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Facilitating Transitions: Post-Mortem Processing of the Dead at the Carrowkeel Passage Tomb Complex, Ireland (3500–3000 cal B.C.)

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Post-Mortem Processing of the Dead at the Carrowkeel Passage Tomb Complex

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This study explores the burial practices and secondary funerary rites at the Carrowkeel Neolithic passage tomb complex, located in County Sligo in the north-west of Ireland. An osteological and taphonomic re-assessment of cremated and unburnt human bones recovered from the complex during an archaeological excavation over 100 years ago has produced significant new insights into how the people of Carrowkeel perceived death, and how they maintained and manifested social links with their ancestors. In addition to the rite of cremation, a complex post-mortem burial practice is further attested by the presence of cut-marks on several of the unburnt bones, which indicate that dismemberment was undertaken on the bodies of the dead before they were placed in the tombs. It is argued that both cremation and dismemberment (and possible de-fleshing) may have been physical expressions of similar objectives, relating to excarnation and removal of flesh from the bodies of the deceased. Processing the bodies, and thereby assisting the dead to transcend to an extra-bodily realm of existence, may have been the main focus of the burial rite. The passage tombs at Carrowkeel should perhaps be viewed as places of curation, transformation and regeneration of enduring ancestors that enabled both a physical and spiritual interaction with the dead and allowed for them to be omnipresent among the living.

Facilitating Transitions: Post-Mortem Processing of the Dead at the Carrowkeel Passage Tomb Complex, Ireland (3500–3000 cal B.C.)

Ireland has a rich prehistoric archaeological record. This is particularly evident in the substantial number of surviving Neolithic funerary monuments (Jones 2013; Scarre 2007; Shee Twohig 2004). Apart from the well-known passage tombs, these also included portal tombs, court tombs, so-called Linkardstown-type tombs and other unclassified megalithic monuments (Cooney 2000; Scarre 2011; Shee Twohig 2004). The dead were also interred in caves (Dowd 2008). The diversity in modes of burial suggests that the perceptions of death and the afterlife in the Neolithic were subject to phases of change and evolution both with and as a consequence of social changes (Bradley 2007; Parker Pearson 1999; Whittle 1996). Societal change is implicit in the sudden appearance (a "frenzy" of construction (Scarre 2010:183) of a variety of mega funerary monuments and communal tombs beginning in the Neolithic period. Over the period when passage tombs were constructed in Ireland, a decrease in the archaeological evidence of settlement is observed, which suggests substantial societal and economic shifts occurred simultaneously (McLaughlin et al. 2016). A sense of transformation – and, in particular, shifting perceptions of death and the afterlife – is also apparent in the changing funerary practices relating to the treatment of the dead, and how their mortal remains were perceived by society. It is, for instance, evident that post-mortem processing and diverse secondary burial practices were particularly important funerary rites for Neolithic societies (see Crozier 2016; Fowler 2010; Murphy 2003; Reilly 2003; Robb et al. 2015).

This study discusses new evidence of body processing and secondary funerary rites undertaken in the Irish Neolithic, as revealed from an osteological and taphonomic re-analysis of human bones excavated at the Carrowkeel passage tomb complex in County Sligo over 100 years ago. The complex at Carrowkeel includes 26 passage tombs and probable passage tomb tradition sites (Hensey et al. 2014), as well as over 150 enclosures/hut sites within an area of about 25 km^2 (Bergh 2015) (Figure 1). The tombs/monuments are prominently situated in the Bricklieve Mountains with panoramic views of the surrounding landscape. In addition to its impressive topographical location, the investment of imagination and energy that produced the remarkable diversity of forms and scale of its monuments indicate that Carrowkeel had a particularly important role and function in this region in the Neolithic. Despite this, however, the complex has, up to recent times, been subjected to comparably little modern research compared to its more famous counterparts of Loughcrew and the Boyne Valley *(Brú na Bóinne)* in County Meath in the east of Ireland (e.g. Eogan 1986; O'Kelly 1982; Shee Twohig

et al. 2010; Smyth 2009) and Carrowmore in County Sligo (Bergh 1995; Bergh and Hensey 2013; Burenhult 1984, 2003).

Archaeological Background

The first substantial archaeological investigation of Carrowkeel was conducted in the late spring and summer of 1911. The excavation was directed by Robert Alexander Macalister (1870–1950), Professor of Celtic Archaeology at University College Dublin, assisted by Robert Lloyd Praeger (1865–1953), a naturalist, writer, and librarian at the National Library of Ireland, and Edmund Clarence Richard Armstrong (1879–1923), Assistant Keeper of Antiquities at the National Museum of Ireland. During a total of only 18 days, and with the help of local labourers, the team investigated and described 14 cairns (Figure 2). They also recorded two megalithic structures and 47 enclosures/hut sites (Hensey et al. 2014; Macalister et al. 1912). A substantial amount of human and animal bone, together with a small collection of pottery and bone and stone artefacts, was recovered. The skeletal material was analysed by Macalister's father, Professor of Anatomy at the University of Cambridge, Alexander Macalister (Snr) (1844–1919), who also was present during the archaeological excavation. Macalister Snr's analysis of the remains was published as a summary in the excavation report in the *Proceedings of the Royal Irish Academy* in early 1912, only a few months after the excavation was concluded (Macalister et al. 1912). Radiocarbon dates that have been obtained from human and animal bones recovered from within the passage tombs in later studies have consistently returned Middle to Late Neolithic dates (3600–2500 cal. BC) (Bergh 1995; Hensey et al. 2014; Kador et al. 2015), although the area continued to be used for funerary purposes well into the Bronze Age as indicated by cist burials and Bronze Age pottery vessels associated with some of the monuments (Hensey et al. 2014).

Osteological Material and Methods

The human bone assemblage from Macalister's excavations at Carrowkeel is curated by the Duckworth Laboratory at the Leverhulme Centre for Human Evolutionary Studies (LCHES), University of Cambridge, England. A small amount of material is also held by the National Museum of Ireland (NMI) in Dublin, Ireland. For a long time, the whereabouts of the Cambridge assemblage was unknown to Irish archaeologists, and the bones have not been studied since the original analysis in 1911 (discussed in Hensey et al. 2014). The material comprises of 5.7 kg (2,344 fragments) of cremated and 9.7 kg (755 fragments) of unburnt co-mingled remains that had been recovered from at least five individual passage tombs (Table 1). The bones were analysed macroscopically in a well-lit laboratory environment, with the occasional aid of a magnifying glass, following standard osteological guidelines and protocols (Brickley and McKinley 2004; Buikstra and Ubelaker 1994). Age at death was estimated

from bone measurements of neonatal and infant remains, and epiphyseal fusion of juveniles and adults (Scheuer and Black 2000; Szilvássy 1988). Sex was determined from pelvic and cranial morphological features (Sjøvold 1988). Bone surface analysis with the aid of a scanning electron microscope (SEM) was not available for this study.

The degree of incineration of the cremated bones, and the condition of the unburnt bone was determined and classified according to the descriptions by Wahl (1982) and McKinley (2004). The relative fragmentation of the cremated and unburnt samples was assessed consistently by considering both the average weight (W) per fragment (NISP = Number of Identified Specimens) and the ratio of the number of fragments (NISP) by the minimum number of elements (MNE) (Lyman 1994:336–338).[1] Bone fragment weight was measured using an electronic digital scale with 0.01 g accuracy (OHAUS Scout Pro).

Result

Cremated and unburnt bones are present in nearly equal proportions when quantified by the minimum number of individuals (MNI), with at least 22 individuals present in the cremated and 18 individuals present in the unburnt material. These samples include remains of both non-adults and adults, and males and females (Geber et al. 2016). By context, the largest quantity of the bone assemblage derives from Cairn K and the smallest amounts from Cairn F (Table 1). The assemblage is characterised by its uniformity in appearance and its generally excellent state of preservation, both within and between tomb contexts. The unburnt material is comprised of bone fragments that almost exclusively display solid cortices and primarily only none (Grade 0) to moderate (Grade 3) post-depositional surface alterations (Table 2) (McKinley 2004). The bones display no clear evidence of bleaching or exfoliation due to exposure and weathering (see Behrensmeyer 1978), which is of particular interest in this context (see discussion below). These bones do not display any evident humus soil stains, which would suggest that they had been surface depositions, and had not been exhumed from the ground prior to being deposited in the chambers. Furthermore, there are only seven bone fragments that displayed distinct marks of rodent gnawing (most likely caused by wood mice, see Haglund 1997), and there is no evidence of carnivore gnawing on any of the remains that might have indicated that body exposure and excarnation by animal scavenging were parts of the burial rite (see Smith 2006).

Cremated remains

[1] The calculation of MNE values considered crania as complete units, and quantification of number of elements for individual cranial bones was not undertaken as many of these were in articulation.

The demographic profile of the individuals represented by the cremated material in the Carrowkeel assemblage has a higher proportion of non-adults and adult females compared to those represented in the unburnt remains (see discussion in Geber et al. 2016), although this difference is not exclusive as unburnt child and female remains are also present in the tombs.

The efficiency of the cremations and the consistency of the appearance of the Carrowkeel cremated bones suggests that a particular result was being sought in a careful and measured process. The predominantly pale cream-white colour of the bones (see Table 3) indicates that they had been exposed to temperatures exceeding 800 °C during the cremation and that they had been fully and completely incinerated (Ellingham et al. 2015; Ulguim 2015; Wahl 1982). This observation alone is significant, as it indicates that the physical end result of a cremation – in terms of the appearance of the cremated bones – was potentially equally as important as whatever symbolic value was attached to the process (c.f. McKinley 2008). The heat-induced cracks and fissures on the cortical bone surfaces were curvilinear and transverse in appearance, which indicates that they are more likely to have been cremated while "fleshed" or "green" rather than "dry" (see Baby 1954; Binford 1963; Buikstra and Swegle 1989; Thurman and Willmore 1981), although the reliability of using these features and patterns to determine pre-burning conditions of human bone has been questioned (see Gonçalves et al. 2015). The bones did not display any evidence of secondary staining (e.g. from soot and smoke, as described by Herrmann 1972), and this may suggest that they had been sorted and possibly cleaned (or even washed) before they were collected and interred in the tombs (see Gejvall 1961). This is further indicated by a complete lack of pyre-debris in the material (c.f. O'Donnell 2016). The curated cremated bone samples from Carrowkeel comprise substantial and large fragments. By weight, over 90% of the material comprises fragments measuring larger than 10 mm in size (Table 4). This is a stark contrast to other prehistoric cremation burial samples elsewhere in Ireland where fragments of that size category have been observed in relative quantities of about 15% (e.g. Geber 2009). It is even higher in comparison with the degree of fragmentation reported from modern cremations, where between 43% and 71% of bone weights comprise fragments measuring 10 mm in size or more (see McKinley 1993).

Perimortem cut-marks on unburnt bone

The most significant discovery from the re-assessment of the Carrowkeel assemblage was the presence of 91 definite and one possible cut-mark on 13 unburnt bones. These were not mentioned in Macalister Snr's report, and it seems likely that he did not observe them during his analysis. Prior to this study, only two sites were known to display evidence of processing the bodies of the dead during the Neolithic in Ireland in the form of dismemberment and/or de-fleshing with the use of lithic tools. In an unpublished account from the archaeological

excavations undertaken at the Carrowmore megalithic complex in County Sligo during the 1990s, three bones from the same cranium (frontal, right temporal and right zygomatic) from one monument (Tomb No. 51) displayed transverse cut-marks that were interpreted as evidence of de-fleshing (Burenhult 1998:6, 18).[2] Another case was discovered during a re-analysis of human bones excavated from a megalithic tomb at Millin Bay in County Down in 1953, which consisted of an adult male mandible with clear cut marks across the right ramus and gonion (Murphy 2003). This new evidence from Carrowkeel shows that this aspect of the Neolithic funerary rite, which has been frequently reported from numerous locations across Europe (e.g. Crozier 2016; During and Nilsson 1991; Núñez and Lidén 1997; Robb et al. 2015; Walsh et al. 2011), was also present in Ireland. It is a distinct possibility that a re-examination of bone assemblages from other excavations, especially older ones, will reveal further evidence of these practices that has thus far been overlooked. This evidence suggests that the people of Neolithic Ireland may have shared similar beliefs and ideologies about death with communities beyond the Irish Sea.

The cut-marks on the Carrowkeel bones were observed only on post-cranial elements, which anatomically derived from a minimum of one adult individual of unknown sex. The bones in question were, however, present in at least two separate contexts (Cairns H and K). The cut-marks were generally linear or very slightly curved shallow scores with an uneven V-shaped profile (c.f. Greenfield 1999) located at or near the attachment sites for tendons and ligaments associated with the major joints of the body. The cut-marks were identified as perimortem on the basis of the sharpness of the margins, and a patination of the internal surface of the incisions that corresponded to the surface condition elsewhere on each affected bone. The scores themselves displayed a uniform appearance, which is likely to indicate that they were all conducted using the same type of lithic tool, which for an north-west Irish Neolithic context most likely to be either locally sourced chert (Bergh 2009), flint from Cretaceous geological deposits (Costa et al. 2005), or possibly even quartz (some fragments of which were found with the bone curated at LCHES). No scrape marks were identified and this, in combination with the anatomical location of the incisions, suggests that they were undertaken for the purpose of disarticulation and dismemberment rather than de-fleshing (Reichs 1998), although it cannot be ruled out that the latter occurred as part of this process. The disarticulation involved the shoulder, elbow, hip, knee and ankle/foot joints. The absence of evidence elsewhere does not necessarily mean that other articulations were not involved as the frequency of cut marks made by lithic tools on bones are likely to also have been dependent on the skill and experience of the person(s) who performed them (c.f. Dewbury

[2] This specimen has been radiocarbon dated to c. 3500 cal. BC (4625±60 BP) (Ua-11581).

and Russell 2007). Radiocarbon dating of two of these bones indicated a date of c. 3500–3050 cal. BC (Table 5).

Disarticulation of a left and right shoulder was interpreted from two bones found in two separate contexts. A left first rib from Cairn H displayed multiple ($n \geq 18$) coronal cuts across the attachment sites for musculature (e.g. the *scalenus medius et/sive serratus anterior* m.) on the superior surface (Figure 3a). The primary objective of the cuts, however, is likely to have been to sever the brachial plexus, and thereby allow for the shoulder and upper limb to be anatomically separated from the trunk. A similar somewhat indirect evidence of shoulder disarticulation, which reveals a detailed understanding of the gross anatomy of the human body by the person(s) who undertook this procedure, can be interpreted from the presence of a minimum of 19 cuts running superoinferiorly across the dorsal surface of the right lamina of a cervical vertebra (from level C3–C6) found in Cairn K (Figure 3b). While these cuts may potentially relate to an effort to disarticulate the head from the neck, a more probable interpretation is that they were made in a procedure where the superficial and intermediate dorsal neck muscles (e.g. the *trapezius* and *splenius capitis et cervicis* m.) and adjacent structures were severed in order to enable the *levator scapulae* and/or the *rhomboid minor* muscles to be exposed, so that the superomedial connection between the scapula and the neck could be separated.

A fragment of a left humerus recorded as being recovered from Cairn K, displayed two or possibly three transverse cut-marks across the anterior surface of the distal portion, just superior of the medial epicondyle (Figure 4a). These incisions would have cut through the *pronator teres* muscle and adjacent connective tissues, and thereby allowed for the bones to be exposed and separated at the joint.

Fragments from one left coxae and a left and a right femur recovered from Cairn K, all possibly from the same individual, displayed multiple cut-marks that are consistent with an intentional disarticulation of the hip joints. The coxae exhibited four oblique cut-marks on the anterolateral surface of the iliac blade (Figure 4b), which would have cut through the proximal attachments of the *gluteus minimus et medius* muscles. The left femur displayed five or possibly six oblique cuts across the anterior surface of the shaft, just inferior of the greater trochanter. These are likely to have cut through the distal attachment of the *gluteus minimus* muscle. At roughly the same level on this bone fragment, on the posterior surface, were four oblique cuts and one almost longitudinal cut located on the proximal portion of the linea aspera, that would have cut through the distal attachment of the *gluteus maximus* muscle. There were also two possible cuts, running at an oblique angle, on the anterior surface further

down towards the mid-shaft portion of this bone. These are more difficult to interpret but may relate to incisions through the *vastus lateralis* muscle, which in that case may primarily relate to cutting through the superficial *tensor fascia lata* muscle that runs across the thigh at that location. If so, this would have aided in exposing the hip joint, and thereby allowed for the bones to be disarticulated.

The right femur displayed a transverse cut-mark running across the anteromedial surface of the neck, which is likely to have been undertaken for the purpose of disconnecting the ischiofemoral ligament to enable the head of the femur to be pulled out of the acetabulum. There was also a shallow oblique cut running across the anterior surface just medial of the greater trochanter, which may have preceded the cut on the neck, as it would have enabled the bones to be exposed by cutting open the overlying muscle tissues at the anterior portion of the hip joint. This femur fragment also displayed five oblique and two transverse cuts at the quadrate tubercle on the posterior surface (Figure 4c), that would have cut through the lateral attachment of the *quadratus femoris* muscle which connects to the ischial tuberosity of the coxae.

The remaining 37 cuts identified in the Carrowkeel material were located on adult tarsal and metatarsal bones from an unknown context, and they all appear to relate to disarticulation of a left and right ankle joint (Figure 5). The original context from which all these elements were found is uncertain, but the overall shape and size – and the re-association of bones which was possible with many of these – would suggest that they are from the same individual and that they probably were all recovered from a single original context. One left calcaneus displayed a minimum of five axial cuts across the superior aspect of the lateral surface of the body that is likely to have cut through the distal attachment of the calcaneofibular ligament, and there were also two slightly oblique cuts running across the medial surface which would have involved the long tendon of the *flexor hallucis longus* muscle. The latter structure, along with the tendon of the *tibialis posterior* muscle, was most likely also cut through at the mid-tarsal level on the plantar surface of a left foot, as indicated from three parallel cuts on the plantar surface of a cuboid bone.

Another tarsal bone, a lateral cuneiform from a left foot, displayed one, or possibly two, cuts across the dorsal surface. This or these incisions would have cut through the long tendon of the *extensor digitorum longus* muscle amongst other structures, and this would have severed the soft tissue connection between the distal phalanges and the leg. While the anteroposterior direction of the cuts in the sagittal plane may argue against that interpretation, they do make functional sense when considering that a cut through cadaveric tissue with a lithic blade most

likely required a support base as flaked stone tools dull quickly, particularly during the process of disarticulation (Braun et al. 2008), and the bone itself was probably used as a base on which the tendon could have been placed and arranged so that it could have been cut through with more ease. The remaining cuts were all present on metatarsal bones. Longitudinal and oblique cuts were present on the shafts on the dorsal surface of all of these bones which are likely to have cut through the *extensor digitorum brevis* tendons, and also on the plantar surface of three bones which would have involved the *flexor digitorum brevis* tendon.

In addition to these cut-marks described above was a possible – but rather uncertain – cut noted across the superior margin of the neck of a right adult rib from Cairn H. If this is a true incision from a lithic blade, it is likely to have originated either from a cut through the costotransverse ligament, or it may derive from a procedure where the vertebral attachments of the tendons of the back muscles (e.g. *trapezius* m.) were cut through. In the latter suggestion, this would then have enabled the shoulder to be disconnected from the trunk.

Fragmentation of bone

In their description of one of the tombs (Cairn F), Macalister et al. mentioned that some bones (described as "bone dust") were found to be "much trampled" on the floor (Macalister et al. 1912:326). It is apparent, however, that the bone material they described as bone dust is not part of the collection curated by the LCHES or the NMI. The degree of fragmentation of the human bone material that has been assessed appears to conform to a general pattern: the samples that included the smallest fragments of cremated bone also included the smallest fragments of unburnt bones and vice versa. Whether this pattern signifies an aspect of the rite that was spatially manifested within the Carrowkeel complex is worth consideration, but difficult to ascertain as it is unclear to which degree the curated samples from the 1911 excavation represent a bias towards larger fragments. Macalister et al.'s (1912) description of the cairns, *vis a vis* the levels of prehistoric structural damage or collapse – for instance, the collapse of the passage at Cairn H (ibid.:328–329) – could not account for the degree of fragmentation of cremated bone present at different sites across the complex.

The most noticeable and highest degree of bone fragmentation was observed in samples from Cairn B, which stands out as a clear outlier in comparison with other tombs, and for the unburnt bone in particular. Of the cremated samples, the least fragmented material was recovered from Cairns H and K (see Table 4), and of the unburnt samples, the least fragmented bones were present in Cairns K and E (see Table 2). The significance of these differences (and similarities) between tomb contexts is difficult to determine. The large

fragments of the cremated bone would imply that intentional crushing and pounding of remains after a cremation (see Lisowski 1968; Sigvallius 1994) is unlikely to have been part of the funerary rite at Carrowkeel – at least not involving the bones that were deposited in the tombs.

The fragmentation of the unburnt bone, however, is unexpected considering the excellent state of preservation of these remains. Amongst these samples, only one humerus, two radii and one ulna were complete amongst the major long bones in adult remains. The remainder (including femora, tibiae and fibulae and fragmented portions of humeri, radii and ulnae), were all fragmented. Nearly 70% (114/165) of all fragments from these long bones comprised less than half of the element, and it is evident that these fragments comprised primarily the shaft portions of these bones. The least relative fragmentation was observed in the smaller tubular bones, such as the metapodials and phalanges, but also spongious elements such as tarsals and vertebrae (see Figure 6). Considering that the latter bones would be generally more fragile than primarily compact skeletal elements such as crania and long bones, it does suggest that fragmentation of the unburnt remains was, to a certain extent, a *pars pro toto* component of the overall burial practice. The fragmented bones all displayed typically "dry" or "mineralized" bone fracture patterns, with perpendicular transverse or splintered uneven fracture margins, rather than helical oblique patterns with a smooth fracture surface textures expected from "fleshed" or "green" bone (Outram 2001; Outram et al. 2005), which indicate that these alterations occurred post-mortem.

The Funerary Rites at Carrowkeel: Processing the Dead

A complex and widely diverse set of funerary rites are characteristic of burial practices in the Neolithic across Europe. The reasons for the diversity of burial practice has long been discussed in the archaeological literature. Sometimes a chronological explanation is proffered, but divergent forms of "burial" are often found within the same monument and in some cases have been demonstrated to be of similar age. Most commonly, it has been interpreted as an expression of social stratification (e.g. Binford 1972; Brown 1981). However, this diversity can also be viewed merely as a mortuary variation, which in fact is a rule rather than an exception in most cultures throughout history, including those of today (see Larsson 2003), and hence does not necessarily correlate to status. The manner in which corpses were processed and handled may, therefore, be less important than the actual physical interaction between the dead and the living. The fact that the burial practice involved a secondary stage does indicate that this interaction or interrelation with the deceased was particularly important. It can be perceived as a manner in which the living were able to physically aid the dead reach their next transitional stage, but also most likely enable themselves to come to terms with

their loss. At Carrowkeel, complex and varied interactions with the dead are attested through choices made by the living which resulted in the cremation, dismemberment or fragmentation of the bones of the dead.

The ideological background for the intended physical destruction (or perhaps better described as "de-construction") of the body, either through fire, stone tools or natural decomposition, has often been discussed as a reflection of a dualistic religious concept in which people transitioned into different realms of consciousness after death (Lewis-Williams and Pearce 2005; Midgley 2010). The processing of bodies could, therefore, be interpreted as a way to aid the deceased, or rather their non-material selves, in the transition to a further state of post-mortem existence. The bodies of the deceased being brought to the passage tomb complex could be seen as an important first milestone on that journey, a place of introduction to the land of the dead. In addition, the practice may also have helped the survivors to come to terms with their loss. Goss and Klass (1997) have discussed four methods of contemporary Tibetan death rituals – sky rituals (exposure), cremation, ground burial (inhumation) and water burial – as different means for the dead to transition to other states. These post-mortem journeys involve a transference of consciousness which is aided and facilitated by the surviving relatives and the living community who perform these rites. By facilitating these transitions, the living are not only performing a "final act of compassion"; by assisting the dead they are also resolving their own grief.

Transition through fire

The process of cremation is a process of transformation, and it is easy to understand how the fire and the heat that engulfs the corpse and the smoke it generates (both its smell and visual effect), could have been viewed as a physical transitional event in which the soul or spirit of the dead was finally released from its physical boundaries (see Gräslund 1994; Nilsson Stutz and Kuijt 2014; Oestigaard 2005; Thompson 2015). The transformation is also materialist in terms of how the skeletal remains change form through cremation – after the flesh and soft tissue has been consumed by the fire, the bones of the skeleton will fragment, distort, shrink, change colour, and becomes more dense and brittle (Buikstra and Swegle 1989; Ellingham et al. 2015; Iregren and Jonsson 1973; McCutcheon 1992; Shipman et al. 1984; Walker et al. 2008). This is, however, only apparent in fully incinerated and completely cremated remains where all organic components of bones have been destroyed and fusion of bone mineral has occurred (Ellingham et al. 2015; Iregren and Jonsson 1973); charred and burnt bones keep their shape and appearance, with the exception of black and sooty patches observed on the surfaces. To make sense of these processes and their end results, and understand their significance, it is important to make a clear distinction between cremation and cremation

burial or deposit. These are not synonymous terms; cremation relates to the process of burning/cremating a corpse on a pyre, while a cremation burial or deposit is the interred or placed material of the cremated remains (McKinley 2000; Thompson 2009). These two distinctive "phases" within the funerary rite would have held different symbolic meaning and significance, and therefore requires clear differentiation when being discussed and interpreted (see Quinn et al. 2014).

When discussing the significance of cremation in prehistory, it is of importance to also consider the practical aspects of the rite. A cremation would have required a lot of communal investment, not only in terms of resources but also in regards to labour. McKinley (2008) has in a general approximation stated that 700–900 kg of fuel would have been required to complete a cremation of an adult corpse in prehistory. In addition to the time required to construct a pyre, the procedure in which the cremation was prepared, maintained, and eventually, the bones collected after it had been completed, would have taken numerous hours, possibly even days (Holck 1997; McKinley 2006). A cremation would also have been a highly visual manifestation; depending on where the cremation took place, it may have been visible for miles. It is currently not known where the cremations at Carrowkeel took place. No indications of pyre sites or cremation trenches were discovered during previous excavations at the complex – such as seemed to be the case at Fourknocks II, for instance (Hartnett 1971) – however, even with modern excavation techniques low archaeological visibility could mean pyre sites might not be found (Arcini 2005; Gräslund 1975; McKinley 1997).

Depriving the body of flesh

Witnessing the dismemberment of human remains as a ritual practice would have been a very different experience to attending a Neolithic cremation. Those in attendance would have observed specialist(s) carrying out physical work that involved blood, secretions, smells and intimate contact with the corpses. The detail shown by the examination of the bones suggests a daytime activity; and not one easily witnessed by large crowds unless somehow staged. The evidence of dismemberment, as indicated from the location of the perimortem cut-marks on bones, suggests that excarnation was part of the burial practice at Carrowkeel. This procedure has commonly been suggested to have been an integral part of the Neolithic funerary rite (e.g. Dowd 2008; Renfrew 1979; Smith 2006), but the definition of the term "excarnation" has not been used in a consistent manner, and therefore has come to entail different meanings in the literature. For example, Reilly defined excarnation as the process of "burying the corpse in a temporary grave or exposing it to the elements until only a skeleton remained" (2003:135), while Dowd defined it as a procedure where "the corpse is exposed and the flesh decomposes naturally, leaving a dry skeleton" (2008:309). Linguistically, however, the term relates to the

exposing the bones from covering soft tissues, deriving from the Latin word *excarnāre*, meaning "deprive of flesh" (Oxford English Dictionary 2016). To explain the processes relating to some of the aforementioned definitions, the term "exposure" has been used (e.g. Harris 2010; Knüsel and Robb 2016), which in many cases would be more appropriate and correct.

When attempting to interpret the burial rite at Carrowkeel, the use of an accurate definition of excarnation provides a significant aid. While cremated and unburnt bone derive from two distinctly different mortuary practices, in the context of excarnation and following the true meaning of the word they achieve a certain degree of commonality. This would, in that case, relate to cremation and skeletonizing of bodies as potentially equally accepted modes of depriving the body of flesh, and that this was done primarily for symbolic reasons rather than for the process of cremation or inhumation and/or exposure alone. At Carrowkeel, removal of flesh had been achieved by cremation as well as allowing for bodies (or perhaps only body parts) to be left to decompose within the tomb chambers. The latter is not only indicated by the lack of bone surface staining, but also the fact that cancellous bone portions and elements (e.g. epiphyseal ends of long bones and vertebrae) were relatively well preserved in this assemblage. This would suggest that bones had not been exposed to the elements during the process of decomposition (Galloway 1997). For this reason, the passage tombs at Carrowkeel should perhaps be considered as not only containers of the funerary rites, but also physical spaces that were integral to how the bodies of the dead were treated and handled by the living.

The uniform appearance of the bone assemblage from Carrowkeel, and indeed the very distinct pattern of anatomical precision in relation to where cut-marks were located on bones, indicate that the specific manner of the process through which these transitions were achieved had a significant role as well. This process most likely also included the physical act of bringing the human remains to the passage tombs themselves (c.f. Appleby 2013; Oestigaard 1999), and the deposition of the skeletal materials in the chambers and passages. These processes, when practised within the ceremonies of the funerary rite, would have provided opportunities to maintain or create new social bonds within and between societies (see Tilley 1996). As such, the importance of the rites would have encompassed much more than achieving the requisites and expectations of the communal religious beliefs and cult praxis.

Processing bodies through fragmentation

The evident fragmentation of human remains in the Carrowkeel passage tombs, either by cremation, dismemberment and potentially further post-mortem processing, may be an attempt to homogenize the bone material and form a coherent physical representation of the

dead that would no longer be represented by a body or corpse. Fragmentation of human remains as an integrated anthropogenic component in the Neolithic burial rite has also been suggested in a recent taphonomic study of funerary deposits from Orkney (Crozier 2016). Crozier's (ibid.) study identified not only evidence of dismemberment and de-fleshing, but also intentional breaking of bones by stone tools, as indicated by the presence of percussion pits. No such evidence was observed in the remains from Carrowkeel, but the fracture pattern of the unburnt bone – and indeed protected structural context in which they were found – suggest that post-mortem breakage of the bones was considered a part of the rite.

On a more holistic level, this fragmentation of the dead may be viewed as an expression of a broader paradigm that has been suggested for Neolithic societies. The evident intentional fragmentation and destruction that is often observed in the case of the material culture have been suggested to represent modes of "enchainment" between people and their environs, and that the rituals and processes during which they were made enabled social unifications and identities to be formed (Chapman 2000; Larsson 2015). When taking this idea into consideration, the rites and procedures involved in the act of processing the dead at Carrowkeel may therefore not only have helped the dead in their transitions to other realms, but also functioned as important social constructs for the living community and people who performed them.

Contextualising the Mortuary Rite at Carrowkeel

The human remains from Carrowkeel reveal diversity in secondary funerary practices, something that may have been of particular importance to the community or communities who constructed and used the monuments. The fact that a significant proportion of the human bone material from Carrowkeel comprised unburnt bones is noteworthy due to the fact that cremation is generally the predominating funerary rite associated with passage tombs excavated elsewhere on the island (Cooney 2014; Cooney and Grogan 1994; Dowd 2015). Cremation also seems to have been the dominant funerary rite in the Irish Neolithic overall, occurring in nearly 60% of all burials known to date (Murphy et al. 2010). That a large proportion of the bones from the tombs were not cremated is therefore of particular interest. It does indicate that the use of diverse funerary rites was integral to the use of these monuments, but the original significance of these is difficult to ascertain. When considering the relative representation of individual skeletal elements between the cremated and unburnt material, there was no substantial difference between these samples. In general, the material was dominated by compact and dense bones such as crania, mandibles and long bones, and the more fragile spongious bones (e.g. vertebrae, ribs and coxae) were least frequently observed (Geber et al. 2016).

The choice between cremation and non-cremation in prehistory has traditionally been interpreted as manifesting adherence to social practices, that the rites had different symbolic meanings and roles (Rebay-Salisbury 2012). Cooney discusses inhumation (he uses the term to include surface depositions of unburnt bone in megalithic tombs, which are technically not "inhumed" in the strict meaning of the word) and cremation as two distinctly different but contemporaneous mortuary rites in the Irish Neolithic, and he argues that unburnt and cremated bones had different symbolic connotations that were spatially manifested in the manner in which they were deposited both within and in the perimeters of megalithic monuments (Cooney 2014). The chronological relationship between the cremated and unburnt human bone deposits at Carrowkeel will be discussed in a forthcoming paper. In a handwritten note present with the material curated at the LCHES, Macalister Snr had stated that the cremated and unburnt bone from one box (CAK 2) was of "apparent contemporaneity", but this was a conclusion drawn from a macroscopic assessment of bones, long before the advent of radiocarbon dating.

What the spatial distribution of cremated and unburnt bones inside the Carrowkeel tombs was originally is largely unclear. The original excavation and analysis of the remains from 1911 have unfortunately contributed to a deterioration of the archaeological record as many of the remains have been mixed, and the original context and stratigraphy of a substantial proportion of the material cannot be ascertained (see Geber et al. 2016; Hensey et al. 2014). The infrequent direct references to the location of the bones in 1912 publication only state in general terms that they were located in the main chambers and recesses of the tombs (Macalister et al. 1912) (though more specific locational information is in certain instances alluded to in Macalister Snr's handwritten notes found with the bone assemblage at the LCHES). The quantitative and demographic analysis of the remains (see Geber et al. 2016) has been able to discern potential but only tentative contextual disparities in relation to the physical build and sex of the individuals interred in the monuments. Although the picture is unclear, it may be possible that the tombs had different social functions.

The taphonomic analysis in this study appears to single out Cairn B as an outlier in relation to the other contexts; this tomb included a higher proportion of more fragmented bones in both the cremated and unburnt samples. Other potentially disparate tombs were Cairn H and K, which were not only the monuments that included bones with evidence of dismemberment, but they also contained amongst the least fragmented bone samples. While there is an overall uniformity of the condition and appearance of the human remains from the various tombs at Carrowkeel, these subtle taphonomic differences may be indications of variability in the

funerary rite that was expressed spatially within the complex, which may relate to the architectural variation of the passage tombs themselves (Hensey 2015:144–147; Macalister et al. 1912). This variation may thereby be interpreted in a similar manner as Cooney's (2014) reading of the spatial pattering of cremated and unburnt bone depositions at Irish megalithic tombs. The bones may have incorporated a symbolic meaning relating to identity that defined both the use of the monuments as well as how they were socially perceived in the landscape itself. The manner in which they were deposited in the passage tombs following processing could have been one of the most significant aspects of the burial rite.

The megalithic passage tombs of the Neolithic have sometimes been interpreted as architectural imitations of caves that also served a mortuary purpose (Dowd 2015; Lewis-Williams and Pearce 2005), and that the construction of these monuments not only manifested social presence in the landscape but also a certain degree of control of access and connection to the realm of the dead. Dowd (2015) has argued that caves performed a particular mortuary function in Neolithic Ireland as excarnation places, with, in some instances, the bones later being deposited in megalithic monuments .If so, the use of passage tombs not only for containing human remains but also as places where bodies (or body parts) underwent the processes of excarnation and fragmentation appears plausible. In contrast to caves, however, the bones would then remain at the location where they were excarnated. It should be noted that the recent discoveries of probable excarnation practices from Cave K near Queen Maeve's tomb on Knocknarea Mountain, only 25 km north of Carrowkeel, may have a bearing on this discussion (Dowd and Kahlert 2014). Though Neolithic bone has not been found in the extensive Kesh Caves or the seven additional caves found in the vicinity of the Carrowkeel complex it cannot be ruled out that similar practices occurred there.

Conclusion

Macalister Snr's analysis of the bones in 1911 stands up well to modern scrutiny when taking his estimations of the minimum number of individuals and his metrical analysis into account (Geber et al. 2016). His study was, however, a product of its time, which placed a particular focus on craniology and metric analysis. To include new methods from the evolving discipline of bioarchaeology and its precursors and, in particular, the advent of taphonomic analyses of bone, was, therefore, a focus of the current re-assessment of the Carrowkeel material. This study has demonstrated that many old curated collections of previously studied archaeological bone still have considerable scientific potential, and this has been shown from many re-assessments of Neolithic samples in particular (e.g. Crozier 2016; Walsh et al. 2011).

In the case of Carrowkeel, the re-analysis of the assemblage has highlighted the high level of complexity and diversity of the funerary rites, which perhaps has not been fully recognised previously. This complexity is particularly evident in the manner in which the bodies of the deceased were processed and handled after death. This included cremation, dismemberment and possible intentional fragmentation of remains. The evidence of post-mortem body processing at Carrowkeel is not unique from a European perspective, but it remains a rarely reported occurrence from the bioarchaeological record from Ireland. This discovery provides another key to understanding the social significance of this fascinating cultural and ritual landscape for the people who constructed and used it over several centuries, five thousand years ago.

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Literature Cited

Appleby, Jo. 2013. Temporality and the Transition to Cremation in the Late Third Millennium to Mid Second Millennium BC in Britain. *Cambridge Archaeological Journal* 23(01):83–97. DOI: 10.1017/s0959774313000061.

Arcini, Caroline. 2005. Pyre Sites Before Our Eyes. In *Dealing With the Dead: Archaeological Perspective on Prehistoric Scandinavian Burial Ritual*, edited by Tore Artelius and Fredrik Svanberg. Riksantikvarieämbetet, Stockholm, pp. 63–72.

Baby, Raymond S. 1954. *Hopewell Cremation Practices*. Papers in Archaeology of the Ohio Historical Society 1. Ohio Historical Society, Columbus, OH.

Behrensmeyer, Anna K. 1978. Taphonomic and Ecologic Information from Bone Weathering. *Paleobiology* 4(2):150–162.

Bergh, Stefan. 1995. *Landscape of the Monuments: A Study of the Passage Tombs in the Cúil Irra Region, Co Sligo, Ireland*. Riksantikvarieämbetet, Stockholm.

Bergh, Stefan. 2009. Black is the Colour... Chert, Concave Scrapers and Passage Tombs. In *Materialitas: Working Stone, Carving Identity*, edited by Blaze O'Connor, Gabriel Cooney and John Chapman. Prehistoric Society Research Papers 3. Oxbow Books, Oxford, pp. 105–112.

Bergh, Stefan. 2015. Where Worlds Meet: Two Irish Prehistoric Mountain-top 'Villages'. *Il Capitale Culturale: Studies on the Value of Cultural Heritage* 12:21–44. DOI: 10.13138/2039-2362/1129.

Bergh, Stefan, and Robert Hensey. 2013. Unpicking the Chronology of Carrowmore. *Oxford Journal of Archaeology* 32(4):343–366. DOI: 10.1111/ojoa.12019.

Binford, Lewis R. 1963. An Analysis of Cremations from Three Michigan Sites. *Wisconsin Archeologist* 44:98–110.

Binford, Lewis R. 1972. *An Archaeological Perspective*. Seminar Press, New York.

Bradley, Richard. 2007. *The Prehistory of Britain and Ireland*. Cambridge University Press, Cambridge.

Braun, David R., Briana L. Pobiner, and Jessica C. Thompson. 2008. An Experimental Investigation of Cut Mark Production and Stone Tool Attrition. *Journal of Archaeological Science* 35:1216–1223. DOI: 10.1016/j.jas.2007.08.015.

Brickley, Megan, and Jacqueline I. McKinley, eds. 2004. *Guidelines to the standards for recording human remains*. British Association for Biological Anthropology and Osteoarchaeology/Institute of Field Archaeologists, Reading.

Brown, James A. 1981. The Search for Rank in Prehistoric Burials. In *The Archaeology of Death*, edited by Robert Chapman, Ian Kinnes and Klavs Randsborg. Cambridge University Press, New York, pp. 25–38.

Buikstra, Jane E., and Mark Swegle. 1989. Bone Modification Due to Burning: Experimental Evidence. In *Bone Modification*, edited by Robson Bonnichsen and Marcella H. Sorg. Center for the Study of the First Americans, University of Maine, Orono, ME, pp. 247–258.

Buikstra, Jane E., and Douglas H. Ubelaker. 1994. *Standards for data collection from human skeletal remains: Proceedings of a seminar at the Field Museum of Natural History*. Arkansas Archeological Survey Research Series 44. Arkansas Archeological Survey Press, Fayetteville, AR.

Burenhult, Göran. 1984. *The Archaeology of Carrowmore: Environmental Archaeology and the Megalithic Tradition at Carrowmore, Co. Sligo, Ireland*. Thesis and Papers in North-European Archaeology 14. G Burenhults Förlag, Stockholm.

Burenhult, Göran. 1998. *The Swedish Excavations at Carrowmore, Co. Sligo, Ireland. Campaign Season 1998. Excavation Report: Tomb No. 51 (Listoghil) (SMR Number SL014-20922).* Unpublished report. Department of Archaeology, Stockholm University, Stockholm.

Burenhult, Göran. 2003. The Chronology of Carrowmore. In *Stones and Bones: Formal Disposal of the Dead in Atlantic Europe During the Mesolithic Neolithic interface 6000–3000 BC. Archaeological Conference in Honour of the Late Professor Michael J. O'Kelly*, edited by Göran Burenhult. BAR International Series 1201. Oxford: Archaeopress, pp. 66–69.

Chapman, John. 2000. *Fragmentation in Archaeology: People, Places, and Broken Objects in the Prehistory of South-eastern Europe*. Routledge, London.

Cooney, Gabriel. 2000. *Landscapes of Neolithic Ireland*. Routledge, Abingdon.

Cooney, Gabriel. 2014. The Role of Cremation in Mortuary Practice in the Irish Neolithic. In *Transformations by Fire: The Archaeology of Cremation in Cultural Context*, edited by Ian Kuijt, Colin P. Quinn and Gabriel Cooney. The University of Arizona Press, Tuscon, pp. 189–206.

Cooney, Gabriel, and Eoin Grogan. 1994. *Irish Prehistory: A Social Perspective*. Wordwell, Dublin.

Costa, Laurent J., Farina Sternke, and Peter C. Woodman. 2005. Microlith to Macrolith: The Reasons Behind the Transformation of Production in the Irish Mesolithic. *Antiquity* 79:19–33. DOI: 10.1017/S0003598X00113675.

Crozier, Rebecca. 2016. Fragments of Death: A Taphonomic Study of Human Remains from Neolithic Orkney. *Journal of Archaeological Science: Reports*. DOI: 10.1016/j.jasrep.2016.05.036.

Dewbury, Adam G., and Nerissa Russell. 2007. Relative Frequency of Butchering Cutmarks Produced by Obsidian and Flint: An Experimental Approach. *Journal of Archaeological Science* 34:354–357. DOI: 10.1016/j.jas.2006.05.009.

Dowd, Marion. 2008. The Use of Caves for Funerary and Ritual Practices in Neolithic Ireland. *Antiquity* 82(316):305–317. DOI: 10.1017/S0003598X00096824.

Dowd, Marion. 2015. *The Archaeology of Caves in Ireland*. Oxbow Books, Oxford.

Dowd, Marion, and Thorsten Kahlert. 2014. *Final Excavation Report For Knocknarea Cave K, Carrowbunnaun Td., Co. Sligo (SL014-288----)*. Unpublished report submitted to the National Monuments Service and the National Museum of Ireland. School of Science, Institute of Technology Sligo, Sligo.

During, Ebba M., and Lennart Nilsson. 1991. Mechanical Surface Analysis on Bone: A Case Study of Cut Marks and Enamel Hypoplasia on a Neolithic Cranium from Sweden. *American Journal of Physical Anthropology* 84:113–125. DOI: 10.1002/ajpa.1330840202.

Ellingham, Sarah T. D., Tim J. U. Thompson, Meez Islam, and Gillian Taylor. 2015. Estimating Temperature Exposure of Burnt Bone – A Methodological Review. *Science and Justice* 55:181–188. DOI: 10.1016/j.scijus.2014.12.002.

Eogan, George. 1986. *Knowth and the Passage-Tombs of Ireland*. Thames and Hudson, London.

Fowler, Chris. 2010. Pattern and Diversity in the Early Neolithic Mortuary Practices of Britain and Ireland: Contextualising the Treatment of the Dead. *Documenta Praehistorica* 37:1–22. DOI: 10.4312/dp.37.1.

Galloway, Alison. 1997. The Process of Decomposition: A Model from the Arizona-Sonoran Desert. In *Forensic Taphonomy: The Postmortem Fate of Human Remains*, edited by William D. Haglund and Marcella H. Sorg. CRC Press, Boca Raton, FL, pp. 139–150.

Geber, Jonny. 2009. The Human Remains. In *In the Shadow of the Galtees: Archaeological Excavations Along the N8 Cashel to Mitchelstown Road Scheme*, by Melanie McQuade, Bernice Molloy and Colm Moriarty. NRA Scheme Monographs 4. The National Roads Authority, Dublin, pp. 209–240.

Geber, Jonny, Robert Hensey, Pádraig Meehan, Sam Moore, and Thomas Kador. 2016. Reassessing the Age, Sex and Metric Variation of Commingled Human Remains from a 1911 Excavation of a Neolithic Passage Tomb Complex in North-West Ireland. *International Journal of Osteoarchaeology* (early view). DOI: 10.1002/oa.2521.

Gejvall, Nils-Gustaf. 1961. Anthropological and Osteological Analysis of the Skeletal Material and Cremated Bones from Simris 2, Simris Parish. In *Simris II: Bronze Age Problems in Light of the Simris Excavation*, edited by Berta Stjernquist. Acta Archaeologica Lundensia 4:5. Rudolf Habelt Verlag, Lund, pp. 157–173.

Gonçalves, David, Eugénia Cunha, and Tim J. U. Thompson. 2015. Estimation of the Pre-Burning Conditions of Human Remains in Forensic Contexts. *International Journal of Legal Medicine* 129(5):1137–1143. DOI: 10.1007/s00414-014-1027-8.

Goss, Robert E., and Dennis Klass. 1997. Tibetan Buddhism and the Resolution of Grief: The Bardo-Thodol for the Dying and the Grieving. *Death Studies* 21(4):377–395. DOI: 10.1080/074811897201895.

Gräslund, Anne-Sofie. 1975. Bränning På Platsen Eller Särskild Bålplats? Några Notiser Om Ett Bränningsförsök. *Tor* 17:363–373.

Gräslund, Bo. 1994. Prehistoric Soul Beliefs in Northern Europe. *Proceedings of the Prehistoric Society* 60:15–26. DOI: 10.1017/S0079497X00003364.

Greenfield, Haskel J. 1999. The Origins of Metallurgy: Distinguishing Stone From Metal Cut-Marks on Bones From Archaeological Sites. *Journal of Archaeological Science* 26:797–808. DOI: 10.1006/jasc.1998.0348.

Haglund, William D. 1997. Rodents and Human Remains. In *Forensic Taphonomy: The Postmortem Fate of Human Remains*, edited by William D. Haglund and Marcella H. Sorg. CRC Press, Boca Raton, FL, pp. 405–414.

Harris, Oliver. 2010. Emotional and Mnemonic Geographies at Hambledon Hill: Texturing Neolithic Places with Bodies and Bones. *Cambridge Archaeological Journal* 20(3):357–371. DOI: 10.1017/S0959774310000466.

Hartnett, Patrick J. 1971. The Excavation of Two Tumuli at Fourknocks (Sites II and III), Co. Meath. *Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature* 71:35–89.

Hensey, Robert. 2015. *First Light: The Origins of Newgrange*. Oxbow Books, Oxford.

Hensey, Robert, Pádraig Meehan, Marion Dowd, and Sam Moore. 2014. A Century of Archaeology—Historical Excavation and Modern Research at the Carrowkeel Passage Tombs, County Sligo. *Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature* 114C:57–87. DOI: 10.3318/priac.2014.114.04.

Herrmann, Bernd. 1972. Zur Beurteilung von Kohlenstoffverfärbungen bei Leichenbränden. *Ausgrabungen und Funde. Nachrichtenblatt für Ur- und Frühgeschichte* 17(6):275–277.

Holck, Per. 1997. *Cremated Bones: A Medical-anthropological Study of an Archaeological Material on Cremation Burials*. Antropologiske Skrifter 1c. University of Oslo, Oslo.

Iregren, Elisabeth, and Rolf Jonsson. 1973. Hur Ben Krymper Vid Kremering. *Fornvännen* 68:97–100.

Jones, Carleton. 2013. *Temples of Stones: Exploring the Megalithic Tombs of Ireland*. Collins Press, Cork.

Kador, Thomas, Jonny Geber, Robert Hensey, Pádraig Meehan, and Sam Moore. 2015. New Dates from Carrowkeel. *PAST* 79:12–14.

Knüsel, Christopher J., and John Robb. 2016. Funerary Taphonomy: An Overview of Goals and Methods. *Journal of Archaeological Science: Reports*. DOI: 10.1016/j.jasrep.2016.05.031.

Larsson, Åsa M. 2003. Secondary Burial Practices in the Middle Neolithic: Causes and Consequences. *Current Swedish Archaeology* 11:153–170.

Larsson, Lars. 2015. Fragmentation During the Neolithic: Transformation and Enchainment from a South Swedish Perspective. In *Neolithic Diversities: Perspectives From a Conference in Lund, Sweden*, edited by Kristian Brink, Susan Hydén, Kristina Jennbert, Lars Larsson and

Deborah Olausson. Acta Archaeologica Lundensia Series in 8°; Vol. 65. Department of Archaeology and Ancient History, Lund University, Lund, pp. 233–240.

Lewis-Williams, David, and David Pearce. 2005. *Inside the Neolithic Mind: Consciousness, Cosmos and Realm of the Gods*. Thames & Hudson, London.

Lisowski, F. Peter. 1968. The Investigation of Human Cremations. In *Anthropologie und Humangenetik: Festschrift zum 65. Geburtstag von Professor Dr. Dr. h. c. Karl Saller*, edited by Institute für Anthropologie und Humangenetik der Universität München. Gustav Fischer Verlag, Stuttgart, pp. 76–83.

Lyman, R. Lee. 1994. *Vertebrate Taphonomy*. Cambridge Manuals in Archaeology. Cambridge University Press, Cambridge.

Macalister, Robert Alexander Stewart, Edmund Clarence Richard Armstrong, and Robert Lloyd Praeger. 1912. Report on the Exploration of Bronze-Age Carns on Carrowkeel Mountain, Co. Sligo. *Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature* 29:311–347.

McCutcheon, Patrick T. 1992. Burned Archaeological Bone. In *Deciphering a Shell Midden*, edited by Julie K. Stein. Academic Press, San Diego, CA, pp. 347–370.

McKinley, Jacqueline I. 1993. Bone Fragment Size and Weights of Bone from Modern British Cremations and the Implications for the Interpretation of Archaeological Cremations. *International Journal of Osteoarchaeology* 3(4):283–287. DOI: 10.1002/oa.1390030406.

McKinley, Jacqueline I. 1997. Bronze Age 'Barrows' and Funerary Rites and Rituals of Cremation. *Proceedings of the Prehistoric Society* 63:129–145. DOI: 10.1017/S0079497X00002401.

McKinley, Jacqueline I. 2000. Putting Cremated Human Remains in Context. In *Interpreting Stratigraphy: Site Evaluation, Recording Procedures and Stratigraphic Analysis. Papers Presented to the Interpreting Stratigraphy Conferences 1993–1997*, edited by Steve P. Roskams. BAR International Series 210. Archaeopress, Oxford, pp. 135–140.

McKinley, Jacqueline I. 2004. Compiling a Skeletal Inventory: Disarticulated and Co-Mingled Remains. In *Guidelines to the Standards for Recording Human Remains*, edited by Megan Brickley and Jacqueline I. McKinley. IFA Paper 7. British Association for Biological Anthropology and Osteoarchaeology/Institute of Field Archaeologists, Reading, pp. 14–20.

McKinley, Jacqueline I. 2006. Cremation ... the Cheap Option? In *Social Archaeology of Funerary Remains*, edited by Rebecca Gowland and Christopher Knüsel. Oxbow Books, Oxford, pp. 81–88.

McKinley, Jacqueline I. 2008. In the Heat of the Pyre: Efficiency of Oxidation in Romano-British Cremations – Did It Really Matter? In *The Analysis of Burned Human Remains*, edited by Christopher W. Schmidt and Stevens A. Symes. Elsevier, Amsterdam, pp.

McLaughlin, T. Rowan, Nicki J. Whitehouse, Rick J. Schulting, Meriel McClatchie, Philip Barratt, and Amy Bogaard. 2016. The Changing Face of Neolithic and Bronze Age Ireland: A Big Data Approach to the Settlement and Burial Records. *Journal of World Prehistory* (early view):1–37. DOI: 10.1007/s10963-016-9093-0.

Midgley, Magdalena S. 2010. Monuments and Monumentality: The Cosmological Model of the World of Megaliths. *Documenta Praehistorica* 37:55–64. DOI: 10.4312/dp.37.5.

Murphy, Eileen. 2003. Funerary Processing of the Dead in Prehistoric Ireland. *Archaeology Ireland* 17(2):13–15.

Murphy, Eileen, Barra O'Donnabhain, Harry Welsh, Mara Tesorieri, and Cormac McSparron. 2010. *INSTAR The People of Prehistoric Ireland, Progress Report Phase 2: Synthesis of Osteological, Contextual & Chronological Data Relating to Irish Prehistoric Human Remains*. Unpublished report. Queen's University Belfast/University College Cork, Belfast/Cork.

Nilsson Stutz, Liv, and Ian Kuijt. 2014. Perspectives–Reflections on the Visibility of Cremation as a Physical Event. In *Transformations by Fire: The Archaeology of Cremation in Cultural Context*, edited by Ian Kuijt, Colin P. Quinn and Gabriel Cooney. The University of Arizona Press, Tuscon, pp. 143–147.

Núñez, Milton, and Kerstin Lidén. 1997. Taking the 5000 Year Old "Jettböle Skeletons" Out of Their Closet: A Palaeo-Medical Examination of Human Remains from the Åland (Ahvenanmaa) Islands. *International Journal of Circumpolar Health* 56(1–2):30–39. DOI: 10.1177/1465712002005001170.

O'Donnell, Lorna. 2016. The Power of the Pyre – A Holistic Study of Cremation Focusing on Charcoal Remains. *Journal of Archaeological Science* 65:161–171. DOI: 10.1016/j.jas.2015.11.009.

O'Kelly, Michael J. 1982. *Newgrange: Archaeology, Art and Legend*. Thames and Hudson, London.

Oestigaard, Terje. 1999. Cremations As Transformations: When the Dual Cultural Hypothesis Was Cremated and Carried Away in Urns. *European Journal of Archaeology* 2(3):345–364. DOI: 10.1177/146195719900200304.

Oestigaard, Terje. 2005. *Death and Life-Giving Waters: Cremation, Caste, and Cosmogeny in Karmic Traditions*. BAR International Series 1353. Archaeopress, Oxford.

Outram, Alan K. 2001. A New Approach to Identifying Bone Marrow and Grease Exploitation: Why the "Indeterminate" Fragments Should Not Be Ignored. *Journal of Archaeological Science* 28:401–410. DOI: 10.1006/jasc.2000.0619.

Outram, Alan K., Christopher J. Knüsel, Stephanie Knight, and Anthony F. Harding. 2005. Understanding Complex Fragmented Assemblages of Human and Animal Remains: A Fully Integrated Approach. *Journal of Archaeological Science* 32:1699–1710. DOI: 10.1016/j.jas.2005.05.008.

Oxford English Dictionary. 2016. *'† ex'carnate, v.'*. Oxford University Press, OED online (http://www.oed.com), accessed 6 June 2016.

Parker Pearson, Mike. 1999. *The Archaeology of Death and Burial*. Sutton Publishing, Stroud.

Quinn, Colin P., Lynne Goldstein, Gabriel Cooney, and Ian Kuijt. 2014. Perspectives–Complexities of Terminologies and Intellectual Frameworks in Cremation Studies. In *Transformations by Fire: The Archaeology of Cremation in Cultural Context*, edited by Ian Kuijt, Colin P. Quinn and Gabriel Cooney. The University of Arizona Press, Tuscon, pp. 25–32.

Rebay-Salisbury, Katharina. 2012. Inhumation and Cremation: How Burial Practices are Linked to Beliefs. In *Embodied Knowledge: Historical Perspectives on Belief and Technology*, edited by Marie Louise Stig Sørensen and Katharina Rebay-Salisbury. Oxbow, Oxford, pp. 15–26.

Reichs, Kathleen J. 1998. Postmortem Dismemberment: Recovery, Analysis and Interpretation. In *Forensic Osteology: Advances in the Identification of Human Remains*, edited by Kathleen J. Reichs. 2nd ed. Charles C. Thomas, Springfield, IL, pp. 353–388.

Reilly, Stuart. 2003. Processing the Dead in Neolithic Orkney. *Oxford Journal of Archaeology* 22(2):133–154. DOI: 10.1111/1468-0092.t01-1-00002.

Renfrew, Colin. 1979. *Investigations in Orkney*. Society of Antiquaries of London, London.

Robb, John, Ernestine S. Elster, Eugenia Isetti, Christopher J. Knüsel, Mary Anne Tafuri, and Antonella Traverso. 2015. Cleaning the Dead: Neolithic Ritual Processing of Human Bone at Scaloria Cave, Italy. *Antiquity* 89(343):39–54. DOI: 10.15184/aqy.2014.35.

Scarre, Chris. 2007. *The Megalithic Monuments of Britain and Ireland*. Thames & Hudson, London.

Scarre, Chris. 2010. Rocks of Ages: Tempo and Time in Megalithic Monuments. *European Journal of Archaeology* 13(2):175–193. DOI: 10.1177/1461957110370731.

Scarre, Chris. 2011. *Landscapes of Neolithic Brittany*. Oxford University Press, Oxford.

Scheuer, Louise, and Sue Black. 2000. *Developmental juvenile osteology*. Academic Press, London.

Shee Twohig, Elizabeth. 2004. *Irish Megalithic Tombs*. Shire Publications, Princes Risborough.

Shee Twohig, Elizabeth, Corinne Roughley, Colin Shell, Ciarán O'Reilly, Peter Clarke, and Gillian Swanton. 2010. Open-air Rock Art at Loughcrew, Co. Meath. *The Journal of Irish Archaeology* 19:1–28.

Shipman, Pat, Giraud Foster, and Margaret Schoeningen. 1984. Burnt Bones and Teeth: An Experimental Study of Color, Morphology, Crystal Structure and Shrinkage. *Journal of Archaeological Science* 11:307–325. DOI: 10.1016/0305-4403(84)90013-X.

Sigvallius, Berit. 1994. *Funeral pyres: Iron Age cremations in North Spånga*. Theses and Papers in Osteology 1. Stockholm University, Stockholm.

Sjøvold, Torstein. 1988. Geschlechtsdiagnose am Skelett. In *Anthropologie: Handbuch der vergleichenden Biologie des Menschen. Band I: Wesen und Methoden der Anthropologie. 1. Teil: Wissenschaftstheorie, Geschichte, morphologische Methoden*, edited by Rainer Knußmann. Gustav Fischer Verlag, Stuttgart, pp. 444–480.

Smith, Martin. 2006. Bones Chewed by Canids as Evidence for Human Excarnation: A British Case Study. *Antiquity* 80:671–685. DOI: 10.1017/S0003598X00094126.

Smyth, Jessica, ed. 2009. *Brú na Bóinne World Heritage Site: Research Framework*. The Heritage Council, Dublin.

Szilvássy, Johann. 1988. Altersdiagnose am Skelett. In *Anthropologie: Handbuch der vergleichenden Biologie des Menschen. Band I: Wesen und Methoden der Anthropologie. 1. Teil: Wissenschaftstheorie, Geschichte, morphologische Methoden*, edited by Rainer Knußmann. Gustav Fischer Verlag, Stuttgart, pp. 421–443.

Thompson, Tim. 2009. Burned Human Remains. In *Handbook of Forensic Anthropology and Archaeology*, edited by Soren Blau and Douglas H. Ubelaker. Left Coast Press, Inc., Walnut Creek, CA, pp. 295–303.

Thompson, Tim. 2015. Fire and the Body: Fire and the People. In *The Archaeology of Cremation: Burned Human Remains in Funerary Studies*, edited by Tim Thompson. Oxbow Books, Oxford, pp.

Thurman, Melburn D., and L. James Willmore. 1981. A Replicative Cremation Experiment. *North American Archaeologist* 2(4):275–283. DOI: 10.2190/29A5-84ED-4MB8-EP3M.

Tilley, Christopher. 1996. *An Ethnography of the Neolithic: Early Prehistoric Societies in Southern Scandinavia*. Cambridge University Press, Cambridge.

Ulguim, Priscilla Ferreira. 2015. Analysing Cremated Human Remains from Southern Brazilian Highlands: Interpreting Archaeological Evidence of Funerary Practice at Mound and Enclosure Complexes in the Pelotas River Valley. In *The Archaeology of Cremation: Burned Human Remains in Funerary Studies*, edited by Tim Thompson. Oxbow Books, Oxford, pp. 173–212.

Wahl, Joachim. 1982. Leichenbranduntersuchungen: Ein Überblick über die Beartbeitungs- und Aussagemöglichkeiten von Brandgräbern. *Prähistorische Zeitschrift* 57(1):1–125.

Walker, Phillip L., Kevin W. P. Miller, and Rebecca Richman. 2008. Time, Temperature, and Oxygen Availability: An Experimental Study of the Effects of Environmental Conditions on the Color and Organic Content of Cremated Bone. In *The Analysis of Burned Human Remains*, edited by Christopher W. Schmidt and Stevens A. Symes. Elsevier, Amsterdam, pp. 129–135.

Walsh, Samantha, Christopher Knüsel, and Nigel Melton. 2011. A Re-Appraisal of the Early Neolithic Human Remains Excavated at Sumburgh, Shetland, in 1977. *Proceedings of the Society of Antiquaries of Scotland* 141:3–17.

Whittle, Alasdair W. R. 1996. *Europe in the Neolithic: The Creation of New Worlds*. Cambridge University Press, Cambridge.

Figure 1. Map of the location of the megalithic monuments at the Carrowkeel passage tomb complex.

Figure 2. Photograph of Cairn F, taken during the 1911 excavation. Courtesy of the Ulster Folk and Transport Museum, Green Collection.

Figure 3. Cut-marks, marked in white (above) and magnified (below), observed on a first rib from Cairn H (a) and a cervical vertebra from Cairn K (b).

Figure 4. Cut-marks, marked in white (above) and magnified (below), observed on a left humerus from Cairn K (a), the ilium of a left coxae from Cairn K (b) and a right femur from Cairn K (c).

Figure 5. Illustration of the anatomical location and distribution of cut-marks on re-associated foot bones from Carrowkeel (unknown tomb context), involving a minimum of one left foot (a = dorsal aspect; b = medial aspect) and one right foot (c = dorsal aspect; d = plantar aspect). Shaded elements illustrate the bones that could be re-associated, and the darker shade the bones with evidence of cut-marks. Illustration by Robert McPhee.

Figure 6. The relative fragmentation and photograph of the unburnt adult human bone sample from Carrowkeel, by skeletal elements per anatomical region, expressed in ratios between weight per fragment (W:NISP) and number of fragments per minimum number of elements (NISP:MNE). The category ‘Total’ includes all elements for each anatomical region.