 2013; Booth et al 2015) – selected bones were subjected to histological analysis using micro-Computed Tomography (micro-CT).

After the death of an organism, its bones are subject to physico-chemical reactions that result in their destruction or fossilisation (diagenesis). Principal among these processes is bioerosion, the bacterial alteration of the internal bone microstructure (Hackett 1981; Bell et al 1996; Hedges 2002; Turner-Walker et al 2002; Jans et al 2004; Nielsen-Marsh et al 2007; Booth 2016). Bacterial bioerosion is composed of characteristic lesions known as non-Wedl micro-foci of destruction (non-Wedl MFD: see Hackett 1981: 250). Variation in bacterial bioerosion in bone from forensic and archaeological contexts has suggested that its extent relates to variation in early post-mortem soft tissue decomposition (Bell et al 1996; Jans et al 2004; Nielsen-Marsh et al 2007; Hollund et al 2012; White & Booth 2014; Booth 2016). Analysis of internal bone microstructures can help to distinguish between early post-mortem events that affect early bodily decomposition (Booth & Madgwick 2016; Mollerup et al 2016; Scorrano et al 2016). These events include funerary practices such as primary burial, dismemberment and excarnation. For instance, excarnation results in rapid soft tissue loss by scavenging fauna and invertebrates, limiting skeletal exposure to bacterial decomposition. Burial prevents defleshing agents from accessing the corpse, ensuring bones are exposed to maximal bacterial attack. The internal microstructures of Ava's bones were analysed microscopically to investigate taphonomically significant diagenetic changes and to refine interpretations of early post-mortem treatment.

TABLE 2
Results of the histological analysis of the bones from the Ava skeleton

| *Element* | *OHI score* | *Bioerosion* | *Staining, inclusions and infiltrations* |
|---|---|---|---|
| Femur | 0 | Bacterial (non-Wedl) | None |
| Metacarpal | 2 | Bacterial (non-Wedl) | None |
| Rib | 0 | Bacterial (non-Wedl) | None |




Illus 10 (a) Transverse micro-CT slice through the femoral shaft fragment from Ava. Most of the internal microstructure has been bioeroded by bacteria (OHI = 0) making it appear mottled and dark. The natural porosities are free from extraneous particles; (b) Transverse micro-CT slice through the metacarpal shaft fragment from Ava. Most of the internal microstructure has been bioeroded by bacteria (OHI = 2). Exogenous particles are absent from the natural porosities and medullary cavity; (c) Transverse micro-CT slice through the rib fragment from Ava. The central trabecular microstructures have been bioeroded by bacteria. The surrounding cortical structures show reduced, variable bone density, but the contrast is less marked than in the femoral and metacarpal images. However, lighter smooth-textured banding at the outer edges suggests differential preservation of the periosteal fringe, characteristic of bone that has been extensively bioeroded by bacteria. No exogenous particles are observable in the trabecular or Haversian porosities, by Thomas Booth

*Method*

Bone fragments from a rib, left femoral shaft and metacarpal shaft were taken to the Natural History Museum Image Analysis Centre (IAC) for micro-CT scanning. Unlike other methods of histological analysis, micro-CT is non-destructive, provided that the same sample is not scanned repeatedly (Dal Sasso et al 2014; Hall et al 2015; Immel et al 2016). A femoral fragment was chosen initially for the sake of consistency, as this bone has been analysed most often by studies of bone diagenesis. Consistency in the choice of element is important, as there is some evidence for intra-skeletal variation in bacterial bioerosion (Hanson & Buikstra 1987; Jans et al 2004; Nielsen-Marsh et al 2007; Booth 2016). The precise cause of this intra-skeletal variation is unknown, although possible influential factors include frequencies of natural porosities (Haversian systems or trabecular bone) which expose larger bone surface areas to attacking bacteria, and proximity of the bone to the gut as the source of putrefactive bacteria. Fragments of rib and metacarpal were micro-CT scanned additionally to provide complementary data from elements that might be expected to show contrasting levels of degradation. All bones were scanned using the method outlined in Booth et al (2016). Bone bioerosion was assessed using the standard OHI (Hedges et al 1995; Millard 2001).

*Results and discussion*

The results of the histological analysis are presented in Table 2. Variation in bone density consistent with the morphology of bacterial tunnelling (ie accumulations of non-Wedl MFD) can be seen in the micro-CT scans of the metacarpal and femoral fragments (Illus 10a and b). In both cases, bacterial tunnelling is extensive, taking up large proportions of the internal microstructure (OHI $<$ 2), but leaving the periosteal and endosteal fringes intact. The periosteal and endosteal surfaces are almost always preserved in archaeological bones that have otherwise been extensively bioeroded by bacteria (Booth 2016). The metacarpal fragment shows lower levels of bioerosion, which may be related to the lower frequency of vascular structures (particularly secondary osteons) that act as route-ways for osteolytic bacteria.

The micro-CT scan of the rib fragment is more difficult to interpret (Illus 10c). Variation in bone density, corresponding with the morphology of non-Wedl MFD, can be seen in the trabecular structures, suggesting that they had been extensively attacked by bacteria. Bone density in the cortical rib structure is also variable, but the contrast is low and it is difficult to discern whether this variation corresponds with the morphology of non-Wedl MFD. There is a slight but noticeable difference in bone density between the periosteal surface and the rest of the cortical bone, consistent with the characteristic distribution of bacterial bioerosion. Chemical alteration of the bone microstructure affects bone density in micro-CT scans, but rarely avoids the external periosteal surface, which is most susceptible to deleterious environmental interactions (Turner-Walker & Peacock 2008). It is possible that abiotic diagenetic processes subsequent to the bacterial attack had altered bioeroded bone, reducing the contrast in the micro-CT scan. Loss of the distinctive morphology of MFD due to continued diagenetic alteration of bioeroded bone (described as 'generalised destruction') is a known phenomenon in studies of bone diagenesis but has not been documented using micro-CT, making it difficult to assess whether this type of attack is responsible for the ambiguous signal from the rib fragment (Hollund et al 2012). Therefore, the best interpretation for the variation in bone density observed in the rib micro-CT scan is that it had been extensively bioeroded (OHI = 0), although the aforementioned ambiguities mean that this conclusion is tentative. Analysis of each bone sample in three dimensions determined that levels of bacterial bioerosion were invariable through each sample, consistent with previous diagenetic studies that have used micro-CT (Dal Sasso et al 2014; Booth et al 2016).

The extensive bacterial bioerosion present in two – and probably all three – bone fragments examined here suggests that the Ava skeleton was exposed to high levels of soft tissue decomposition. Bones that show extensive patterns of bacterial attack usually originate from bodies that were buried intact soon after death (Nielsen-Marsh et al 2007; White & Booth 2014; Booth 2016). Therefore, the patterns of bacterial attack seen in the bones of the Ava skeleton are consistent with the deposition of an intact body in the cist soon after death. While issues of equifinality mean that we cannot rule out the possibility that Ava's body had been interred elsewhere and reburied in this cist (since this would produce the same pattern of bioerosive attack), the fact that her remains were not wholly disarticulated argues in favour of burial in the cist soon after death. Another piece of evidence in support of this interpretation is the fact that no staining, inclusions or infiltrations were observed in the micro-CT scans of the bones studied here. The presence of such features in bone microstructures, which are normally composed of products of bone decomposition and compounds transported into the bone by percolating groundwater, can provide information about the deep depositional history of archaeological bones (Turner-Walker & Jans 2008; Hollund et al 2012; Booth 2016). These diagenetic changes are observed to some degree in most archaeological bones, particularly bones from graves dug into soil. The absence of these changes in the case of Ava suggests that her bones had not decomposed in sediment for a significant time and had thus probably not been subject to primary burial.

These observations suggest that primary deposition of Ava's body in the cist represents the most parsimonious interpretation of the funerary practice. In this scenario, skeletal disarticulation could have occurred as the body decomposed in its tightly contracted position in the environment of the cist (Duday 2006). Gravity, combined with cavities produced by soft tissue decomposition, would have allowed body parts to disarticulate and collapse outside the silhouette of the body. The absence of particular skeletal elements is likely to be due to localised destructive diagenetic processes (Scott 1992): as noted in the report on the Beaker (below), there had clearly been percolation of groundwater into the cist, and this could well have led to selective dissolution of some bones.

### *Histological assessment: conclusion*

Three bones from Ava were scanned using micro-CT to analyse taphonomically significant alterations to the internal microstructure and to investigate aspects of early post-mortem treatment. All three had been attacked extensively by bacteria associated with soft tissue decomposition, consistent with the body having decomposed in the cist. The lack of evidence for diagenetic changes in the bones suggests that primary interment of the body in the cist soon after death is the most plausible scenario. Decomposition in the cist and localised diagenetic processes could be responsible for the skeletal disarticulation and loss of certain bones.

## ISOTOPE ANALYSIS OF TOOTH ENAMEL AND BONE

Jane Evans, Carolyn Chenery and Hilary Sloane

A second molar tooth (M2) and a rib fragment from the Achavanich skeleton were sent to the NERC Isotope Geosciences Laboratory for isotope analysis to investigate the childhood origins and diet of this individual.

Strontium (Sr) and oxygen (O) isotope data from tooth enamel are used to investigate the childhood origin of individuals, and hence to determine whether an individual had moved from the area in which she or he was raised. Tooth enamel forms in childhood and locks into its structure information about the geographic origins of individuals. By using reference datasets we can exclude areas that do not match the composition of the tooth. The primary reference datasets for Britain are Evans et al 2010 and Evans et al 2012. These suggest that an individual who was raised in the Caithness area would have an oxygen isotope composition in tooth enamel within the range 17.2 ± 1.3‰ (2SD) and a strontium isotope composition within the range 0.709–0.710. It should be noted that the coverage of biosphere Sr is poor in the Caithness region.

The carbon and nitrogen isotope composition of bone collagen provides evidence for the nature of the food consumed. It can distinguish between a diet that had been primarily based on terrestrial resources and one that had been dominated by marine resources, and it can also indicate the level within the food chain that the diet implies (Richards et al 2006).

### *Analytical methods*

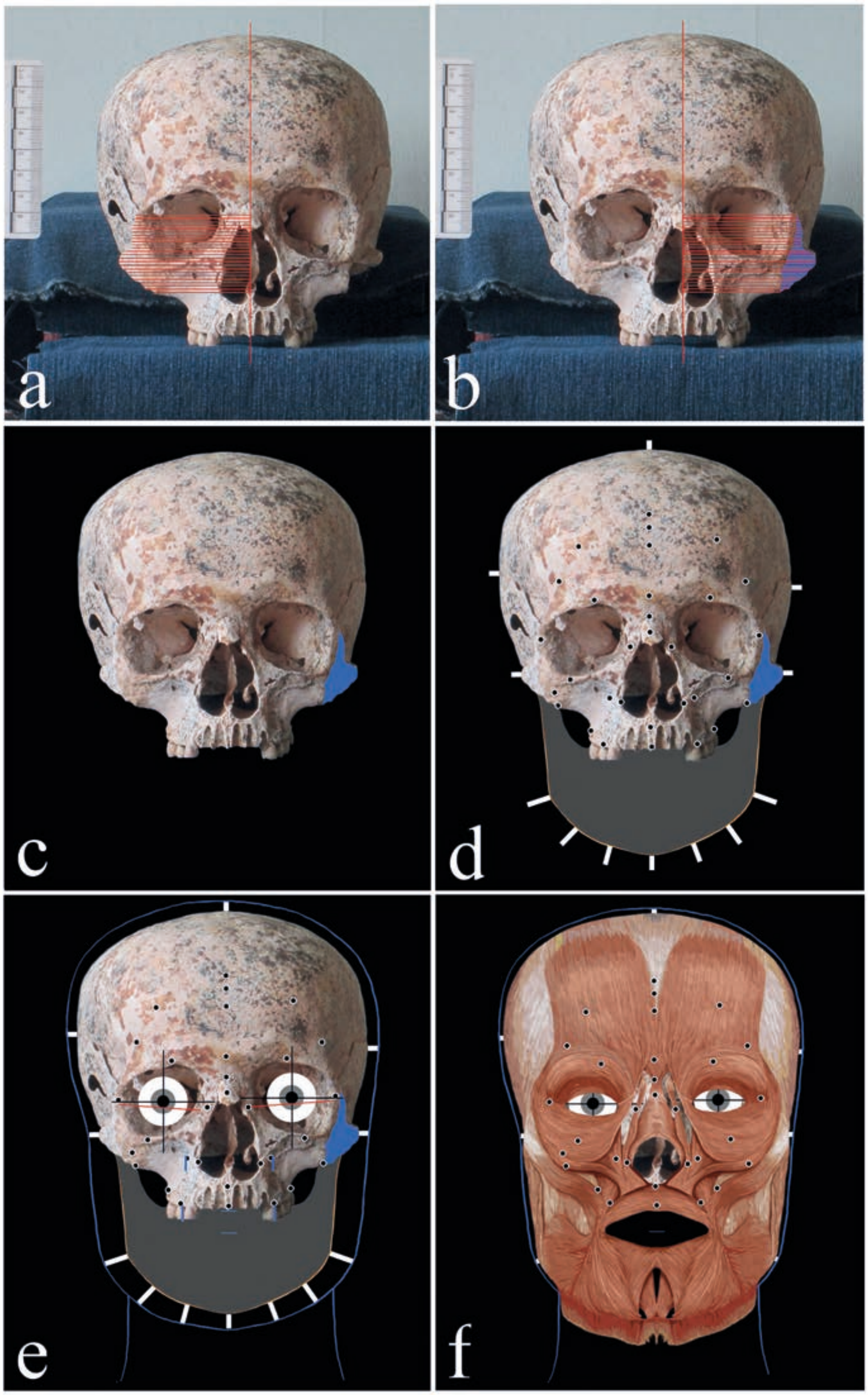
The sample preparation and analytical methods used on these samples are documented for strontium and oxygen, and carbon and nitrogen in Neil et al (2017) and Miller et al (2016). During the Sr analysis of this sample the international standards for $^{87}Sr/^{86}Sr$, NBS987, gave a value of 0.710250 ± .000006 (2σ, n = 8). Blank values were in the region of 100pg. Analytical reproducibility for carbonate oxygen analysis for laboratory standard calcite (KCM) was $d^{18}O_{SMOW}$ = ± 0.04‰ (1σ, n = 9) and $\delta^{13}C_{PDB}$ is ± 0.02‰ (1σ, n = 9). The carbonate oxygen results $^{18}O_{SMOW(c)}$ are converted phosphate values $\delta^{18}O_{SMOW(p)}$ using the equation of Chenery et al (2012): ($\delta^{18}O_{SMOW\ (p)} = 1.0322*\delta^{18}O_{SMOW\ (c)} - 9.6849$). And for carbon and nitrogen analysis of collagen the 1σ reproducibility for mass spectrometry controls was $\delta^{15}N$ = ± 0.07‰ and $\delta^{13}C$ = ± 0.06‰ (1σ, n = 24) and the repeatability of triplicate analyses is better than 0.2‰ for both isotopes.

### *Results of isotopic analyses*

The results are presented in Table 3. The M2 enamel from this individual gives a $^{87}Sr/^{86}Sr$

TABLE 3
Data results from stable isotope analysis of strontium and oxygen

| *Sample* | *Sr ppm* | *$^{87}Sr/^{86}Sr$* | *$^{13}C_{PDB}$* | *$\delta^{18}O_{CSMOW}$* | *$\delta^{18}O_{phos\ SMOW}$* |
|---|---|---|---|---|---|
| Achavanich (Enamel) | 95.9 | 0.71144 | –16.4 | 26.2 | 17.4 |
| *Sample* | *%C* | *%N* | *C/N $_{at}$* | *$\delta^{13}C_{PDB}$* | *$\delta^{15}N_{AIR}$* |
| Achavanich (Bone) | 44.3 | 13.8 | 3.7 | –22.0 | 12 |




Illus 11 The different stages of facial reconstruction: (a) and (b) show the reconstruction of the damaged left zygomatic bone; (c) and (d) show the cranium before and after the mandible was rebuilt and the tissue depths were applied; (e) after the eyes had been inserted; (f) showing the underlying facial tissue and muscles. Copyright © Hew Morrison

ILLUS 12 Facial reconstruction of Ava, which draws on evidence from research undertaken throughout the project. Copyright © Hew Morrison

strontium isotope composition of 0.71144 and a strontium concentration of 95.9ppm. This isotope value is slightly elevated relative to the predicted range (0.7090–0.710) (Evans et al 2010) for the Achavanich area which is underlain by Old Red Sandstone, but adjacent areas to the west and south, underlain by older rocks, could supply such a value.

The oxygen isotope composition of 17.4 is well within the expected range of 17.3 ± 1.3‰ (2SD) for the east coast region of Britain (Evans et al 2012). The carbon value of $d^{13}C_{PDB} = -22$ is low relative to much available data from Britain but is most likely to be due to the individual having consumed a strongly terrestrially sourced diet (Iacumin et al 2004).

## FACIAL RECONSTRUCTION

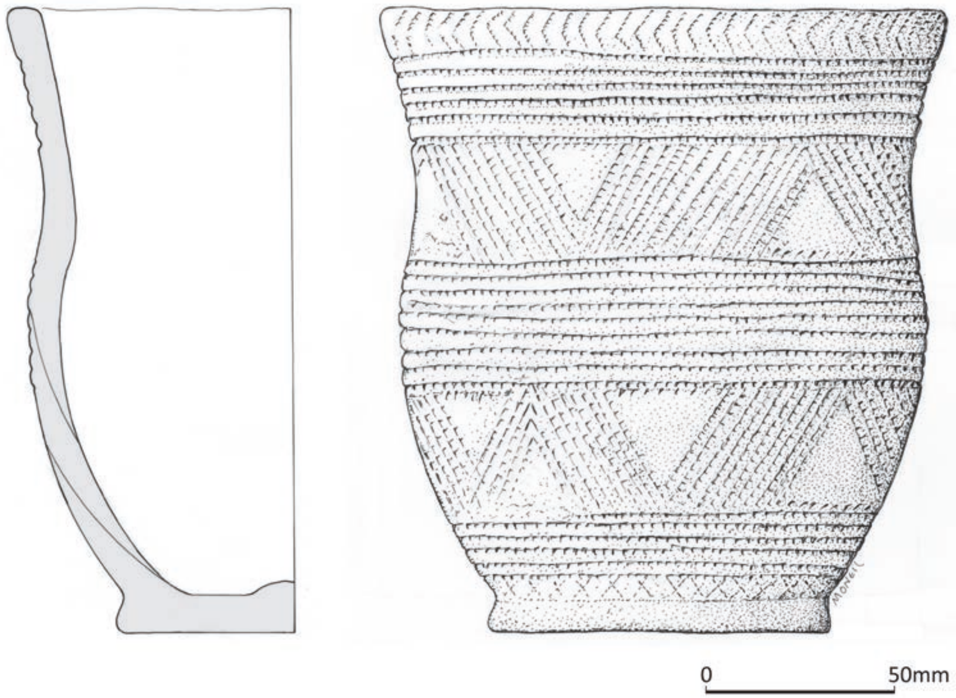
Hew Morrison

Due to the fragile nature of the cranium, a two-dimensional approach to reconstructing Ava's facial appearance was chosen. The available osteological and DNA evidence, described above, were combined with surviving anatomical information to depict age, gender and physical appearance (Illus 11).

Damage to the left zygomatic bone was compensated for by mirroring the complete structure on the opposite side. The shape of the missing mandible was reconstructed using a method pioneered by Krogman (Krogman & İşcan 1986) to create an outline of the jawline in the correct place and size relative to the cranium (Illus 11d). The nasal aperture, measured at its widest point, equates to three-fifths of the overall nasal width, allowing for the overall size and shape to be determined. This individual's left nostril was significantly lower than the right, indicating that the nose would have had an asymmetrical appearance. The enamel of the teeth was measured to calculate the depth of the teeth using the following formula: upper lip thickness = $0.4 + 0.6 \times$ (upper teeth height); lower lip thickness $= 5.5 + 0.4 \times$ (lower teeth height); total lip thickness $= 3.3 + 0.7 \times$ (total teeth height) (Wilkinson 2004). The width of the lips was calculated – thereby creating the position of the corners of the mouth – by using the point on each side where the canines and first premolars meet as the extent (Taylor 2001). The eyes were positioned to correlate with the anatomy and shape of each orbit (Illus 11e). The overall diameter of each eye was 24mm, with the corresponding iris diameter at 12mm (Gibson 2008). As with the nose, the eye sockets were uneven in height, creating a slightly (but less noticeable) uneven appearance. Lastly, tissue depths for the average modern European Caucasian female of the appropriate age were applied to recreate the depth between skin and bone (Helmer 1984). This decision was made prior to genetic analyses; skin tissue depths do vary, but as no data was available to determine the reconstruction, the average depth of modern populations was applied as a best estimate.

To create the overlying physical appearance, matching features were identified from photographs from a large database of high-resolution stock images of Caucasian faces to reconstruct the anatomy and face shape. Hair colour (black), eye colour (brown) and skin tone (tan but pale) were selected to reflect the results of the ancient DNA analysis presented above. Final adjustments were made to match the underlying anatomy (Illus 12).


Illus 13 Cattle scapula, before radiocarbon sampling. Scale: 5 cm. Photo: Maya Hoole




Illus 14 Illustration of the Achavanich Beaker, by Marion O’Neil

## RESEARCH ON THE GRAVE GOODS

Due to the fact that the present whereabouts of the flint ‘thumbnail’ scraper and two flint flakes are unknown, it was not possible to undertake any research on those objects.

### THE CATTLE SCAPULA

Sheena Fraser

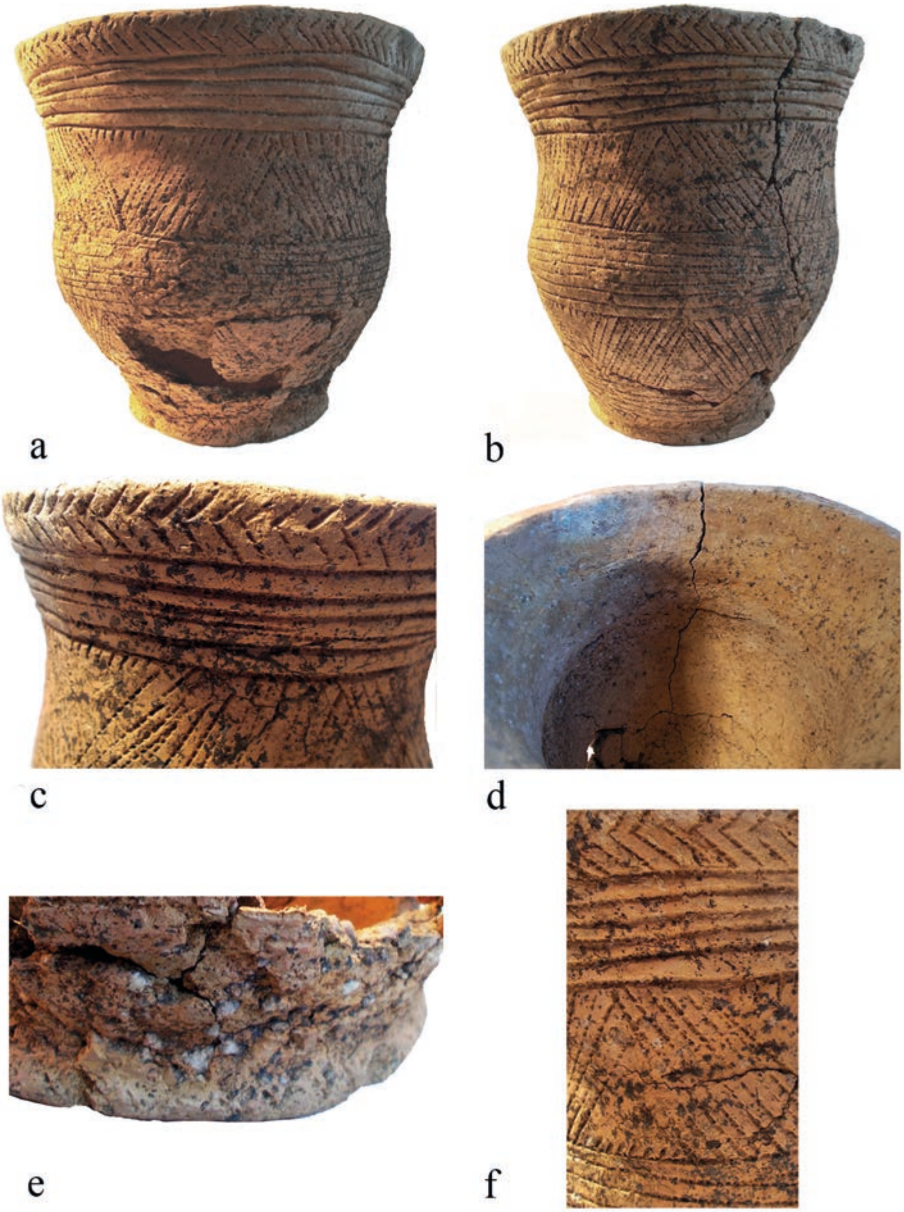
This is a left cattle (*bos taurus Linnaeus*, 1758) scapula (Illus 13). The bone exhibits well-developed muscle attachments and a fused glenoid cavity, indicating that it is from an adult/sub-adult. There is no evidence of how the animal died.

The scapula has numerous root-etched channels on its surface. In addition, there are a few faint multi-directional striations which do not seem to form a design or provide clear evidence of butchery. The distal scapula is missing but this break, and another on the spinous process, are ‘dry breaks’, indicating that these had not occurred when the bone was fresh. In cases where scapulae have been used as tools, such as Neolithic sites in Orkney (Foxon 1991), the spinous processes on the concave face of the scapulae have been removed in order to allow use as scoops. The spinous process from the scapula at this site has not been deliberately removed. In addition, the blade shows no evidence of smoothing, erosion or parallel scrape marks to indicate it had ever been used for excavating the pit. It is therefore assumed that its presence in the cist most likely indicates that it had been deposited as a food offering – a shoulder of beef. This will be discussed further below.

### THE BEAKER

Alison Sheridan

This pot (Illus 14–15) is virtually complete, lacking a small part of its lower belly and parts of the exterior of the lower belly, which have spalled off (Illus 15a). It is also cracked, with one




Illus 15 Details of the Beaker: (a) view showing area of spalling and loss on the lower belly; (b) roughly vertical and horizontal cracking; (c) black speckles of precipitated, oxidised manganese on the pot's exterior; (d) interior showing whitish encrustation (almost certainly precipitated calcium carbonate) on the rim and neck interior. Also note traces of faceting on the interior of the neck, from scraping, and a cluster of black speckles, probably of manganese, further down on the belly; (e) white quartz inclusions visible on the exterior of the pot; (f) detail of comb impressions. Scales: various. Photos: Alison Sheridan. Note that the pot's shape is slightly distorted through the angle of photography. Illus 14 conveys the shape correctly

long near-vertical crack running down from the rim (Illus 15b) and with three roughly horizontal cracks on the neck, upper belly and lower belly. These cracks had developed and the lower belly had come apart from the rest of the pot shortly after discovery; loss of a sherd and of parts of the surface will no doubt have occurred at that point. Removal of the complete pot from the cist by the finders means that it is impossible to tell whether it had been deposited upright in the cist, although this seems likely.

The Beaker has a maximum height of 166mm, a rim diameter of 152–3mm, a maximum diameter of *c* 140mm at its belly (around the pot's mid-height) and a base diameter of 90–1mm. The wall thickness is around 9mm, rising to 15mm at the thickest part of the base. The vessel has a sinuous, S-shaped profile, terminating in a pedestalled base. The rim is gently squared off; the base is flat on the outside and has an omphalos on its interior (as can be seen in the section drawing, Illus 14 left). The exterior is a salmon-pinkish-brown and buff colour, the core light grey, and the interior is light brown with a slight reddish tinge. On the exterior and parts of the interior there are black speckles of what is likely to be precipitated and oxidised manganese (Illus 15c), and patches of creamy encrusted material, almost certainly calcium carbonate, particularly on the rim and interior of the neck (Illus 15d). Both substances will have accreted post-depositionally from the percolation of groundwater into and through the cist, rather than being deliberate inlays. (Cf Davis 2006 and Curtis et al 2010 regarding the use of white inlay in some Beakers.) The former correspond to Moffat's deposits 'A', 'B', 'C' and 'E' as shown on his 1988 sketch (Moffat 1988) and to Scott Timpany's sampling locations 3, 7, 9 and possibly also 4 and 5 (as discussed below, and see Illus 17), while the latter correspond to Moffat's 'limey deposits', 'F' and 'yellowing breakdown of fabric', 'G' (Illus 17; cf Scott Timpany's sampling locations 1 and 2). This will be returned to below.

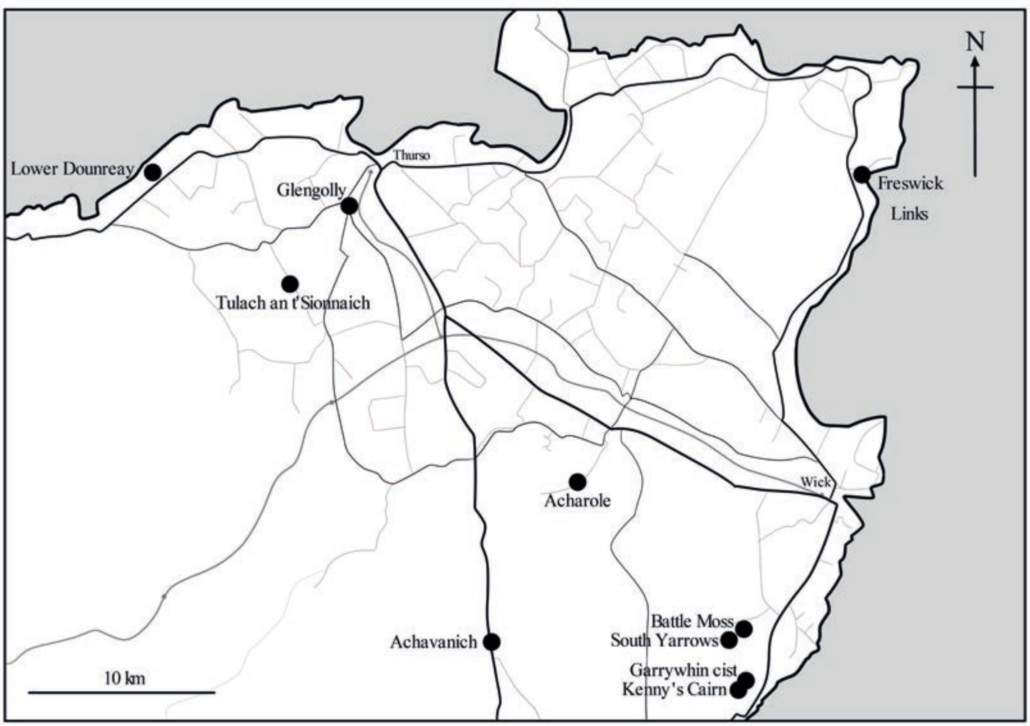
That the pot had been built up by adding successive flattened coils (straps) of clay above the base is clear from the way in which the surface has spalled off from the exterior of the belly, and also from the position of the horizontal cracks on the belly and neck. Two of the sloping strap joint planes are shown in the section drawing, Illus 14 left; their shape indicates that the straps were articulated by smoothing the exterior upwards, and the interior downwards. A further indication of the manufacture process is given by the faint faceting on the interior of the neck (Illus 15d), showing that it had been scraped. The surfaces had been carefully smoothed and have a slip-like appearance, probably produced through wet-smoothing. Inclusions in the clay have mostly been concealed but some protrude through the surfaces (Illus 15e). These consist of angular and sub-angular fragments of white quartz, some associated with a black mineral; they are mostly 2–7mm across but include one fragment as large as *c* 12 × 6mm. The inclusion density, estimated using charts devised by Matthew et al (1991), is 10–15%.

The exterior of the pot, from the outside of the rim (but not the rim-top) to just above the pedestal, has been decorated with comb impressions, arranged in zones (Illus 14, 15a, b, f). Three bands of deeply impressed horizontal lines (comprising six lines on the upper neck, nine around the broadest part of the belly and five on the lower belly) are interspersed with more complex designs. Above the uppermost band is a herringbone design of short impressions, and below the lowest band is a narrow zone of criss-cross impressions, framed at its bottom by a shallow horizontal line. On the neck and mid-belly, between the bands of horizontal lines, are two roughly matching zones of diagonal comb impressions, arranged as bands alternately sloping up and down. In the 'blank' triangular areas between these bands, on the sides adjacent to the bands of horizontal lines, is a fringe of short, vertical or slightly sloping comb-tip impressions. The impressions appear to have been made using three or four combs of different lengths, but each around 0.5mm wide, and each with rectangular teeth: that used for the herringbone is around 8mm long; that for the criss-cross design, *c* 10mm long; for the horizontal lines, *c* 53–5mm long (and minimally curving); and for the sloping lines, *c* 37mm long (and with long teeth up to *c* 2.75mm long). The short 'fringe' impressions, as noted above, were probably made using the end few teeth of one of the combs.

There is no clear sign of the pot's former contents (if indeed it had been buried containing drink or food for the deceased, as seems likely). In contrast to several other Beakers, there is (*contra* Moffat 1987, 1988) no obvious stain, blackish organic encrustation or 'tide-mark' on the interior that would indicate where contents had evaporated; nor are there any indications of spillage of contents over to the exterior of the pot. Moffat's claim (1988) that the Beaker had contained an alcoholic porridge or gruel flavoured with honey has not stood up to Scott Timpany's rigorous re-examination of the pollen relating to the pot (as presented below), and in this author's opinion it cannot be accepted. There are speckles of a very thin blackish encrustation, clustering on one side of the interior (Illus 15d), and these are probably the feature that Moffat referred to as a 'tide-line', but these appear rather to be examples of the aforementioned precipitated, oxidised manganese rather than the remains left by the evaporation of the pot's contents.

*Discussion of the Beaker*

The Achavanich Beaker joins the small number of other Beakers from Scotland north of the Great Glen (Clarke 1970: maps 1–10; Gibson 1982: fig 22). The paucity of finds in this part of Scotland contrasts with the marked concentration of finds along Scotland's eastern seaboard from Inverness to the Borders and extending southwards into England. In terms of Beaker typology, it has been variously described in the past as belonging to Clarke's 'N4' ('Final Northern') or Lanting and van der Waals' 'step 6' categories (Kinnes et al 1991; Ambers et al 1992), and as a 'short-necked' Beaker (Sheridan 2007; that attribution is superseded here). In fact, within Clarke's scheme, it finds its closest parallels, in both shape and decoration, among examples of his 'N/NR' ('Northern/North Rhine') category, with one of the Beakers from Dalmore, on the Cromarty




Illus 16 Map showing Beaker distribution from the old county of Caithness, by Maya Hoole

Firth, sharing its sinuous profile (Clarke 1970: fig 276), and with another N/NR Beaker from Akeld, Northumberland, sharing the ‘fringed triangle’ motif (ibid: fig 272). According to the most recent classificatory schemes, it would fall within Needham’s ‘“S”-profile’ and Wilkin’s ‘Basic “S”-Profile’ categories (Needham 2005: 198–200; Curtis & Wilkin in press).

The weighted mean date for the Achavanich grave of 3808 ± 21 BP (2300–2140 cal BC at 95.4% probability; see Derek Hamilton, below) is consistent with the style of the vessel: this is not one of the very earliest Beakers in Scotland (cf Sheridan 2007), although it does fall within the early part of Beaker currency and it is contemporary with the *floruit* of Beaker use in north-east Scotland (cf Shepherd 1986 and Curtis & Wilkin 2012).

Other finds of Beakers from the old county of Caithness (Illus 16) comprise examples from cists at Battle Moss (Baines et al 2003; Sheridan 2010), Heathfield, Glengolly (Anderson 1866; Clarke 1970: fig 731) and Acharole (ibid: fig 656), and possibly also Garrywhin (Anderson 1868: 503); from the Neolithic chamber tombs at Tulach an t’Sionnaich and Lower Dounreay – and also possibly South Yarrows North and Kenny’s Cairn, in each case representing a secondary deposit within an ancient monument (Davidson & Henshall 1991: 70, 71, 120, 141); and from a putative settlement site on Freswick Links (Gibson 1982: 157–8, 408). The possible examples are lost vessels described as having twisted-cord impressed decoration. The late David Clarke excluded them from his inventory (Clarke 1970: 516) on the grounds that they could theoretically have been Food Vessels or cinerary urns; this, however, is unlikely since cord-decorated cinerary urns are not found that far north in Scotland, and Food Vessels are even rarer than Beakers in Caithness. (Moreover, on the Food Vessel from Dalmore, Halkirk that is in Aberdeen University Museums’ collection, twisted cord impressions form only a minor part of the decoration.) At Battle Moss, one crushed Beaker and sherds representing small parts of two other Beakers were found (rather than three complete Beakers, as stated in Baines et al 2003), and for Heathfield, Clarke listed two Beakers, although only one is recorded by Anderson as


Illus 17 Scott Timpany’s sampling locations (1–9) as used in his pollen assessment. (Sample 6 is on the opposite side from Sample 3.) Photos: Maya Hoole

Table 4
Pollen assessment results (analyst – Scott Timpany)

| | | *Inside of Vessel* | | | *Outside of Vessel* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Sample* | *4* | *5* | *8* | *3* | *6* | *7* | *9* |
| *Pollen, Spores, NPPs* | *Context* | *A* | *A* | *B* | *E* | *E* | *D* | *D* |
| ***Trees*** | | | | | | | | |
| Pinus | | – | – | 1 | – | 2 | – | – |
| Betula | | 1 | – | 1 | – | – | – | 4 |
| Alnus | | – | – | – | – | 1 | – | – |
| ***Shrubs*** | | | | | | | | |
| Corylus avellana | | – | – | – | 1 | – | – | 3 |
| ***Dwarf shrubs*** | | | | | | | | |
| Calluna vulgaris | | 1 | – | – | – | – | 1 | 1 |
| ***Herbs*** | | | | | | | | |
| Filipendula | | – | 1 | – | – | – | – | – |
| Hypericum elodes | | – | – | – | – | 1 | – | – |
| Poaceae | | 1 | – | 1 | – | – | 1 | 1 |
| ***Spores*** | | | | | | | | |
| Pteropsida (monolete) indet. | | – | – | – | – | 1 | – | – |
| Pteridium | | – | – | – | – | – | – | 1 |
| Sphagnum | | 1 | – | 3 | – | – | – | – |
| ***NPPs*** | | | | | | | | |
| HdV-8 (A-G) | | – | – | 1 | – | – | – | – |
| HdV-11 | | 1 | – | – | – | – | – | – |
| HdV-18 | | – | 1 | – | – | – | – | – |
| HdV-96 | | – | – | – | – | 1 | – | – |
| HdV-112 (Cercophera sp) | | – | – | – | – | – | 1 | – |
| HdV-391 (Pinus stomata) | | – | – | – | – | – | 5 | – |
| ***Microscopic charcoal*** | | | | | | | | |
| Microscopic charcoal | | 37 | 126 | 255 | 22 | 331 | 20 | 78 |

TABLE 4
Pollen assessment results (analyst – Scott Timpany) (*cont*)

| | | *Inside of Vessel* | | | *Outside of Vessel* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Sample* | *4* | *5* | *8* | *3* | *6* | *7* | *9* |
| *Pollen, Spores, NPPs* | *Context* | *A* | *A* | *B* | *E* | *E* | *D* | *D* |
| ***Preservation*** | | | | | | | | |
| Lycopodium | | 160 | 56 | 618 | 44 | 987 | 53 | 319 |
| Corroded – known | | 1 | – | – | 1 | – | – | 1 |
| Corroded – unknown | | 1 | – | – | – | – | 3 | 1 |
| Degraded – known | | – | – | – | – | 1 | – | – |
| Degraded – unknown | | – | – | – | – | – | – | – |
| Broken/Torn – known | | 1 | – | – | – | 1 | – | – |
| Broken/Torn – unknown | | – | – | – | – | – | – | – |
| Crumpled – known | | – | – | – | – | – | – | 2 |
| Crumpled – unknown | | – | – | – | – | – | – | – |
| Unknown | | – | – | – | – | – | 1 | – |
| ***TOTAL POLLEN GRAINS*** | | ***3*** | ***1*** | ***3*** | ***1*** | ***4*** | ***2*** | ***9*** |

having been found in the cist. Several vessels are represented at Freswick Links.

The Beakers from Caithness are stylistically diverse, and Achavanich is the only dated example; the yet-to-be dated crushed Beaker from Battle Moss, examined by the author, might be earlier than the Achavanich Beaker as it is of 'low-bellied "S"-profile' type, with impressed herringbone decoration and a sub-rim cordon (Sheridan 2010). The loss of the vessels with impressed twisted cord decoration is particularly regrettable since some, at least, of these might also be early (as early examples of All Over Cord-decorated Beakers).

## ASSESSMENT OF THE POLLEN PRESERVED IN SEDIMENT ATTACHING TO THE BEAKER

Scott Timpany

As noted above, following its discovery, the Beaker was sent to Brian Moffat in Edinburgh for pollen analysis of material attaching to its surfaces, in the hope that this would elucidate its former contents. Moffat reported 'I have scanned the entire surface at 50× magnification, inside and out. I have sketched the main discrete deposits … given the great variety and bulk of the deposits, it would be useful to examine them all' (Moffat 1988: 1). Moffat identified deposits in seven areas of the vessel (Moffat 1988). They included: a 'tide-mark band' inside the mid-belly (deposit 'A'); a 'pour or flow mark (or spillage)', noted as a 'double flow' inside the neck (deposit 'B'); 'slight carbon on deposits – dregs?' inside the base (deposit 'C'); 'cereal grains &c. evident in the fracture' around the lower belly (deposit 'D'); 'caked dark soil with sooty smears' on the outside (deposit 'E'); the aforementioned whitish limey encrustation on the rim (deposit 'F'), and 'yellowing / breakdown of fabric' on the rim (deposit 'G').

The assessment work presented here was undertaken to follow up on Moffat's pollen analytical work (1988). Its main objectives were to investigate whether more pollen, and any non-pollen palynomorphs (NPPs) and microscopic charcoal, could be recovered from the deposits present on the vessel; to assess their state of preservation; and to determine the likely origin of the pollen: was it from the pot's former contents (as Moffat had claimed), from the environment around the cist, or both? Particular attention was paid to Moffat's claim for the presence of pollen relating to honey, and to the claimed presence of cereal pollen.

*Methods: pollen assessment*

It was observed during sub-sampling that the deposits were very dry and represented thin encrustations adhering to the vessel. A total of nine sub-samples were taken from the inside and outside of the pot, with care taken not to damage the vessel itself. Samples 1 and 2 were taken from the rim of the vessel, Samples 3 and 6 from the middle part of the outside of the vessel, Samples 7 and 9 from the base of the outside of the vessel, and Samples 4, 5 and 8 from the pot's interior. The locations of all the samples are shown in Illus 17. Only a small amount of material was available for sub-sampling and sample sizes were all <1g. As limited material was gained from Samples 1 and 2 – not surprisingly since, as noted in the previous section, the deposits seem to represent calcium carbonate accretions deriving from groundwater percolation – these were not submitted for preparation.

Samples were prepared for pollen, non-pollen palynomorph (NPP) and microscopic charcoal analyses using the procedure described by Barber (1976). In order to remove mineral matter, the organic component of each sample was separated using a density flotation method, which also aids in concentrating the pollen from each level (Nakagawa et al 1998). Identification was aided by reference keys in Fægri et al (1989) and Moore et al (1991), with use of the modern reference at Orkney College, University of the Highlands and Islands. Any possible cereal-type pollen would be identified using the identification keys from Fægri et al (1989) and Moore et al (1991) and differentiated from wild grass pollen on the basis of grain size, pore and annulus diameter and surface sculpturing (Andersen 1979). Pollen preservation was recorded following Cushing (1967) and each pollen grain was classified as broken, corroded, crumpled or degraded. Pollen grains that had no remaining distinguishing features were categorised as unidentified. NPPs were recorded during routine pollen counting and they were identified using the descriptions and photomicrographs of van Geel (1976), van Geel et al (1989, 2003) and van Geel and Aptroot (2006). Microscopic charcoal was routinely counted during pollen assessment.

The pollen and non-pollen palynomorph results are listed in Table 4. Plant nomenclature follows Stace (2010); NPP terminology follows the type system devised by van Geel (1976) and uses the laboratory code as prefix (HdV), followed by the type number.

*Results*

The results of the pollen assessment (Table 4) show the grains that were present in Samples 3–9 from the outside and inside of the vessel. Overall, very low numbers were recovered from the samples. The low numbers of pollen grains are likely to be a result both of the small volume of material sub-sampled from the vessel and of this material having further desiccated since discovery. Preservation of surviving grains was generally good, with five grains too poorly preserved (corroded) to be identified. The condition of most of the poorly preserved grains, of known and unknown species, is due to biological damage (namely corrosion and degradation). This is likely to be due to the drying of the sediment attaching to the Beaker, and its exposure to air, causing a loss of the pollen through bacterial attack. Lycopodium spores were added to the pollen slides as a control; the abundance of these spores, particularly in Samples 6 and 8, highlights the low number of pollen grains present on the slides, since the higher the number of Lycopodium spores, the lower the abundance of pollen grains.

Of those pollen grains that were recorded on the slides, most are arboreal pollen of trees and shrubs, including birch (*Betula*), pine (*Pinus*, most likely to represent Scots pine *Pinus sylvestris*), hazel (*Corylus avellana*) and alder (*Alnus glutinosa*). Pollen from dwarf shrubs including heather (*Calluna vulgaris*) was identified in three samples. Poaceae (grasses) was the commonest herbaceous taxon recorded, with single occurrences of meadowsweet (*Filipendula ulmaria*) and marsh St John's-wort (*Hypericum elodes*). Spores of ferns (*Pteropsida* (monolete) indet), bracken (*Pteridium*) and sphagnum mosses (*Sphagnum*) were present across four samples. A small assemblage of NPPs were also recorded, including coprophilous dung fungi (HdV-112; *Cercophera*-type). This sample also contained a number of pine stomata (HdV-391), suggesting a local presence of pine (Tipping et al 2008). The NPPs were indicative of host plants with HdV-8(A-G) – indicating the presence of rushes (*Juncus* sp) – and HdV-18 – indicating the presence of cottongrass (*Eriophorum* sp) (van Geel 1976). No cereal pollen was found. Microscopic charcoal was present in all samples with counts of >250 fragments from both the inside and outside of the vessel.

*Discussion*

The low number of pollen grains present across all slides means that it is not possible to provide a meaningful, statistically valid interpretation of the deposits or their depositional environment. However, some cautious suggestions can be offered. From the results of the pollen assessment there appears to be no discernible difference between the assemblage from the inside of the vessel (Areas A and B) and that from the outside of the vessel (Areas D and E) (Table 4). The former contained no more than one grain of each taxon present, with a mixture of arboreal pollen (pine and birch), heather and herbaceous pollen of grasses and meadowsweet. The assemblage also included spores of sphagnum mosses, fruit bodies of HdV-8(A–G) and fungal spores of HdV-11 (a probable indicator of dead wood) and HdV-18, together with microscopic charcoal. This contrasts with Moffat's reported findings (1988): in that report the deposits from inside the vessel were found to be much more polleniferous, with counts claimed to be in excess of 100 grains from three samples taken from Areas A and B. Moffat reported high counts of heather, cereal, daisy and meadowsweet pollen within the assemblage from inside the vessel, and this led him to suggest the vessel had probably contained a fermented porridge or gruel, sweetened with honey and flavoured with meadowsweet and other flower heads or fruit, with birch and alder sap added. The current assessment has failed to produce similar results, and while there may well have been loss and degradation of the sediments adhering to the vessel over time, the marked disjunction between the findings and the absence of cereal pollen remain troubling.

The assemblage from those samples taken from the outside of the vessel is similar to that inside the vessel with the presence of arboreal pollen of birch, alder and pine, together with hazel. Heather is again present in the assemblage, together with herbs of grasses and marsh St John's-wort. Spores of ferns and bracken are both recorded in this assemblage, together with fungal spores of HdV-96, coprophilous fungi HdV-112 and pine stomata HdV-391. A high microscopic charcoal count was recorded from Sample 6, with microscopic charcoal present in all other samples. In the previous pollen analytical work, Moffat (1988) had also reported that the assemblage on the outside of the vessel was similar to that on the interior, with cereal, heather, daisies and devils-bit scabious pollen all present; he offered the same interpretation for their presence. The assessment results presented here once again failed to match those of this initial analysis.

The addition of the NPP and microscopic charcoal data presented in this assessment adds another dimension to the analysis undertaken by Moffat (1988) and, despite the low numbers of each that were recovered, these data pose some interesting questions in relation to whether this vessel had contained food substances. The NPPs recovered from the inside of the vessel are mainly host species, indicative of a local presence of rushes and cottongrass, such as those which belong to a heathland and woodland environment. The presence of heather pollen and tree pollen from woodland associated with heathland (namely birch, hazel, alder and pine), from both inside and outside the vessel, also suggests that the assemblage is more a representation of the local heathland that was present across this area than of any foodstuff or drink that the Beaker may have contained. Similarly, the grasses, marsh St

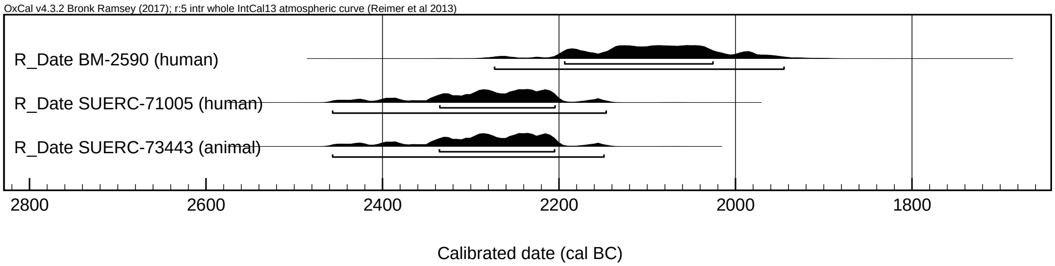
John's-wort and meadowsweet, together with sphagnum mosses, ferns and bracken, can also be found growing on heathland. The pollen results from this current assessment would appear more likely to be an indicator of the local depositional environment than of any substance within the vessel. While it could be argued that this was an effect of the degradation of the sampled material since Moffat's assessment, such degradation would have had to be highly selective to account for the differences in species representation between the two studies, especially as regards the claimed presence of barley and oats (ibid).

The recording of coprophilous HdV-112, an indicator of animal dung (van Geel et al 2003), suggests that grazing animals were present around the cist during the funeral. The occurrence of a number of pine stomata, HdV-391, also indicates a local presence of pine trees in the vicinity; this, together with the other arboreal taxa, suggests that the cist may have been set within a woodland context while the other pollen mentioned above suggest the presence of heathland in the vicinity.

The presence of meadowsweet and marsh St John's-wort pollen within the assemblage is of particular interest. Meadowsweet is known to have been used in the historical past as a medicinal plant (with the chemical in its leaves and flowers acting in a similar way to aspirin), as a flavouring agent in ale, and as a sweet-smelling plant for strewing around to mask bad odours (Tipping 1994; Davies & Tipping 2007). Its pollen has been found in several Chalcolithic and Early Bronze Age cists, such as at Udny Green, Aberdeenshire (Davies & Tipping 2007), and Whitsome, Scottish Borders (Berwickshire: Clarke 1999). At Udny Green, where samples from both the interior of a Beaker and sediment on the cist floor were analysed, the localised concentration of meadowsweet pollen in the pot's interior led Davies and Tipping to conclude that it had probably been used as the basis of, or else a flavouring agent in, a fermented liquid within the Beaker; whereas at Whitsome, where the meadowsweet pollen was concentrated around the head of the interred individual, it was inferred that the plant may have formed a kind of pillow. (See also Tipping 1994 on the use of meadowsweet as a floral tribute in Chalcolithic and Early Bronze Age cists.) In the case of Achavanich, however, no confident assertions can be made about how this plant had been deployed from the presence of just a single grain (or indeed of the 36 other grains recorded by Moffat in 1988). Marsh St John's-wort, related to the better-known St John's-wort (*Hypericum perforatum*), also has medicinal properties and is believed to have been used in a similar way to St John's-wort, as an antidepressant, a plant to help staunch bleeding from wounds, to treat stomach upsets and to aid the healing of fractures and sprains. Marsh St John's-wort has been specifically identified as a cure for

Table 5
Radiocarbon results for Ava and for the cattle scapula

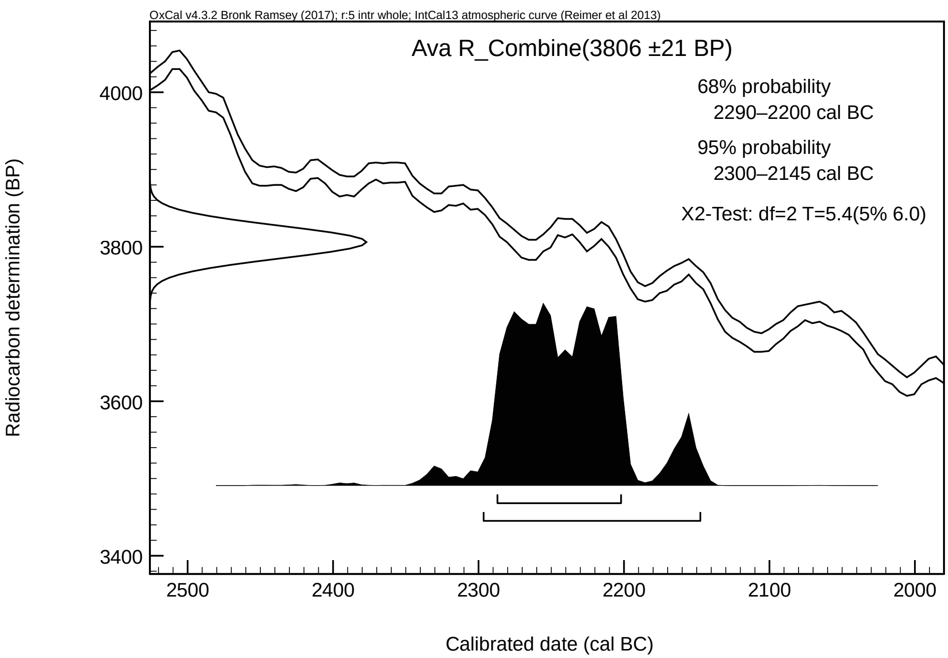
| *Lab ID* | *Sample ID* | *Material* | $\delta^{13}C$ (‰) | $\delta^{15}N$ (‰) | *C:N* | *Radiocarbon age* (BP) |
|---|---|---|---|---|---|---|
| BM-2590 | – | Human bone: right femur | –20.2 | – | – | 3700 ± 50 |
| SUERC-71005 | CAIT:2006:11-3.9 | Human bone: right tibia | –21.4 | 11.4 | 3.2 | 3827 ± 33 |
| SUERC-73443 | CAICT-2006-11-3-17 | Animal bone: Cattle, scapula | –21.7 | 4.9 | 3.0 | 3829 ± 32 |
| mean 'Ava' burial | | T' = 5.4; *v* = 2; T'(5%) = 6.0 | | | | 3806 ± 21 |




Illus 18 Calibrated dates for Ava and for the associated cattle scapula, by Derek Hamilton

diarrhoea (Allen & Hatfield 2004: 104, 106). It is tantalising to speculate that the presence of this herb at Achavanich may relate to the treatment of an ailment: it could have been added to a drink to treat a stomach complaint, or applied to the body as a poultice (although the surviving bones show no sign of ancient fracture).

The high microscopic charcoal counts from both the inside and outside of the vessel suggest that some burning had taken place in the landscape around the cist, although whether that had related to deliberate burning of vegetation (eg to prepare the area for creating the grave), or to a non-anthropogenic fire, is impossible to say. It may be noted, however, that charcoal has been detected in other cists containing unburnt individuals (as, for example, at Udny Green and Whitsome), so it may be that it relates to the ritual purification of the area as part of funerary practices.




Illus 19 Calibration of the combined radiocarbon age for the three dated samples for Ava and the cattle scapula, by Derek Hamilton

## RADIOCARBON DATES

Derek Hamilton

A sample of human bone (from the right tibia) and a sample from the cattle scapula were submitted to the Scottish Universities Environmental Research Centre (SUERC) for radiocarbon dating by accelerator mass spectrometry (AMS) in 2017. Both were single-entity samples (Ashmore 1999) and were pre-treated following the protocols described in Dunbar et al (2016). The SUERC laboratory maintains rigorous internal quality assurance procedures; these, plus its participation in international inter-comparisons (Scott et al 2003, 2007, 2010), indicated that there were no laboratory offsets, thereby validating the measurement precision quoted for the radiocarbon ages.

The right femur from the same individual had previously been radiocarbon dated at the British Museum (Ambers et al 1992), with the whole of that bone being used.

All three conventional radiocarbon ages (Stuiver & Polach 1977) are presented in Table 5, where they are quoted in accordance with the Trondheim convention (Stuiver & Kra 1986). Calibrated date ranges were calculated using the internationally agreed calibration curve of Reimer et al (2013) and OxCal v4.3 (Bronk Ramsey 1995, 1998, 2001, 2009). The date ranges in Table 5 have been calculated using the maximum intercept method (Stuiver & Reimer 1986) and quoted with the endpoints rounded outward to 10 years. The probabilities shown in Illus 18 and 19 were calculated using the probability method of Stuiver and Reimer (1993).

As part of the dating procedure, the purified bone collagen routinely undergoes carbon and nitrogen stable isotope analysis to examine both the quality of the bone collagen being dated and to determine whether an individual may have consumed protein from marine animals, which would offset the radiocarbon age and require a form of correction. The C:N ratios on the samples all fall within the range DeNiro (1985) deemed acceptable for bone collagen, suggesting that bone preservation was sufficiently good to have confidence in the accuracy of the radiocarbon determinations (Table 5; Masters 1987; Tuross et al 1988). Furthermore, the stable isotopes for Ava suggest she ate a largely terrestrial diet, and so no marine reservoir offset is expected. However, the slightly elevated $\delta^{15}$N value suggests that her diet consisted of animals that were further up the food chain (ie on a higher trophic level) than cattle or sheep; this could be the result of a diet that included relatively high quantities of pig or freshwater fish. (See also the results of Evans et al's isotopic analyses, above.) At any rate, there is no reason to expect the radiocarbon ages for Ava to need any form of dietary correction when calibrated (Illus 18).

If we accept that the cattle scapula was deposited in the cist at the same time as the human body, and that it was not old when deposited, then we can assume that both the human and the animal had the same concentration of radiocarbon in their bodies at death. Doing so allows us to combine the three radiocarbon determinations prior to calibration using a weighted mean (Ward & Wilson 1978). The three radiocarbon ages are statistically consistent ($T' = 5.4$; $\upsilon = 2$; $T'(5\%) = 6.0$) and combine to form a mean 'Ava' burial date, 3806 ± 21 BP. This result calibrates to 2300–2145 cal BC (95% probability; Illus 19).

## OVERALL DISCUSSION, CONCLUSIONS, AND COMMENTS ON DISSEMINATION AND ENGAGEMENT

Maya Hoole and Alison Sheridan

A considerable amount of new information has been obtained about the occupant of the cist, about some of the grave goods with which she was buried, and about the landscape around the cist. We are able to delineate, in unprecedented detail, aspects of her life, ancestry, diet and appearance, and we can reconstruct some details of her funeral.

The individual who has been dubbed 'Ava' had been between 18 and 25 years old when she died, at some time between 2300 and 2145 cal BC. She had been 1.71m tall – comparable with a fairly tall woman today – and had had brown eyes, black hair, a complexion similar to that of modern individuals from southern Europe, and an unusually broad head, comparable with that of a man buried 9.5km away at Acharole. (That individual also shared with Ava the congenital absence of third molar teeth, a wide nasal aperture and platymery of the femora; future research can address the question of whether the two individuals might have been related.) Ava was descended on both sides from immigrants into Britain, possibly from what is now the Netherlands, but she had probably grown up within the Caithness region. Her ancestors had probably arrived a few generations before; this tallies with the style of the Beaker found in her cist, which is not the earliest type of Beaker to have been found in Scotland. In common with other Chalcolithic (and indeed earlier) individuals in Europe, she was intolerant to lactose, but that does not mean that she did not consume dairy products: she could have eaten processed dairy products such as yoghurt, fermented milk, or cheese in some form. Her diet had been obtained from terrestrial, rather than marine resources. Her dental calculus reveals that she had eaten a high-protein, meat-rich diet, low in carbohydrates. She had suffered illness and/or nutritional stress in her childhood and infancy – possibly even before birth – and the Schmorl’s nodes in the bones of her back show that she had suffered stress-related trauma (eg from the carrying of heavy loads) – a condition that commonly develops in young adults. We do not know how she had died, but the presence of pollen from meadowsweet and marsh St John’s-wort in the cist – both plants known to have been used in more recent times for their medicinal properties – could conceivably relate to attempts to treat an illness, perhaps one involving her digestive system or else a wound. Sphagnum moss, also represented by pollen, is another plant that is known to have been used in the past to promote healing as it has antiseptic properties and can staunch bleeding from wounds; it was used as a dressing in both World Wars. If these three plants had indeed been used as healing plants then their inclusion in the cist could have had a metaphorical significance over and above any practical use: they could have been intended to ‘heal’ the deceased individual in the Afterlife.

Histological analysis of her bones has revealed that Ava was buried shortly after she died. A considerable amount of effort was expended on her funeral, with a pit for her cist being hewn out of the living Caithness flagstone rock: a task that could have taken around a day by a couple of people, as discussed above. The ground may have been ceremonially purified beforehand by burning vegetation from the surface, leaving microscopic charcoal fragments that ended up in the cist. Ferns, bracken and rushes might have been laid on the base of the pit that contained the cist. Ava’s legs were drawn up tightly – her body may have been bound, but this cannot be proved – and, broadly in keeping with the norm for Beaker-associated female interments as recorded by Alexandra Shepherd for north-east Scotland and Yorkshire (Shepherd 2012), she was deposited in the cist largely on her right side, with her line of ‘sight’ approximately to the south-east. (Her arrangement deviates slightly from this norm, however, in that her body was not orientated to the west, but rather to the south-west, assuming that the cist’s orientation has been assessed correctly; this might have been due to the difficulty of creating a rock-cut pit for the cist that was aligned due west.) A flint scraper and two flint flakes were placed near her head, and to sustain her on her journey into the Afterlife, food and (probably) drink were also provided, the former represented by the shoulder of beef, and the latter likely to have been the contents of the Beaker. Inclusion of joints of meat in graves dating to the late 3rd and early 2nd millennia is well attested in Britain (Wilkin 2011), with at least one example – from Kintyre Nurseries, Campbeltown, Argyll and Bute (Sheridan 1992) – showing singeing, indicating that the meat had been cooked. It is arguably reasonable to assume that the meat in Ava’s grave had indeed been cooked.

The pollen and the non-pollen palynomorphs found on the sediments attaching to the Beaker have provided valuable clues as to the landscape around the cist: animals probably grazed nearby (and we know from the shoulder of beef in the cist that the community had access to cattle), and there was both heathland, including wet areas, and associated woodland (birch, hazel, alder and pine) in the vicinity.

Setting this grave within the context of Chalcolithic and Early Bronze Age Caithness is a challenge, since so little is known about these periods in this part of Scotland (Heald & Barber 2015). The paucity of Beaker and Food Vessel finds has been noted above, and while this may partly be due to the fact that there is relatively little arable agriculture in this region in comparison to some other parts of Scotland (and thus not many opportunities for the discovery of chance finds), nevertheless it may reflect a genuine tail-off in the use of these types of pottery north of the Great Glen. What evidence there is for Chalcolithic and Early Bronze Age activity indicates that some people were choosing to bury their dead at Neolithic chamber tombs (eg Tulach an t'Sionnaich, where a small, incomplete, thin-walled pot in front of the entrance was found to contain cremated human remains dating to 2201–1980 cal BC, GrA 28611, 3705 ± 35 BP: Sheridan 2005: 183), while others followed the funerary tradition of their continental ancestors. (See also Wilkin 2016 for a discussion of the deposition of Beakers at Neolithic chamber tombs.) Many questions remain, including: was Ava's grave an isolated cist, or was it part of a cemetery? Why did the community choose to bury her in a cist within a rock-cut pit, rather than in a pit cut through sand or gravel, as was the normal practice for Beaker and Food Vessel graves in Scotland (eg at Acharole)? And was the U-shaped stone setting at Achavanich (Canmore ID 8271; Highland HER ID MHG 1315), a couple of kilometres to the south, constructed some centuries after Ava was interred, as is currently assumed (cf Heald & Barber 2015: 63–70)?

There is scope for undertaking new research on some old finds, however, with the aforementioned individual buried with a Beaker at Acharole, West Watten (Canmore ID 8804; Highland HER ID MHG 1980; Bryce & Low 1905: 418), being a prime candidate for comparative ancient DNA and isotopic analysis. Similarly, ancient DNA analysis could usefully be undertaken on the four individuals buried in an Early Bronze Age cemetery at Dalmore, Halkirk (Canmore ID 8236; Highland HER ID MHG 1587), a few kilometres to the north-east of Achavanich. All have been radiocarbon-dated, with dates ranging between 2140–1950 cal BC and 1920–1740 cal BC (at 95.4%: see Wilkin et al 2009: 217 for details). One individual was associated with a Food Vessel (with the Canmore entry suggesting that a second pot was found in one of the other cists, but was broken and not kept), and some isotope analysis has already been undertaken on all four individuals as part of the *Beakers and Bodies Project* and the *Beaker People Project* (Curtis et al in press).

Finally, the effectiveness of the strategy employed to disseminate the results of the research undertaken on Ava and her grave needs to be highlighted. The first-named author has employed numerous ways of engaging the public, with the use of various electronic and social media platforms proving to be particularly successful in reaching a global audience. The *Achavanich Beaker Burial Project* website was launched in 2015 and it has had over 48,000 views, and over 19,500 unique visitors from more than 130 countries around the world, as of July 2018; it includes recorded lectures by the first-named author. On social media the project has over 5,700 subscribers worldwide, with particularly large numbers (almost half) from Brazil and one-fifth from the United States of America. When the first facial reconstruction was loaded onto social media it 'went viral' and was shared to over 50 million people on one platform alone. Two podcast interviews with the two authors of this section, recorded by the *British History Podcast*, were listened to by over 110,000 people in the first six months (British History Podcast). A virtual reality experience is being developed in collaboration with Samsung Internet and the University of Edinburgh's Schools of Informatics and of History, Classics and Archaeology. Three comic book-style pop-up banners describing the project have been displayed at conferences and fairs and have been particularly popular with young people; these are currently being redeveloped into a comic book for children. And there has been considerable press coverage, following the issue of press releases.

Throughout this project it has been clear that there is a thirst for information about Scottish prehistory, locally and globally. While traditional methods of dissemination – such as publication – engage a certain number of people, the employment of alternative methods can successfully engage millions across the globe. It is hoped that the *Achavanich Beaker Burial Project* might encourage others to broaden the channels used to disseminate information about Scottish prehistory and engage non-traditional audiences.

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