BOGGED DOWN: HUMAN PRESERVATION AND DECOMPOSITION. USING FORENSIC SCORING METHODS TO ASSESS THREE BOG BODIES FROM DENMARK, ENGLAND & IRELAND

MASTERS IN ARCHAEOLOGY: THEORY AND PRACTICE

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TABLE OF ABBREVIATIONS

ADD - Accumulated Degree Days

ADT - Average Daily Temperature

ATP - Adenosine Triphosphate

BADS - Body Aquatic Decomposition Score

BBSM - Bog Body Scoring Method

FADS - Facial Aquatic Decomposition Score

FSM - Forensic Scoring Method

LADS - Limbs Aquatic Decomposition Score

PMI - Post-Mortem Interval

TADS - Total Aquatic Decomposition Score

TDS - Total Decomposition Score

TSD - Time Since Death

DEDICATION

I would like to dedicate this work to my beloved Nanna, who sadly passed away in August 2020 and who I miss every day.

My Nanna was there to see me graduate from Durham University with my BA Honours Archaeology degree and, although she will never get to see me complete this Masters programme in the field that means the world to me, she has been on my mind and in my heart every step of the way – ‘shy bairns get nowt’.

Mary Clyburn
1936-2020

ACKNOWLEDGEMENTS

I would like to acknowledge and give thanks to my family and friends near and far, without who I would have been lost many times during the process, especially to my parents and my closest friends. Extra special thanks to my Mam for her unconditional, unwavering support, and her encouragement in anything and everything I do, and to my fiancé David for his constant kindness, patience, understanding and his total support on a daily basis. A little extra acknowledgement to our little Nala, who was a light in my day and who we miss very much.

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ABSTRACT

This work looks at three case studies from bog body research in Denmark, England and Ireland in order to investigate the variation of human decomposition in different depositional environments and the application of forensic methods to the area of bog body research in archaeology. The work attempts to assess the chosen case studies using an established forensic scoring method by Heaton et al (2010) and discusses the possible benefits of using an appropriately adapted scoring method for bog body research.

The work discusses the importance of increasing the general knowledge of the human body itself and human decomposition or human taphonomy in archaeology, as well as contextual knowledge regarding the depositional environment itself. Our field constantly strives to develop knowledge of the human past and to build on our understanding and interpretations of the lives of past peoples, which also inevitably includes the process of death and any associated burial practices and/or other mortuary traditions.

This paper concludes that that there is a considerable variation in both the availability of adequate training opportunities in forensic techniques in archaeology and in terms of the analyses carried out on bog body remains. In order to effectively excavate, analyse and develop interpretations from human remains, this paper concludes that all practicing archaeologists should have at least a basic understanding of the human bodies through which those lives (and deaths) took place and how the preservation and decomposition of those bodies and the material culture they leave behind can vary considerably dependent on the composition of the depositional environment. The work concludes that the creation of a bog body research database and a specific bog body scoring method through which to assess bog bodies and decomposition in archaeology could be useful, and proposes a further wide-scale quantitative research project to assess whether this could indeed prove beneficial in practice.

Key words: bog bodies, bog body research, human remains, Denmark, England, Ireland, forensics, decomposition, preservation, taphonomy, depositional environment.

TW / TRIGGER WARNING:

As per the title, this work contains images of human decomposition.

Images of the recently deceased and selected stages of decomposition are shown on the following pages:

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Images of the long deceased, skeletal material, partial remains and bog bodies are shown on the following pages:

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1. INTRODUCTION

1.1. General introduction

This work aims to contribute to knowledge regarding human decomposition and varying preservation states of human remains in archaeological contexts, specifically that of the bog environments in Northern Europe. The work will consider if and/or how the application of some methodologies from forensics, such as an adapted forensic scoring method, could be used in the field of archaeology. In the field of archaeology, we are continually working with notions and interpretations of the human past, analysing material culture and artefacts, trying to analyse past human societies and what it meant to be human within those societies, and yet during education programmes in archaeology, we generally learn so little regarding the human body itself; the bodies in which all the thoughts we have occur, the bodies from which our actions and behaviours take place, and the bodies in which everything that makes up our human life itself took and takes place within. Archaeology endeavours to continually develop knowledge and build further understanding on the human past, actions, behaviours and material culture. Yet, from personal experience and from the research for this work, without following a specific education in forensic medicine, biological anthropology or anatomical sciences, or specialising in human osteology as part of a wider archaeological education, the curriculum can vary and we can learn so little about uncovering human remains as part of an archaeological excavation, and the potential impact of various depositional environments on those human remains. Additionally, as argued by Chapman et al (2019), the focus in bog body research history has largely been on the remains themselves and the “environmental setting of the finds has been largely overlooked” (2019, 227), yet knowledge and understanding of the contextual environment itself, both in terms of the physical and cultural significance, should have paramount importance alongside the human remains. When excavation inevitably makes up at least some degree of work in archaeology, this paper will argue that increased general knowledge in the area of the human body during its lifetime, human remains after death and the impact of various depositional environments on those remains should not only be increased, but should actually form an integral part of any education in archaeology.

The field of bog body research is wide-ranging, both geographically and in terms of the techniques used to analyse the human remains which were placed into the watery depths of the bog. The research history shows that the preservation and decomposition level of those human remains is also variable, with some bodies found incredibly preserved in terms of skin, hair and clothing, still able to show the injuries and/or pathologies they faced during their lifetimes, others found preserved as bog skeletons devoid of soft tissues, or anywhere in between. Osteological expertise can of course enable analysis of bog skeletons or any other such human skeletal remains, but the presence of flesh or other soft tissues may actually hinder such analyses from taking place (Asingh & Lynnerup 2016, 87). Bog bodies are incredible examples of human remains that allow us to gain a glimpse into the human past that many other human remains do not, largely thanks to the special environmental conditions that past peoples chose to place these individuals into (van der Sanden 1996). Each bog body is unique, each case having a different degree of preservation and with different analyses carried out on the remains after the bodies have been uncovered. Where human osteology has several internationally used methods with which to assess skeletal material, for example the standards developed by Buikstra and Ubelaker (1994), there are no specific methods found through which bog bodies specifically are assessed. Although the finding of bog bodies may be sporadic or even rare, there have been over 500 cases of bog bodies found in Denmark alone (National Geographic 2014); bog bodies are a specific kind of human remains which arguably, should have a specific analytical method through which they can be assessed, should these remains be uncovered accidentally, or as part of an archaeological excavation.

Similar to osteological analysis on ancient human remains, finding recent human remains is assessed through specific sets of analytical methods. Alongside forensic pathologists, forensic anthropologists work with “the application of the science of physical anthropology to the legal process in order to identify human remains and assist in the detection of crime” (FASE, 2021) and forensic archaeologists may be employed “in cases involving buried human remains and buried evidence that is related to crime” (FSS, 2021). Although ancient remains in a solely archaeological context are usually far beyond the scope of a legal or criminal investigation due to their age, many of the techniques and methods used by archaeologists are applicable to the field of forensics (as seen in forensic archaeology) and vice versa. When osteological analyses can analyse archaeological human skeletal material through established methods, bog bodies present a somewhat unusual case – how can we assess ancient remains that retain flesh, and through what methods can such remains be analysed?

The analysis of each bog body case is dependent on where it was found, who has been investigating each case and what the overall degree of preservation and decomposition of the human remains actually leaves preserved enough to be analysed as part of the investigation. Upon the discovery of such remains, archaeologists will inevitably work with many other specialists both within the field itself and with others via interdisciplinary and transdisciplinary collaboration, to ensure the remains are treated, preserved and analysed. Whilst the bog body research history is an incredibly rich source of information that can be incredibly educative, can rehumanise these past peoples beyond their seemingly violent deaths and can provide a fascinating insight into some aspects of a past society, it also results in a research history that is highly variable between cases of bog bodies, with each set of analyses being highly specific and individual. This perhaps leaves the bog body research history somewhat fragmented and arguably a little difficult when attempting to compare examples with one another.

Within this context, this work aimed to analyse three case studies from the bog body research history, with one case study each from Denmark, England and Ireland, using an established technique from forensic science – the forensic scoring method. The work aimed to use this as an opportunity to contribute to the overall research history regarding human decomposition by looking at how deposition into the bog affected the overall human decomposition and preservation process, i.e. the taphonomy of the body (Duday et al 2009, 13), and how decomposition in the bog compares to examples from the literature regarding burials in soils, in aquatic environments and in ground surface decomposition. The work aimed to discuss whether a forensic scoring method used for assessing human remains in forensic cases could have any potential benefit for archaeology, if appropriately adapted to the needs and requirements of bog body research.

1.2. Bog bodies – a brief research history

This chapter aims to give a relatively brief overview of bog body research in each of the case study countries of Denmark, England and Ireland, and information regarding the methods applied to bog body research in these countries. There are several works which synthesise and give an overview to the general bog body research history at various points (e.g. Glob 1969; Coles & Coles 1989; Sanders 2009; Lynnerup 2015; Aldhouse-Green 2015; Giles 2020, etc) therefore, this chapter will instead aim to discuss just some of the ‘finds’ for each country rather than covering every single example, with reference to some of the varied analyses and methods used to assess the remains.

1.2.1. Denmark

Denmark has an extensive history of bog body research, with one of the highest concentrations of bog bodies found across Northern Europe. As such, just some of the cases will be discussed here, not only due to the number of bog bodies found in Denmark, but also as the amount of published research literature on such bog bodies varies considerably, with some cases being comprehensively covered (e.g. Tollund Man) and some having little to no published research at all (Nielsen, Christensen & Frei 2020). According to Glob (1969, 66) reports of finds of bog bodies in Denmark began on Fyn as early as 1773. The first highly publicised find in the country was the remains which are now known as Haraldskjær Woman, found in late 1835 by peat-cutters near Vejle in south-eastern Jylland. Her remains were preserved with skin, teeth, woollen textiles, a cape and her long hair. Although it was almost immediately refuted (Worsaae 1842) it was suggested after her excavation that she was “the Viking queen Gunhild from Norway, who was to marry the Viking king of Denmark, Harald Bluetooth, but who instead was killed and cast into a bog” as per the Icelandic Sagas (Frei et al 2015). Despite being uncovered a considerable time ago in 1835, the remains have undergone considerable testing, including radiocarbon dating in 2010 (which cemented these remains as c.500-1 BC - Mannering et al 2010) and strontium isotope analysis from teeth and hair in 2015 (Frei et al 2015) to investigate the provenance of this woman. Fræer Mose ‘Woman’ was discovered several years later in 1842 in north Jylland. Unlike the Haraldskjær Woman, the remains found in 1842 consisted of just one preserved foot, alongside a leather shoe and woollen textiles (Glob 1969, 81-82). In contrast to the Haraldskjær Woman, there is very little published information on this find, but published work does include a later confirmation of the foot as male. After measurement, visualisation and assessment of the calcaneus, and a forensic anthropological regression analysis, the results showed that the foot was more likely to have been from the remains of a biological male rather than female individual (Lynnerup 2015, 1009; Introna et al 1997; Gualdi-Rosso 2007).

Stidsholt Woman was found in 1859 also in the area of northern Jylland, around 70km north of the location in which the Fræer Mose foot was located. These remains were also partial, with just a decapitated head complete with hair found preserved in Stidsholtmose. The Stidsholt Woman remains on display in Nationalmuseet (fig.1). Very little published research could be found for the Stidsholt Woman, other than a C14 date of 2240 ± 36 BP (Mannering et al, 2009) and the creation of a 3D model of the Stidsholt Woman’s head (Nosch & Mannering, 2014).

Fig. 1 - Stidsholt Woman, own photo

Fig. 2 – Roberto Fortuna/Nationalmuseet (2021) - Huldremose Woman

Huldremose Woman (fig.2) was uncovered at Ramten during peat-cutting in central Jylland in 1879, preserved as an almost whole body, with one disarticulated arm, and with an accompanying set of clothing and two capes. These remains were initially thought to be much more recent and were removed from the peat bog and inspected by the local authorities, including the police force, a medical doctor and a pharmacist (Gleba & Mannering, 2010, 15), likely one of the first instances of Danish bog bodies to undergo an initial forensic-style investigation. However, after this initial inspection, it soon became clear that the remains were ancient and the remains were reburied in a local churchyard. Nationalmuseet requested the remains to be uncovered once again and they were duly handed over for preservation, the first set of complete bog body remains acquired by the museum (Mannering 2010, 15).

Auning Woman was discovered in 1886 in central Jylland with her skull broken into several pieces due to taphonomic change in the bog. With the preservation methods not at all at the standard we know of and practice in modern archaeology and conservation, her skull was stuffed, leaving it misshapen and damaged (Persson 2018). However, despite this, the development of CT scanning was later able to provide a forensic facial reconstruction of the woman (Lynnerup 2015, 1010) (see fig.3).

Fig. 3 - Auning Woman - Lynnerup (2015) facial reconstruction

Nederfrederiksmose Man or Kraglund man was unearthed in 1898, also in the Jylland area around modern Silkeborg. This was the first ever Danish bog body to be photographed in-situ (see fig.4) and he was found to be well-preserved along with hair, beard, leather boots and textiles, including a woollen coat.

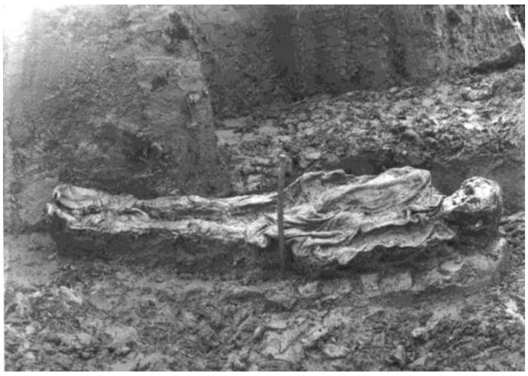

Fig. 4 - Nationalmuseet (2021) - Nederfrederiksmose Man in-situ

1913 marked the first experimental investigation of a bog body in Denmark by the Danish forensic pathologist, which focused on the preservation of human remains in the bog (Asingh & Lynnerup 2016, 86). This work showed how peat tans the skin and soft tissues, identified that sphagnum acid was a key element in this process and that lower temperatures aided in the prevention of decay via putrefying bacteria. Several other Danish bog bodies were found in the ensuing years, including Elling Woman in 1938, Gadevang Man in 1940 and Rappendam Woman in 1941. 1941 also saw the discovery of what was termed ‘Koelbjerg Woman’ on the land of a farm on Fyn, remains which are now known to be the oldest bog body or skeleton, and the oldest set of bones ever found in Denmark (Odense Bys Museer, 2021). The remains saw an initial visual assessment and they have since seen somewhat extensive analysis since then. This has included osteological and palaeopathological assessment, which revealed an individual in general good health with some tooth decay, and a strontium isotopic analysis which revealed the individual likely was born, grew up and died on Fyn. Early DNA analysis was not successful, but this was re-attempted in 2016 and showed that the individual was biologically male (Hansen et al 2017). Other key bog bodies found in the first half of the 20th century include Arden Woman (Ravn 2011), Roum Man (Ashby 2016), Søgårds Man I (van der Sanden 1996) and the Sorø Skeletons in 1942, Søgårds Man II in 1944 (Berghe, Gleba & Mannering, 2010), Borremose Man (Walsh et al 2020) and Porsmose Man in 1946 (Thrane 2006), Borremose II in 1947 (Munksgaard 1984), Borremose Woman in 1948 (Munksgaard 1984; Villa, Møller & Lynnerup 2011; Lynnerup 2015) and the Sigersdal Skeletons in 1949 (Bennike et al 1986). Tollund Man was found in 1950 at Bjældskovdal near modern Silkeborg and his remains were so well-preserved that the peat cutters who found his body reported it to the police, thinking it was a recent murder victim but, as there were no signs of recent digging upon inspection, the case was referred to the Silkeborg Museum (Museum Silkeborg 2021 [2]). Since their excavation, the remains of Tollund Man have become some of the most well-known in terms of bog bodies and has been subjected to many analyses which have included, but are not limited to, an AMS C14 date of 405-380BC and stable isotopic analyses in Denmark (Museum Silkeborg 2021), and more recently a series of medical examinations via CT scanning by French anthropologists which revealed small dots on the base of his feet, which have since been interpreted as small wart-like lesions (Charlier et al 2017). Just two years later, Grauballe Man, which will be the first of the case studies covered for this work, was discovered around the same area of Jylland and these remains also underwent similar analyses to Tollund Man during the same process. At this time, Grauballe Man was immediately identified as a bog body rather than a forensic case, due to Tollund Man's recent and much publicised discovery and to follow this, Grauballe Man underwent almost immediate display to the public (fig.15). Pathologies and stomach contents were analysed by Helbæk, along with an initial C14 and pollen analysis (Helbæk 1958).

Several of these remains found in Denmark underwent analyses after their discovery which have since been followed up with further analyses with new methods (e.g. Tollund Man and Grauballe Man), yet others have seen less research interest in general (Nielsen, Christensten and Frei 2020). The bog body research history in Denmark highlights that, whilst the bog bodies are varied and the appropriate analyses for each case will be somewhat different, there is methodological way of assessing bog bodies at all, despite their relative frequency. This makes each case so individualistic that making comparisons can be somewhat difficult, suggesting that a more methodological way of assessment could prove beneficial.

1.2.2. England

The United Kingdom has also seen a number of bog bodies be unearthed, also usually in the course of peat-cutting work, though this is not quite to the same extent as seen in Denmark. As this paper focuses specifically on England as one of the case study areas and not the entire UK, any bog bodies, skeletons and partial remains from other countries within the UK (i.e. Wales, Scotland and Northern Ireland) will not be discussed here. The first reported bog body found in England is that of Amcotts Moor Woman who found in 1747 in a bog near Amcotts in North Lincolnshire, around 7 miles north of modern Scunthorpe by the River Trent. The body once again was found by a local peat-cutter and is reported to have been damaged in the finding, where the peat-cutter accidentally cut off one foot which still wore a sandal (SYAS 1878). The body was inspected by a medical doctor and his assistant, who remarked that both the skin and the leather were "both tanned by the black water" and that her bones were entirely black and soft, yet the skin was preserved (SYAS 1878). The remains were later buried in a churchyard, but the shoe was rediscovered and was then regarded as "the first shoe, recovered by excavation, to have been subsequently preserved in an antiquarian collection" (Turner & Rhodes 1992) (fig.5).

Fig. 5 - Turner & Rhodes (1992) - Amcotts Moor Woman shoe

In 1850, a "remarkably well-preserved" bog body was found on Grewelthorpe Moor in North Yorkshire (Turner, Rhodes & Wild 1991, 191). The remains were found to be male and wearing brightly dyed woollen clothing and leather shoes, which were determined to be Roman in appearance. The police were duly called to the scene, however, much like the Amcotts Moor Woman, the actual remains themselves were never dated or analysed further than this initial visual inspection but were instead reburied in a churchyard in Kirkby Mazeard, with just the woollen textiles and leather shoes remaining, a reappraisal analysis was carried out confirming their Romano-British origin (Turner, Rhodes & Wild 1991).

Worsley Man, which will be the second case study considered for this paper, was found on Astley Moor just outside of modern Manchester in 1958. Unlike some of the previous examples of bog bodies from both England and Denmark, these remains were just a skull with just 20% skin coverage and preserved hair. Despite the little amount of remains, the preserved material has been able to generate a rather considerable level of research (Garland 1995; Denton 2003; Giles 2020) including 4 different periods of analysis and a facial reconstruction (fig.34).

Likely the most well-known examples from the bog body research history of England and "the first British bog bodies to be studied extensively" (Turner & Scaife 1995, 10) are that of the Lindow bodies: Lindow I or Lindow Woman, Lindow II or Lindow Man and Lindow III, all found on Lindow Moss in Cheshire in 1983, 1984 and 1987 respectively. The remains of Lindow Woman were, like so many other bog bodies, uncovered by commercial peat-cutters who, in this case, found a human skull which was missing the mandible but also still retained its skin, hair, preserved brain matter, the remnants of one eyeball and its associated optic nerve (Turner & Scaife 1995, 12). As a local man was suspected of murdering his wife at the time, a thorough forensic investigation was carried out on the remains which identified the remains as that of a European woman 30 to 50 years old which initially led them to believe this was his murdered wife, however a C14 analysis showed the remains to be 1740±80 BP in 1983, dating the skull to the Roman period (Turner & Scaife 1995, 13). Following this in 1984, Lindow II or Lindow Man was discovered in the same area, initially as a preserved right foot, with the skin of the lower leg attached. As the case of the murder was still at this stage unresolved, the forensic work continued and the police were party to all excavation and analyses though, by 1987 and the discovery of Lindow III, the police were satisfied these cases were not related to the murder (Turner & Scaife 1995, 13-14) and the remains were left in the capable hands of the archaeologists. These three bog bodies are the most extensively covered examples from England, with each being C14 dated and pollen analysed (Branch & Scaife 1995; Housley et al 1995; Scaife 1995), undergoing stomach content analysis where possible (Holden 1995) and with DNA being extracted from Lindow II or Lindow Man (Spigelman et al 1995). As the 'star' of the English bog body excavations, Lindow Man (fig.6.) was dated to 2BC-AD119 and aged at around 25 years old at the time of his death (British Museum 2021). He was conserved in polyethylene glycol and freeze-dried, but there is a lack of standardisation for conservation methods applied to bog bodies and the chosen conservation method varies considerably between cases (Read & Bryan 2021). The method chosen in this case has resulted in a successful preservation outside of the bog environment but now is showing a change in Lindow Man's skin colour over time (Daniels 2019, 57). Analyses showed that Lindow Man lived in relatively good health beyond mild osteoarthritis and tooth caries, before receiving perimortem blows to the head along

Fig. 6 - British Museum (2021) - Lindow Man

with a possible stab wound and a garotte around his neck (British Museum 2021).

As per the Danish bog body research history, the finds from the English context mirror the same issue whereby each case is highly individual and comparing analyses between cases can be somewhat difficult. As Stevens and Chapman note (2020), as we date and analyse bog bodies, many of the comparisons can also negate to include what are regarded as the ‘paper bodies’, those who were reburied or lost since their initial finding, and that perhaps a more standardised and methodological approach that considers the wider scale comparisons between bog bodies could prove beneficial both going forward in English bog body research, and when attempting to reanalyse previous work through new methods.

1.2.3. Ireland

Similar to the UK, Ireland has several cases of bog bodies in the archaeological record, but not to the same scale as is seen in Denmark. As the Republic of Ireland and Northern Ireland are two separate entities, only the ROI finds will be discussed here and will be discussed as ‘Ireland’ from here on. As is common across the three case study areas, earlier examples of bog bodies were briefly visually inspected when found, before reburial in local churchyards. Mulkeeragh Man was found in Co. Cork in 1753. The remains were found to be wearing military uniform and the remains were reburied. There is very little information regarding this find due to the general lack of analyses before his reburial. Gallagh Man was found in Co. Galway in 1821 during peat-cutting and was initially in a remarkable state of preservation. Unfortunately, the property owners who found the remains repeatedly reburied and uncovered the body for several years, charging locals a small fee to take part in the excavation (Irish Archaeology 2015). This mishandling resulted in the poor preservation level of the remains seen today (fig.7). The remains were uncovered with a garotte of ‘withies’ or willow around his neck (Archaeology Ireland 2006; van der Sanden 1996, 73) and a preserved cape around his lower body made from deerskin. The body was thought to have been pinned down to the bottom of the bog by wooden pegs found either side of the remains (Delaney 2006, 99). Analyses showed he was estimated at 20-25 years old at the time of his death based on osteological analyses (Kelly 2012).

Fig. 7 - Healey (2011) - Gallagh Man at the National Museum of Ireland

Stoneyisland Man was found in 1929, also in Co. Galway. The remains were uncovered by peat-cutters in a completely skeletonised condition. Initially, it was thought that these were the remains of a missing-presumed-murdered local man and the police were involved. However, a subsequent analysis showed that the remains were actually dated to c.3320-3220BC, making the skeletonised remains more than 5000 years old. As a result, Stoneyisland man became the oldest bog body found in Ireland (Ó Floinn 1995, 221-234). Kinakinelly Man was also found in the same region of Ireland in 1952, but very little published research was found to be available for this find, other than the remains having been dated to 200-100BCE and having been buried with the bones of a red deer (Ó Floinn 1995).

Fig. 8 - Healey (2011) - Baronstownwest Man, National Museum of Ireland

Baronstown West Man was found in Co. Kildare in 1953 and is currently on display at the National Museum of Ireland (fig.8). His remains were found to be in a mostly skeletal condition, with some skin and soft tissues remaining on the pelvis and legs, which were dated to 424-388CE. Hazel or birch branches were found with the body, as well as textiles and a leather cloak (van der Sanden 1996; Kelly 2012).

Derrymaquirk Woman, found in 1959 in Co. Roscommon as the skeletal remains of a woman along with bone fragments of a young infant. The woman was found to be aged 20-25 years old at the time of her death and her remains were C14 dated to 750-200BCE. (van der Sanden 1996; Kelly 2012). Meenybradden Woman was found in 1978 in Co. Donegal and was also estimated to be c.25 years old at the time of her death. The remains were C14 dated to 1050-1420CE, but were interestingly found wrapped inside a cloak which was thought to be around 500 years younger than the age of the body itself, which has raised discussion regarding whether the remains were indeed wrapped in a cloak much younger than the remains, or if this is the result of an issue with the C14 method used (Ogilvie 2020). Clonycavan Man was found in 2003 in Co. Meath, this will be the final of the three case studies for this work. Discovered as just a head and torso – no post-abdominal remains were ever found. He was not discovered in the ground but was found in a peat cutting machine. He was found to be of a small stature but had a distinctive hair style using hair gel from southern Europe. This was interpreted as being a sign of his power in his society, to have the means through which to obtain such goods. Likely one of the two more well-known examples from the Irish bog body research history, Old Croghan Man was found in

Fig. 9 - National Museum of Ireland (2021) - Old Croghan Man's hand

Co. Offaly mere months after Clonycavan Man was found in 2003. His remains were found as just a torso and arms, and no head or abdominal remains were uncovered (fig.9 & 10).


Fig. 10 - Old Croghan Man

After finding the Clonycavan Man and Old Croghan Man in quick succession, the Bog Bodies Research Project was set up in 2003 to scientifically examine and document the remains using a multidisciplinary team of 35 international experts, including CT and MRI scans, palaeodietary analysis, fingerprint analysis, histological analysis and pathologies analyses (National Museum of Ireland 2021).

Subsequently, Clonycavan Man was found to be male and C14 dated to 392-201BCE, and Old Croghan Man found to be dated to 362-175BCE. The Derrycashel bog body was found in Co. Roscommon in 2005 as almost completely skeletonised remains. Dated to 1431-1291BCE, the remains showed no clear signs of violent death as is common in many other examples of bog bodies (Kelly 2012, 10). Clonshannagh Woman was found in Co. Dublin in 2005, as the completely skeletonised remains of a female that were also damaged by peat cutting machinery. The remains were C14 dated to 645-680CE (Kelly 2012). Derryvarroge Man was found in Co. Kildare shortly after in 2006 and was found to be a male dated to 228-343CE. Opposite to the other partial remains found in Ireland, the remains actually only included the buttocks and a leg (Mulhall 2019). Most recently, Cashel Man was uncovered in 2011 and has since become the most well-known of the Irish bog bodies. This is both due to the age of the remains and the degree of preservation in which the remains were found, after being found by peat-cutting workers and a subsequent investigation by archaeologists and conservators from the National Museum of Ireland (Kelly 2012). He was found in Co. Laois, originally found as “a pair of legs below the knee, and a torso” with two hazel stakes marking his deposition, crossing his head (Kelly 2012, 9). The Cashel Man was dated to 2000BCE, the Irish Bronze Age, becoming the oldest of the fleshed Irish bog bodies (Current Archaeology News, 2011). He was found buried in a crouched position, with a broken arm and his spine broken in two places (Kelly 2012, 9), likely due to blunt force trauma. Though his skull and left arm were initially missing, parts of them were later found around the area the peat-cutting machines were working and were found to have short, cropped hair. The man is estimated at around 25 years old when he died.

The research history here, though brief, highlights that the bog bodies across each of the case study areas have been found at various times, in various degrees of decomposition, preservation and/or damage, and the analyses carried out can vary considerably as can the volume and availability of published research material. A bog body-specific scoring method and a dedicated accessible database for bog body research could prove beneficial.

1.3. Death as a beginning: the process of human decomposition

Death is defined in general terms as “the action or fact of dying or being killed; the end of the life of a person or organism” (Lexico, 2021). With regard to human life specifically, there are many ethical, religious and cultural variations in what ‘death’ actually means and for this reason, it is the clinical and biomedical determination of ‘death’ which will be used from here on. Within that perspective, death can be seen both as a process, defined by a permanent and irreversible loss of consciousness and the cessation of all vital functions in the body that life depends on as a whole (WHO 2012, iii) *and* as a specific momentary event within that process, whereby a person “passes from the state of being alive to that of being dead” (WHO 2012, 11).

Vital functions are determined as those “necessary for sustained life” (WHO 2012, 12) and include all circulatory, neurological, respiratory and cardiac functions, the collective and permanent cessation of which equate to death of the whole organism. This leads to the immediate commencement of biological events known as early post-mortem changes and the various stages of decomposition, a process through which the incredibly complex organic entity that is the human body breaks down.

Decomposition can be a highly variable process determined by many factors, both those internal and specific to the body and/or external factors (Duday et al 2009, 8). These include, but are not limited to: the age of the individual; the general health status of the individual; body mass index; amount of clothing coverage or lack thereof and the consequent exposure to the external elements of the environment; the location of death and deposition e.g. in/on soil, water, open air, etc. and factors related to those specific environments, e.g. the temperature, climate, humidity and moisture levels in the environment of death; any antemortem or perimortem trauma; entomologic activity or lack thereof, and so on (Heaton et al 2010; Tumer et al 2013; De Donno et al 2014; Ceciliason et al 2017; Collins et al 2020; Alfsdotter & Petaros 2021).

Taphonomy can therefore be understood as anything and everything that affects an organism from the time of death, to the time it is discovered / uncovered, whether that is via archaeological excavation, by accident, or other; defined as “the study of post-mortem processes with affect (1) the preservation, observation, or recovery of dead organisms; (2) the reconstruction of their biology or ecology; or (3) the reconstruction of the circumstances of their death” (Haglund & Sorg 1997, 13).

The processes of decomposition can be accelerated, slowed, or halted altogether as a result of any one or many of these factors concurrently, with many of them interrelated, and different areas of the body can decompose at different rates. The same human body can be exposed to different factors simultaneously, e.g. a body with covering on the feet, legs and torso but none on the arms or hands, or a body lying face down in water with the back side of the body exposed to the open air environment, both of which would result in differing states of decomposition on the differently exposed body parts of the same human remains.

Post-mortem change and the onset of the decomposition of the human body begin almost immediately at the point of death, as the body ceases its vital functions and the body’s metabolism grinds to a halt as oxygen ceases to be supplied to the body. These post-mortem changes and the process of decomposition take place via two processes: *autolysis*, which is essentially the self-destruction of the body whereby human tissues decay initially by internal enzymatic degradation through the self-digestion of cells and the organs; and via *putrefaction*, whereby tissues decay via external microbial and bacterial activity (Gelderman et al 2019, 122). Thus, autolysis is an internal or *intrinsic* process, whereas putrefaction is an external or *extrinsic* process.

When a human being is alive, the body as an organic entity exists in a general state of homeostasis, a stable, consistent environment supported by a range of functioning systems and maintaining a state of “dynamic equilibrium, despite changes in the external environment” (Libretti & Puckett, 2021). At the point of death, the state of homeostasis is of course disturbed and destroyed, with this instability leading to the beginning of widespread cell death and the complete structural breakdown of the systems themselves. Autolysis is defined by cell membranes of the body breaking down and enzymes which are usually contained within those cell membranes are released. These enzymes begin the self-digestive degradation of the surrounding cells and organs (Nadol & Burgess 1985; Forbes et al 2017). This intrinsic process triggers the onset of early post-mortem changes, livor mortis, rigor mortis and algor mortis (Hayman & Oxenham, 2016) before the onset of later post-mortem changes and the putrefactive decomposition of the body proper. An early post-mortem change evidencing the onset of autolysis is a white appearance of the cornea (Shedge et al, 2020).

Algor mortis is the process by which the human body begins to cool from the average initial temperature of 37.4°C to ambient temperature post-mortem, with an average cooling rate of 0.8°C per hour (Hayman & Oxenham 2016, 13 & 17). As the body ceases its metabolic activity and vital functions, the cadaver no longer produces this natural consistent heat. Heat loss from the body during the algor mortis stage is variable depending on a range of factors which can include those listed previously, with forensic studies indicating that one of the key factors for the process of algor mortis is the surrounding temperature of the environment at the point of death and/or the environment the individual was moved to or placed into shortly after post-mortem (Shapiro 1954; Henssge et al 1988; Kobayashi et al 2001; Al-Alousi et al 2002; Madea 2016; Alfsdotter & Petaros 2021).

Livor mortis, or post-mortem hypostasis, is generally defined by 'lividity' or the settling and the pooling of blood in the body due to gravity, as a result of the heart ceasing to pump blood and the blood remaining stagnant in the circulatory system. As the body begins to cool towards ambient temperature and the capillaries begin to constrict, the blood pools in the areas of the body most subjected to gravity.

Fig. 11 - Tsokos & Byard (2016) - livor mortis; clear pooling of blood due to gravity on the underside of the deceased

For example, an individual dying whilst laid on their back and not being subjected to being moved would result in a reddish-purple pooling of blood on the back of the body closest to the ground (fig.11), though not in the actual areas touching the ground due to what is termed 'contact blanching' or 'contact pallor' (Shedge et al, 2020) (fig.12 and fig.13). This stage can be variable but can become evident just 15 minutes after death, however, livor mortis most commonly commences around 2 hours post-mortem, with lividity becoming fixed within 4-6 hours (Hayman & Oxenham 2016, 5).

Fig. 12 - Tsokos & Byard (2016) - livor mortis; contact blanching showing outline of a pistol

Fig. 13 - Tsokos & Byard (2016) - livor mortis; contact blanching due to location of death

In a living human, the molecule adenosine triphosphate or ATP is essential to the average daily functionality of the body and is thus highly in demand. ATP is usually synthesised via aerobic cellular respiration in the mitochondria and is the main source of energy, both for use and for storage at the cellular level (Dunn & Grider 2021). On a daily basis in a living body, ATP assists with the proper function of most cellular processes, including neurological processes, chemical synthesis and muscle contraction, among others. For example, during vigorous exercise, lactic acid can build up in the engaged muscles which can cause stiffness and soreness, but it is ATP which helps to clear this lactic acid from the muscles and prevent it building up to a dangerous level known as lactic acidosis (Gunnerson, 2020).

Fig. 14 - Tsokos & Byard (2016) - rigor mortis; the body is rigid and stiff

After death, the muscles of the human body do not immediately become rigid but are usually able to retain some softness for a period of time due to the continued production of ATP through the process of anaerobic glycolysis. In its simplest terms, this is the process through which the body converts glucose into a usable and storable source of energy (i.e. ATP) despite a lack of oxygen. However, this anaerobic process is temporary as it relies on the body's stores of glucose and once these are depleted, ATP is no longer produced. Without ATP, muscles are unable to remain in their relaxed state, causing the entire body to contract and become rigid (fig.14 & 15.) (Hayman & Oxenham 2016, 2; Nilsson Stutz 2003, 143). As the stages are variable due to external factors, it is suggested that cooler temperatures can prevent the onset of rigor mortis (Kobayashi et al 2001) and can thus delay the average onset of decomposition in general.

Fig. 15 - Tsokos & Byard (2016) - rigor mortis; a body recovered from water with rigid hand still clasping leaves

Putrefaction is defined by a range of stages, from discolouration (initially pink/red to green/purple to black), abdominal and limb bloating due to a build-up of gases inside the body as a result of putrefactive bacterial decomposition, onset of skin slippage and the sloughing off of skin from the extremities and limbs, the eventual exposure of fat, organs, bones, and eventual disarticulation of the skeleton, and so on (Heaton et al 2010, 303-304). The discolouration stage of putrefaction is generally first seen on the stomach (fig.16) as a green-hued tone over the location of the right iliac fossa and the caecum, the pouch-like junction between the small and large intestines (Forbes et al 2017; Shedge et al 2020).

Fig. 16 - Tsokos & Byard (2016) - discolouration to the lower abdomen - image cropped & rotated from original

This green-hued tone eventually spreads to a greenish-blue hue covering most if not all of the body, which can also include marbling (see fig.17). As the cell membranes of the intestines are broken down and the self-digestive enzymes are released from within those membranes, the process also releases the natural anaerobic bacteria of the gut. Additionally, external bacteria and microbes can enter the body through the passageways of the respiratory system, via open wounds of injuries, or via other orifices. With the body's natural immune system responses now defunct and unable to initiate defence, these bacteria and microbes can grow and spread, breaking down the soft tissues of the gut as they use the body's natural carbohydrates and proteins as a food source. The process of the bacteria and external fungi etc. is purely aerobic process, causing fermentative gaseous build-up which causes firstly the bloating of the abdomen, then other areas of the body including limbs, face and external genitalia. This also produces the foul-smelling odours commonly associated with human decomposition.

Fig. 17 - Tsokos & Byard (2016) - discolouration and venous marbling - image cropped from original

The liquefaction of the gastrointestinal tract, organs, cartilages and other soft tissues ultimately causes leakage from the orifices of the body and via skin rupture, as the skin begins to slip and slough off (Alfsdotter 2021, 28; Heaton et al 2010, 303-304). In bodies recovered from aquatic environments, this can present as ‘washerwoman’s hands’ or ‘washerwoman’s skin’. This is usually seen on the hands and feet as “glove-like peeling” after a prolonged exposure to water, “mainly as a result of soaking of the keratinous layer of the epidermis” (Tsokos & Byard 2016) (see fig.18).

Fig. 18 - Tsokos & Byard (2016) - ‘washerwoman’s skin’ after prolonged exposure to water after drowning

In addition to the initial intrinsic enzymatic activity and the gut bacteria released due to the breakdown of intestinal cell membranes, the organic entity of the body then becomes party to entomologic activity as insects utilise the decaying body both as a food source and as a host for the predation of other insects (Card et al 2015; Alfsdotter & Petaros 2021, 4 & 11). This entomological activity speeds up the process of decomposition, acting as decomposers by “hastening tissue disintegration and the [overall] spread of bacteria” (Hayman & Oxenham 2016, 93) during the processes of active decay, leading the decomposition process to the eventual state of skeletonisation. Insect activity will of course be another variable factor depending on the environment in which the body decomposes. Different species can be present in different environments due to the differences in oxygen, moisture, ambient temperature etc. (Alfsdotter 2021, 62) but some commonly seen entomologic activity of those who act as decomposers include those of the *Calliphoridae* and *Coleoptera* orders (i.e. the common blow fly and various beetles) (Tumer et al 2013, 153-4; Alfsdotter & Petaros 2021, 2 & 11) with some common predatory species using the corpse as a way of feasting on the decomposers, such as parasitoid wasps, flies and beetles. It is noted that such species colonise the body for only a short period of time, known as ‘faunal succession’ (Tsokos & Byard 2016). According to Shedge et al, the optimum temperature for putrefactive decay is between 25-38°C, with chemical activity doubling with every 10°C temperature increase, and summer roughly equating to a rate of putrefaction twice as quick as that of winter (Shedge et al, 2020). As with all stages noted above, the decomposition process is highly variable and individual to the specific body and the specific environmental circumstances, and certainly not a simple linear process that is always predictable.

Variations in the more ‘standard’ progression of the decomposition process can occur, for example in cases where saponification or mummification takes place. Adipocere formation or ‘grave wax’ occurs via the hydrolysis of fatty tissues, liquefying stored fats which spread into surrounding muscle (see fig.9 below). Through the action of anaerobic bacterial enzymes, unsaturated body fats are transformed into saturated fats which are less water soluble (e.g. palmitic acid and emulsifying hydroxystearic acid) which crystallise into a solid mass in moist and anaerobic conditions, e.g. in damp soil. Adipocere formation is particularly found in individuals prone to higher levels of body fat, e.g. children, women, those with a higher BMI and in areas of the body with naturally higher percentages of fat, e.g. in the buttocks, cheeks, abdomen (Evans 1963; Dix & Graham 2000). The formation of this solid, armour-like mass can make the human remains “almost entirely resistant to decomposition” (Fielder & Graw 2003, 291; Shedge et al 2020) and its initial formation and persistence as a crystallised solid form is dependent both on the maintenance of an anaerobic environment, and on temperatures which do not reach extremes, either hot or cold. This ensures that “adipocere-laden corpses are very resistant to decomposition in unchanging environments” (Fielder & Graw 2003; fig.19).

Fig. 19 - Smithsonian Institute (2021) - white, waxy adipocere formation, as seen on ‘Soap Man’

Mummification, in contrast, tends to be seen in examples of human remains in dry arid conditions, in both extreme cold and extreme hot climatic environments, a key example of which is that of the well-known Ötzi the Iceman, mummified in the dry cold climate of the Austrian-Italian Alps (Dickson et al 2019) and also in the largely acidic and oxygen-poor wet environments of the Northern European bog bodies, where mummification of soft tissues takes place due to the specific anaerobic conditions and general composition of the peat moss that make up the bogs themselves (National Museum 2021). The sphagnan-rich environment has been found to not only be able to preserve the human body for thousands of years, but also preserving other items such as fish, butter, and so on (Painter 1998; Børsheim et al 2001; Stalheim et al 2009; Synnott 2010; Smyth et al 2019). It is this latter form of mummification which forms the topic of this current study.

1.4. Forensic anthropology and forensic archaeology

This subsection aims to provide contextual information regarding forensics in archaeology, and to clarify the status of this field of study in the case study areas this paper will cover.

According to Kranioti & Paine (2011), “forensic anthropology is the discipline that traditionally deals with the examination of human remains for legal purposes and it derives from the fields of anatomy, physical anthropology and forensic medicine”.

Archaeology in general is a highly interdisciplinary field which relies on the specialised knowledge of many highly trained professionals, using many methods and techniques depending on the specific investigation or research questions to be answered. Due to the very diverse nature of the field, these techniques can come from a range of disciplines, some as sub-disciplines or specialisms within archaeology itself, and others from ‘outside’ the field, where interdisciplinary work helps to complement the investigations, helps to meet research aims and helps to answer research questions. Archaeology is also a highly international field, with specialists coming to work together from many different countries, working together in many different projects, with a diverse background in their respective educations, as discussed by Duday et al (2009, 6). This can also mean that the applicable legislation, various ethical guidelines and the general norms of archaeological practice can vary, as can the terminology and the organisation and content of educational backgrounds. Using the USA as an example outside of the European context, unlike the case study areas of this paper, archaeology as a subject comes generally under the wider umbrella of anthropology. Within that wider umbrella of anthropology, we find the subfields of sociocultural anthropology, biological/physical anthropology and linguistic anthropology, alongside archaeology (International Student, 2021). When progressing within the biological/physical anthropology subfield, there are several schools across the USA which offer education at postgraduate level in forensic anthropology, enabling successful graduates to work in academia, alongside law enforcement, as consultants for crime scene investigations, in medical examiner’s offices, and so on (ABFA, 2018).

Beginning to focus on the case study areas this paper will consider, in Denmark, archaeology is a defined field on its own, with a range of specialisms and subfields within it. The field is entirely led by the state via regional museums, with no commercial archaeology companies offering services in the country. Although it is possible to specialise in prehistory, historical archaeology, classics or even Near Eastern archaeology / Assyriology when completing a tertiary education in Denmark, there is no specific whole education in place in order to be trained towards biological/physical anthropology as per the USA, with a view to progress towards forensic anthropology and/or forensic archaeology. For example, at Copenhagen University it is possible to study a Masters programme in Anthropology in general, with specialisms in Business & Organisational Anthropology or Anthropology of Health, but there is no specific content in the curriculum of the Anthropology department regarding forensic anthropology (UCPH, 2021 [2]).

To gain some level of forensic-led education in Denmark, anthropological biology is available as a 'minor' option of up to 45 ECTS as part of a Natural Sciences degree at the University of Southern Denmark (SDU, 2021). An individual can work towards a career as a forensic anthropologist or archaeologist via either a Bachelor and Masters degree in Medicine followed by additional clinical education and experience in the forensic pathology environment, or via a Bachelor in Archaeology or Natural/Health Sciences (which must specifically include anatomical and/or physical anthropology courses) followed by a Masters degree abroad in order to specialise in forensic anthropology (UCPH, 2021 [3]). A specific education to follow this pathway into forensic archaeology simply does not exist in Denmark.

In general, human osteology and palaeopathology largely comes under the banner of archaeology when dealing with ancient remains, with studies in osteology in Scandinavia on a wider scale covering both human and animal remains. In Denmark, it is usually forensic pathologists and/or forensic anthropologists who deal with any modern remains or those found with flesh, but it is noted that the number of cases per year which require the skills of a forensic anthropologist in general are very small (Villa & Jørkov 2021). Archaeologists deal with ancient remains with regard to osteological examination etc, with little to no forensic knowledge or experience. Despite this, there are professional organisations for forensic archaeologists in Denmark, and there has been a formalised collaboration with the Danish National Police and the Moesgaard Museum since 2010 which is continually being refined. The collaboration works to share knowledge both ways between professionals. This can include police sharing knowledge regarding legislation and criminal investigation processes, to archaeologists sharing knowledge regarding excavation and the scientific processes used during a forensic archaeological / anthropological investigation (Krants, 2018).

The forensic anthropologists who do work in Denmark generally work on behalf of the police, courts and other legal institutions to undertake forensic examinations in Copenhagen, Aarhus and Odense as part of a wider crime scene investigation, under a forensic pathologist. This ensures that examinations are carried out by independent, highly trained specialists that are outside of the judicial service and who serve to ensure that the work is carried out on a solely scientific basis. Forensic specialists can be further specialised in forensic chemistry, forensic genetics, forensic pathology and/or forensic anthropology, with the latter covering forensic, physical and palaeo-anthropology (UCPH, 2021 [1]).

Unlike Denmark, England has multiple university locations where it is possible to specialise in a study of forensic archaeology and the techniques, methods and knowledge required to pursue a career in that direction. Such pathways include examples such as the MSc Forensic Archaeology and Crime Scene Investigation in Bradford, which includes the study of forensic taphonomy in a range of depositional environments and the appropriate laws to be considered (University of Bradford, 2021); or the MSc Forensic Anthropology and Forensic Archaeology in Bournemouth, which includes the study of human remains in a wide variety of contexts and environments including the legal considerations, with an emphasis on “the archaeological recovery of human remains rather than taking a view that analysis begins when remains reach the laboratory” whilst providing knowledge on both ancient and modern human remains, e.g. victims of war, genocide and natural disasters (University of Bournemouth, 2021). These are just two examples of multiple Masters-level university educations across England, with additional options also available in other parts of the UK, to the north in Scotland, to the west in Wales and further west in Northern Ireland.

Again unlike Denmark, commercial archaeology is a very common part of the field of archaeology in England as part of the wider UK, with many companies employing the services of osteologists and those trained as forensic archaeologists, in addition to general field archaeologists and other specialisms. England has several organisations regarding working with archaeology which cover both research-led and commercial-led work, and forensic anthropology and archaeology within those sectors, examples of which include the Chartered Institute for Archaeologists (CIfA, 2021), the British Association for Forensic Anthropology (BAFA, 2021 [1]), the Royal Anthropological Institute (RAI, 2021) and the British Association for Biological Anthropology and Osteoarchaeology (BABAO, 2021). Each of these organisations have memberships requiring a certain specified standard of education for the applicants, as well as ethical guidelines and standards (e.g. BABAO’s Code of Ethics and Practice, both 2019). The RAI in particular has set criteria and testing for Forensic Anthropologists to be assessed as Level III, Level II and Level I, with the first being the first level one can enter with, and the latter being the highest one can be accredited to (RAI, 2021 [2]).

Forensic archaeologists, as in Denmark, work closely with the police and crime scene investigation processes where required, working to both national standards set by The Home

Office and as part of the CIfA (MOLA, 2021). The appropriately qualified can also act as witnesses in a court of law. Again, as in Denmark it is usually the forensic pathologist who would be called for work with suspected modern bodies and any fleshed remains, and forensic archaeologists and/or osteologists for ancient human remains.

Finally, in Ireland (the Republic of Ireland - ROI), forensic anthropology and/or archaeology is a similar situation to that of England and the wider UK, whereby gaining education and knowledge of forensic archaeology can be part of an education from Bachelor-level (e.g. the University College Cork, Ireland, 2021). However, postgraduate level study would require an individual to pursue the next level of their education outside of the ROI, either north of the border in Northern Ireland or across the Irish Sea in the mainland of the UK. Further similarly to the UK, commercial archaeology does take place in the ROI, and forensic specialists are able to practice within the commercial space. As the RAI represents the Royal Anthropological Institute of Great Britain and Ireland, it also accredits practicing forensic specialists in both commercial and research-led environments in the ROI to the same levels as per the UK, and ensures that Irish specialists are appropriately qualified and experienced to work with forensic and historical human remains (HRSI, 2021). Additionally, specialists from the ROI also therefore work within the guidelines of the Code of Practice, Ethics and Professional Standards as per their forensic counterparts in the UK (RAI & BAFA, 2021).

As is highlighted by Cunha et al (2009, 2), one of the main problems that is immediately obvious within forensic anthropology and archaeology is “the lack of “consensus” or uniformity of procedures and methods used”, with variations both between countries within the European context and globally. This potential lack of uniformity is one of the considerations to be discussed during the process of this work.

The Code of Practice, Ethics and Professional Standards in Forensic Anthropology (RAI & BAFA, 2021) denotes that all forensic anthropologists must have appropriate experience in “understanding different contexts for skeletal remains with regard to archaeological remains" (2021, 11); that all working with human remains must abide with ethical guidelines which both anthropologists and archaeologists in general strive for (2021, 4-9); and that the specific requirements deemed ‘essential’ to be qualified as a Level-III practitioner on the FA levels of the RAI are those which an individual with human osteoarchaeological experience would have the potential to competently meet with adequate practical experience of working with human remains (2021, 10-11). However, it must be noted that forensic archaeologists generally gain experience with historical/archaeological human remains rather than the remains of the recently deceased, unless their education is specifically targeted towards a mixture of both, e.g. some educations noted previously in the UK which blend forensic archaeology with crime scene or genocide investigations, for example, and that forensic anthropologists in particular would be expected to be familiar with all stages of human decomposition (RAI & BAFA 2021, 12) which archaeologists may not. Generally, the Code denotes that the specifics of each particular case denote whether collaborative work of forensic archaeologists and anthropologists together is required (RAI & BAFA 2021, 15-17).

1.5. Research topics and research questions

This work aimed to analyse three case study examples from the bog body research history of Denmark, England and Ireland in order to investigate the impact of different depositional environments on the overall preservation and decomposition process of human remains. The work aimed to consider taphonomic change vs. human action and to discuss how techniques and methods used to assess human remains in forensics could be applicable to archaeology, or even to bog body research specifically.

With these aims, the specific research questions for this work were:

- Using three case studies from within the bog body research history, one each from Denmark, England and Ireland, how has deposition into the bog affected the overall human decomposition and preservation process? How does decomposition in the bog compare to burials in soils, water or the open air?

- How is taphonomic change and/or loss differentiated from change resulting from deliberate human action, if at all?

- Does a forensic scoring method used for assessing human remains in forensic cases have any potential benefit for archaeology, e.g. if appropriately adapted for implementation in bog body research? Could the field as a whole benefit from increasing forensic knowledge in general, especially in relation to human decomposition, taphonomy and depositional environment, as we work to uncover the buried human past which often includes the finding and recovery of human remains?

1.6. Analytical and theoretical framework

The main premise for this work was to try to investigate how the decomposition and preservation of human remains varies according to the depositional environment, and whether knowledge and methods used in the field of forensics can be appropriately adapted and used beneficially in the field of archaeology. The paper has a particular focus on specific case studies from within the bog body research history of three areas of Northern Europe and will consider if and/or how methods from forensics can be applied to bog body research.

Ravn (2010, 106) and later Nielsen, Christensen & Frei (2020, 9) note that, in regard to the study of bog bodies, it is more often than not the fleshed or still 'human'-looking bog bodies that have historically received the most attention and the most interest in terms of research, public engagement and display, etc. Despite the fact that the perhaps less attention-grabbing bog skeletons or disarticulated preserved body parts still having the potential to give us a fascinating insight into the deposition of human remains into bog environments, many remain much less studied than their fleshed counterparts, and are sometimes left unpublished altogether (as raised in Nielsen, Christensen & Frei 2020). This is despite their varied state of preservation simply being a result of the geo-chemical conditions of their depositional environment, e.g. the soil type, pH, temperature, humidity and/or level of microbial activity (Tumer et al 2013, 154) which is not a reflection of, nor is it comparable to, how useful these remains can be to the wider archaeological record. Nielsen et al regard such remains as holding an "enormous potential of a hitherto overlooked dataset of skeletal remains from bogs" (2020, 1 & 10).

There have already been a number of different studies and research papers exploring and theorising on the importance of the bog environments as meaningful watery spaces that are neither land nor water, but spiritually, ritually and ceremonially significant liminal spaces somewhere in between; and there have been discussions on what the meaning of specific deliberate depositions into those spaces meant to these past peoples, e.g. human sacrifice for the greater good, some kind of ritualised humiliation as punishment, or even accidental deaths in some cases (Aldhouse-Green 2015; Fredengren 2016, 2018; Granite 2016; Lobell & Patel 2010; Lynnerup 2015; Ravn 2010, etc). However, this paper does not seek to enter into this discussion of the ritual importance, significance or reasoning of past peoples for carrying out depositions into the bog and, as such, discussions of that nature are beyond the scope of the research aims of this study and the research questions to be answered here.

Instead, this paper aims to assess and analyse three chosen bog body case studies from Denmark, England and Ireland as an opportunity to explore the impact of deposition of human remains into the bog and to compare that with other different depositional environments and the differing preservation states of human remains in those environments. The work aims to explore the potential of applying techniques and methods from forensics to bog body research by using a method of assessment and analysis from forensics in order to assess the three bog body case studies - the forensic scoring method. There are several such methods used in the field and the method selected is dependent on which is most applicable to the specific depositional environment in which human remains are found (Appendix 1-4). This could be a general forensic scoring method (Megyesi et al (2005); Appendix 2), a forensic scoring method adapted for working with human remains found in indoor environments (Gelderman et al (2018); Appendix 4) or a forensic scoring method specifically adapted for working with remains found in aquatic depositional environments (Heaton et al (2010); Appendix 3). It is the latter which will be used for the analysis of the three case studies considered for this work.

The work is shaped by the basic premise that different depositional environments will inevitably result in different levels of preservation and decomposition of human remains, as natural organic entities subject to decomposition after death occurs. For example, where the geo-chemical composition of some depositional environments may result in preservation of skin or soft tissues but the loss of bone (as seen in bog bodies) others may result in the preservation of bone but a loss of soft tissues (as seen in bog skeletons), or anywhere in between. The work here is shaped by the notion that the level of preservation of soft tissues should not necessarily be the determining factor of which cases receive the most analysis and research, which cases should receive public attention and which cases are ultimately included in shaping the archaeological narrative surrounding bog bodies and which are not. As recent works prove, the bog skeletons are equally valuable and provide a wealth of knowledge about past peoples (Nielsen, Christensen & Frei 2020). The work aims to use a process of documentary analysis and comparative analysis for three chosen case studies from Denmark, England and Ireland, with a view to contribute to general knowledge of human taphonomy in different depositional environments. This will be done by firstly analysing the bog bodies through an analytical framework which assesses specific intrinsic, extrinsic and cultural factors of each case, as well as the post-excavation analyses and treatments (see Appendix 5).

Intrinsic factors included:

- taphonomy and the decomposition stage of the bog body remains
- age at death
- sex

- date of death
- weight and height
- ancestry
- overall general degree of health

Extrinsic factors included:

- contextual details such as the bog location and surroundings
- date found
- environmental factors such as temperature, humidity and rainfall
- any noted entomological activity present
- soil type at the site/area, if included in the research literature

Cultural factors included:

- cause of death e.g. via perimortem violence, poison, natural, unknown
- any signs of trauma and/or injury
- any clothing or coverage on the individual
- % of the remains exposed to the bog environment as a result of the above
- any clothing or additional items included externally to the body but within the burial
- a consideration of the last meal, if known
- any additional factors specific to the case study

Post-excavation analyses and treatment of the remains included:

- which analyses were completed and when
- results of the analyses and their implications where appropriate
- any additional factors

After this general analysis, the case studies were assessed using a forensic scoring method deemed most appropriate for the bog bodies, to assess its potential for further adaptation and subsequent applicability to bog body research (see Appendix 4). The forensic scoring method is the method by Heaton et al (2010) which took a method developed by Megyesi et al (2005, Appendix 2) and adapted it for assessing remains from aquatic environments.

This work uses the case studies of Grauballe Man from Jutland in Denmark, Worsley Man from the Manchester area of north-west England and Clonycavan Man from Co. Meath in the Republic of Ireland. In order to support the documentary and comparative analysis of the three chosen case studies from an archaeological perspective, research in the area of general forensics, more specifically in terms of forensic taphonomy and the methodologies and theories used in forensic investigations, helped to support and shape this study, both on a general level regarding knowledge of the decomposition process itself in different depositional environments and in terms of presenting the forensic scoring method through which the bog body case studies are assessed. Using this type of method allowed assessment of the case studies in a structured and repeatable format by specific criteria, but most importantly, it did not require any physical examination, or in-person assessment of the bog body remains. Instead, the assessment took place via analysing both published reports and photographs of the case studies in question. This was deemed the most suitable for this work, not only as the method seems to be the most well-used by the retrospective forensic studies reviewed during this work, which also did not assess their cases in-person, but also as the COVID-19 pandemic prevented any such examinations even being possible.

It felt important to note here that though there are many forensic studies which have been considered and have contributed as background supporting knowledge in the production of this paper, many of these studies investigate modern burials and not those from archaeological contexts, and many are located in different climatic environments than the chosen case studies (e.g. Tumer et al 2013, Humphreys et al 2012, Suckling et al 2016, Dautartas et al 2018). Some of these studies concern found human remains (van Daalen et al 2017) and others are experimental deliberate depositions which concern the decomposition of non-human remains, often boar or pig rather than human (e.g. again, Tumer et al 2013). Additionally, at the time of this study, there is just one piece of published work regarding the process of decomposition in the open air environment specifically carried out in Scandinavia (Alfsdotter & Petaros, 2021) which, although this leaves space for further experimental forensic-led archaeological and/or forensic research to be conducted with actual human remains in various different depositional environments, especially in the Northern European context, to develop further knowledge which could then be applicable and useful to both fields, it also leaves very little published research with which to have somewhat direct comparisons to in terms of climatic environment and the chosen case study region areas.

As the study covers three separate countries, legal and ethical frameworks which help to guide archaeology as a discipline in the respective countries were consulted and included. Using theoretical underpinnings of burial archaeology and the associated legislation from these countries in addition to taphonomic theory and forensics, the study intends that the discussion of bog body research can be understood in its correct context.

2. MATERIALS AND METHODS

This study was carried out as a retrospective qualitative study of human decomposition and depositional environment in three case studies, intending to act as a test to see if forensic scoring methods could have some potential for being implemented in bog body research. The study could act as preparation for a potential wide-scale quantitative study of a large number of human decomposition cases from the bog body research history via appropriately adapted forensic scoring methods at a later date, if this current study and other potential studies were proven to be of benefit. The study primarily uses comparative analysis and documentary analysis of both primary and secondary written sources, to assess the three case studies selected for the work, using a database template to collate specific information from each case. This was done in order to summarise the research for each case study in the same way, to ensure that the case studies were easily comparable with one another. After completing the database template for each case, the adapted forensic scoring method by Heaton et al (2010 - see Appendix 3) was used to assess the three bog bodies. Using these methods together was deemed substantial enough to give a detailed consideration of the decomposition and preservation level of the remains in the published written material and any such published photographs of the remains, as well as a consideration of how the forensic scoring methods work in practice. It would also serve to highlight how the current scoring methods may or may not be suitable or applicable for bog bodies specifically and would serve to clarify what kind of adaptations may be suitable to make a forensic scoring method specifically applicable for bog bodies going forward.

The documentary and comparative analyses of published work from the archaeological record and support by forensic investigation methodologies is additionally supported by information regarding the environmental conditions of each case study area and the soil classification in which the bog bodies had been placed. Secondary sources include summative books, articles and journals where beneficial, mainly employed for providing wider context.

After providing the results of this work and entering into a discussion around how the work took place, the final discussion of this study also utilises narrative enquiry as part of a wider ethical discussion, to question narrative formation in archaeology. This is done to discuss how these narratives are shaped by the research we choose to carry out, but also to discuss how the lives, deaths and identities of past peoples are developed and perpetuated in research. The discussion presents the idea that, if we only research a portion of the record, we can only base our narratives on those samples and not the record as a whole. The discussion concludes with a general consideration of our ongoing ethical obligations as archaeologists, or as any professional working with human remains, to not only ensure that remains are treated appropriately and respectfully, but also to ensure that problematic narratives are more openly challenged, both in and outside of academia.

Due to the restrictions of the COVID-19 pandemic and the general time constraints of this Master thesis project, it was chosen to consider just three case studies in total, to test how applying forensic scoring methods to archaeological bog body research could work. It was deemed vital to consider the three case studies from different case study areas, to be able to consider in the study the variation in how forensic methods are applied to archaeology, different specialisms, different legislation and any general difference in common practice. To do this, the study has used desk-based qualitative research methods and the study potentially becomes a summative secondary source of its own, through researching, collating and analysing other works in bog body research, using interdisciplinary research methods and identifying potential opportunities for future research on a wider number of case studies.

To commence this work, all known bog bodies in the research locations were collated into a basic database, and it was marked in the database as to whether the studies had previously published papers available. From those marked as published, three case studies were selected at random as a judgement or purposeful sample, with one selected from each case study area of Denmark, England, Ireland, for reasons noted above. This was to ensure that research had actually been published to be able to source material for comparative analysis and for the retrospective study of the human remains against forensic scoring methods to take place to see if this could be transferable to bog body research. As this is a qualitative and methodological study, this was completed without a specific hypothesis to test (Marshall 1996, 523-524). The case study areas were chosen as they all had multiple bog bodies found, rather than just one or two such examples. The case study areas are sectioned as three separate entities in the course of this work, with Denmark, England and Ireland considered individually. The FAO-UNESCO 1974 Soil Classification denotes England and Ireland as the same classification of 7.2. Marine: cool marine to 7.3. Marine: cold marine, and Denmark in a separate climate classification of 7.6. Marine: cool temperate (UNESCO, 1974). The climatic conditions are therefore deemed the same for England and Ireland with Denmark as another, but all 3 were considered individually as separate entities to take into account the different research histories and the different legislation as 3 separate countries, within the wider Northern European context.

A template of the information deemed most pertinent for this study was created (see Appendix 5). Each case study was assessed using this template to make a simple database for each case study containing all of the relevant data, but also to ensure that the case studies were directly comparable with one another. One of the early problems identified during early research of the bog body research history in general was that work carried out on examples of bog bodies had a tendency to vary very widely, with some bodies heavily studied and others less so, or not at all, leaving them not necessarily easy to compare. This work wanted to ensure that the case studies used in this study were directly comparable with one another as far as possible. Each of the case studies were considered initially from the research and various papers published, primarily via descriptive sections and any published photographs.

The development of Galloway et al's 5 stages of decomposition was defined in relation to human remains left in the arid, desert environment of southern Arizona, where they denoted that remains decayed much faster in summer than in winter, where remains could "retain a fresh appearance for a considerable time" (Galloway et al, 1989). From this work, Galloway et al (1989, Appendix 1) defined 5 stages of decomposition: fresh, bloat, early decomposition, advanced decomposition and skeletonisation. Within those stages were defined specific characteristics of the decomposing body which could be seen, e.g. some skin slippage in the stage of early decomposition, through to skeletonisation or mummification in the advanced decomposition stage. Though Galloway et al's stages were defined for their studies of human cadavers in the desert environment, Megyesi et al (2005, Appendix 2) took the five-stage decomposition process of Galloway et al and modified this into a decomposition scoring method with which to assess the decomposition of human remains. The Megyesi et al method splits the stages defined by Galloway et al into more sub-stages and defines points to be given for each of those sub-stages, and additionally separates the body into three regions for assessment, (1) the face and neck; (2) the body; and (3) the limbs, "because these body parts decompose in a different way" (Gelderman et al, 2018; Appendix 4). Heaton et al then took the methods of Megyesi et al which were specific to the forensic assessment of human remains found in terrestrial environments (2005; Appendix 2) and adapted the scoring method for human remains found in aquatic environments, for their work regarding bodies recovered from UK waterways (Heaton et al 2010; Appendix 3). The method also separates the body into the three areas of (1) 'FADS' or facial aquatic decompositional score, for the face/head; (2) 'BADS' or body aquatic decompositional score, for the torso / trunk; and (3) 'LADS' or limbs aquatic decompositional score, for the limbs, hands and feet (fig. 20, 21 & 22). Each body area has a descriptive detailing of visual indicators that could be seen for each stage of decomposition. The method then takes the score for each area of the body, FADS + BADS + LADS, to equal a 'TADS' or total aquatic decompositional score. With the FADS having a maximum score of 8, BADS having a maximum score of 8 and LADS having a maximum score of 9, using this method, there is a possible maximum score for the TADS of 25.

FADS	Description
1	No visible changes.
2	Slight pink discoloration, darkened lips, goose pimpling.
3	Reddening of face and neck, marbling visible on face. Possible early signs of animal activity/predation—concentrated on the ears, nose, and lips.
4	Bloating of the face, green discoloration, skin beginning to slough off.
5	Head hair beginning to slough off—mostly at the front. Brain softening and becoming liquefied. Tissue becoming exposed on face and neck. Green/black discoloration.
6	Bone becoming exposed—concentrated over the orbital, frontal, and parietal regions. Some on the mandible and maxilla. Early adipocere formation.
7	More extensive skeletonization on the cranium. Disarticulation of the mandible.
8	Complete disarticulation of the skull from torso. Extensive adipocere formation.

Fig. 20 - Heaton et al (2010) - FADS or facial aquatic decompositional score; descriptive stages for decomposition observed in the face

BADS	Description
1	No visible changes.
2	Slight pink discoloration, goose pimpling.
3	Yellow/green discoloration of abdomen and upper chest. Marbling. Internal organs beginning to decompose/autolysis.
4	Dark green discoloration of abdomen, mild bloating of abdomen, initial skin slippage.
5	Green/purple discoloration, extensive abdominal bloating—tense to touch, swollen scrotum in males, exposure of underlying fat and tissues.
6	Black discoloration, bloating becoming softer, initial exposure of internal organs and bones.
7	Further loss of tissues and organs, more bone exposed, initial adipocere formation.
8	Complete skeletonization and disarticulation.

Fig. 21 - Heaton et al (2010) - BADS or body aquatic decompositional score; descriptive stages for decomposition observed on the torso

LADS	Description
1	No visible changes.
2	Mild wrinkling of skin on hands and/or feet. Possible goose pimpling.
3	Skin on palms of hands and/or soles of feet becoming white, wrinkled, and thickened. Slight pink discoloration of arms and legs.
4	Skin on palms of hands and/or soles of feet becoming soggy and loose. Marbling of the limbs—predominantly on upper arms and legs.
5	Skin on hands/feet starting to slough off. Yellow/green to green/black discoloration on arms and/or legs. Initial skin slippage on arms and/or legs.
6	Degloving of hands and/or feet—exposing large areas of underlying muscles and tendons. Patchy sloughing of skin on arms and/or legs.
7	Exposure of bones of hands and/or feet. Muscles, tendons, and small areas of bone exposed in lower arms and/or legs.
8	Bones of hands and/or feet beginning to disarticulate. Bones of upper arms and/or legs becoming exposed.
9	Complete skeletonization and disarticulation of limbs.

Fig. 22 - Heaton et al (2010) - LADS or limbs aquatic decompositional score; descriptive stages for decomposition observed in the limbs

The TADS is determined to "represent the overall extent of decomposition observed for a case" (Heaton et al 2010, 303). It is important to note that, when assessing the remains and attempting to assign a score for each area of the body "very rarely does a case show all or even the majority of the descriptions in a scoring category", therefore "a score relies on the investigator making an educated assessment of each individual case to select a category that can be described as a "best fit" which is deemed most appropriate for each individual case (Heaton et al 2010, 303).

The method denotes that their statistical analysis showed "the duration of a body's submergence in water and the temperatures to which it was exposed, as measured in accumulated degree days (ADD), had a significant effect on the decay process" (Heaton et al 2010, 302). ADD is described as "heat-energy units that represent the accumulation of thermal energy that is needed for chemical and biological reactions to take place in soft tissue during decomposition… [and which] represents chronological time and temperature combined" (Myburgh et al 2013, 165.e1). Simmons et al explain this, through a calculation of ADD as the accumulated amount of thermal energy the human remains have been subjected to over time, i.e. via the accumulated average temperature, it should be expected that an equal reaction of decomposition could be expected to occur, i.e. via thermolysis. The results of Simmons et al's work, which compared many different cases from different environments, suggested that there was actually no significant difference between decomposition progression when measured using ADD, but rather the main cause of change in the rate as a result of "insect presence, regardless of depositional environment, species, or season" (Simmons et al 2009, 12). As ADD calculation is used in the Heaton et al method, and as Megyesi et al note that "ADD accounts for approximately 80% of the variation in decomposition" (2005), ADD is therefore calculated for each of the bog body cases by first taking into consideration the 'ADT' or average daily temperature. This is calculated via: *ADT = (highest temp + lowest temp) / 2*

Heaton et al (2010) utilise retrospective temperature data for the calculation of the ADD during their study. To support the use of the method fully, this is replicated in this work by using average temperature data from the DMI / Danish Meteorological Institute for Denmark, the Met Office for England and Met Eireann / the Irish Meteorological Office for Ireland, to ensure that the temperatures being considered were applicable for each case study. Although it is unclear at what temperature putrefaction actually ceases (and there have been differing suggestions e.g. Vass et al (1992) note it stops at 0°C yet Micozzi (1997) notes the base temperature for decomposition as 4°C) it is at least certain that it does stop at 0°C whilst it is actually freezing (Gelderman et al, 2018). For this study, Micozzi et al's 4°C will be considered as the base temperature for which putrefaction will cease/begin. ADD is therefore calculated by: ADT - base temperature, before * the number of days the body has been in-situ.

The case studies were considered against the framework and method defined by Heaton et al (2010 - see Appendix 3), to both assess the remains in general and additionally, in order to determine how such a scoring method could be adapted to bog body research. The Heaton et al (2010) adapted forensic scoring method was chosen due to the bog bodies being placed into a wet bog environment and the scale being specifically adapted for human remains in aquatic environments and waterways. Early research for this work found that each bog body case is so varied and so individual, both in terms of its preservation level and in terms of the analysis/research it has gone through, that making a direct comparative analysis of a number of cases can prove to be challenging. Each case has been subject to different post-excavational treatments, analyses and investigations, resulting in research outputs which are also variable - analyses are often present in some cases and missing in others. This work hopes to ascertain both the general applicability of such methods to bog body research in general and whether, through a process of assessing varied cases through the same appropriately adapted forensic scoring method and assigning a score, a bog body scoring method could enable an additional level of comparability for future research.

3. RESULTS

The three bog body cases were first generally analysed via an analytical framework consisting of intrinsic factors, extrinsic factors, cultural factors and a consideration of the post-excavation treatment and analyses each of the bog bodies had been subjected to. As noted previously, the factors to be considered were as follows:

Intrinsic factors:

- taphonomy and the decomposition stage of the bog body remains
- age at death
- sex
- date of death
- weight and height
- ancestry
- overall general degree of health

Extrinsic factors:

- contextual details such as the bog location and surroundings
- date found
- environmental factors such as temperature, humidity and rainfall
- any noted entomological activity present
- soil type at the site/area, if included in the research literature

Cultural factors:

- cause of death e.g. via perimortem violence, poison, natural, unknown
- any signs of trauma and/or injury
- any clothing or coverage on the individual
- % of the remains exposed to the bog environment as a result of the above
- any clothing or additional items included externally to the body but within the burial
- a consideration of the last meal, if known
- any additional factors specific to the case study

Post-excavation analyses and treatment of the remains:

- which analyses were completed and when
- results of the analyses and their implications where appropriate
- any additional factors

Each of the cases was then assessed using the Heaton et al (2010) forensic scoring method, adapted for assessing human remains recovered from aquatic depositional environments, assessing the body as three separate areas (face, body and limbs) to calculate the FADS or facial aquatic decompositional score, the BADS or body aquatic decompositional score and the LADS or limbs aquatic decompositional score. The accumulation of the three would result in the TADS or total aquatic decomposition score for each case. The ADD or accumulated degree days value was then calculated for each of the case studies. The TADS and ADD were then plotted against one another for the three cases, to see if any correlation or difference was noted. It should be reiterated here that this is a qualitative study, not quantitative, so emphasis was not overly placed on the statistical analysis of this work, but was rather used as the first step in a process of analysing as to whether forensic scoring methods could hold some benefit for relevant adaptation and application to the assessment of bog bodies on a wider scale.

3.1. The bog environment and preservation by sphagnum

This work aimed to answer three research questions, the first of which related specifically to the impact of the bog environment on human decomposition and preservation. As shown in this work, and in many other works regarding bog bodies, human and other organic remains which would usually decompose after death has occurred are able to be preserved to a high degree for hundreds or thousands of years in the liminal watery spaces of the bog. The specific biochemical and geochemical conditions of those spaces enable protein-based tissues to be preserved (Frei et al 2015) even when the process of diagenesis in those conditions leads to calcium leeching and decalcification of the bone matter (Rasmussen et al 2019). As with all environments, each bog can vary in their own specific composition, but this subchapter aims to briefly describe the general conditions that allow the process of bog body formation to place.

Peat bogs are one of the many types of highly unique ecosystems classified as 'wetlands', with other such environments including rivers and streams, floodplains, lakes, ponds, ditches, lowland wet grassland, marshes, mudflats, fens, wet woodlands, reedbeds, mangroves and coral reefs (WWT, 2021). Bog bodies have mainly been found in raised peat bogs, formed over time due to the accumulation and compaction of carbon-rich decaying plant matter that forms the peat itself. The bogs are characterised by an oxygen-deficient and highly acidic environment that is ombrotrophic in nature, dependent entirely on atmospheric moisture via precipitation for nutrients (Lexico 2021 [2]). These spaces are usually rich in peat mosses or sphagnum mosses which are accustomed to thriving in the acidic environment. Although these environments take thousands of years to form, destruction has taken place rapidly due to peat-cutting to use as a fuel source which has, consequently, been responsible for the uncovering of many of the bog bodies in the archaeological record. With the level of peat-cutting activities, drainage of bog environments and afforestation taking place across the last 100 years, raised peat bogs are now an endangered natural habitat, with 94% of raised bogs in Britain and 99% of raised bogs in Ireland lost (Wildlife Trusts, 2021), 95% of Denmark's raised bogs lost (Stenhild et al, 2021) and with all peatlands covering just 3% of the Earth's total surface (Evans 2013, 165) whilst harbouring more than 33% of the world's terrestrial carbon (Weston et al 2015, 1737).

Sphagnum peat mosses have historically been used for several microbial purposes, for example by peat-cutting workers treating open fractures with peat (Drobnik & Stebel 2017), during World War I to treat war wounds and to kill bacteria and fungi during the Irish famine of 1840-45 (McKeon-Bennett & Hodkinson 2021), each working successfully due to their ability to chemically inhibit bacterial growth. It is the combination of their ability to thrive in acidic and anoxic environments, and their ability to inhibit bacterial growth and thus the post-mortem stage of putrefaction, that ensures the preservation of human remains placed into the bog environment after death. As discussed, peat is produced by the build-up of decaying plant matter over thousands of years, and that decaying plant matter releases water-soluble polyphenolic substances or ‘tannins’ via autohydrolysis into the waters of the bog, producing an environment rich in tannic acid (Chung et al 1998, 421). It is one of tannins, sphagnan, which is now believed to be a key element for the tanning process of the protein-rich soft tissues in the bog environments (Painter 1991, 1998; Lynnerup 2015). As the process of diagenesis leaches calcium from the bones via demineralisation, causing a softening and loss of bone mass over time, the soft tissues are conversely preserved, as the body becomes waterlogged with the tannin-rich waters of the bog which inhibit the onset of microbial decay.

3.2. Bog body results: general analysis and use of a forensic scoring method

This subsection serves to give contextual background to each of the case studies. The initial analyses were undertaken using a template (see Appendix 5) to collate the same information for all three case studies where possible, to ensure that the case studies could be directly comparable. This information will be presented before each of the case studies will be assessed using the forensic scoring method of Heaton et al (2010 - see Appendix 3).

3.2.1. Denmark: Grauballe Man

Background

The incredibly well-preserved remains known as Grauballe Man were discovered in 1952 in the village of Grauballe, less than 10km north of modern-day Silkeborg in Jylland, Denmark (fig.23). Found by peat cutters extracting peat for fuel from the rich soils of the area, the find was promptly reported and Grauballe Man was excavated by P.V. Glob.

Fig. 23 – Grauballe Man: Moesgaard Museum (2021) - 2000-year-old Iron Age man found in a bog in Grauballe, Silkeborg Avis 28 Apr. 1952

The famous Tollund Man was found just two years prior in 1950, close-by to the location of Grauballe Man's deposition. After being excavated by P.V. Glob, it was decided by the then-curator of the National Museum and Head of the Prehistoric Department, Therkal Mathiassen, that it was unnecessary to preserve the whole of Tollund Man's body due to the fact that the remains were deemed "quite a macabre sight" which were "difficult to conserve" (Fischer 2012, 31 in Giles 2020, 62) despite the fact that the Silkeborg Museum wished to conserve Tollund Man and the entire exhibit of him. Following the initial analyses of Tollund Man, the head was promptly severed from the body for conservation, preservation and exhibition purposes along with the small hat and leather cord he was buried with. The rest of the remains were kept in various jars and/or preservative fluids, but were left to dry out, becoming "desiccated, shrunken and deformed", with Mathiassen later noting that the rest of the remains "should preferably be hidden away… ideally be forgotten altogether" (Giles 2020, 62). With just two years passing between the discovery of Tollund Man and then Grauballe Man, Glob had decided that such decisions were errors in judgement which would not be repeated in this new case (Glob 1969, 32) and that the entire body of Grauballe Man must be preserved beyond that of the natural preservation that had taken place in the mossy, watery depths of the bog environment "for posterity… [ensuring] the dead man would still have the same bodily appearance and posture as when he had been uncovered in the bog" (Glob 1969, 44 in Giles 2020, 63).

Unlike the treatment of Tollund Man, Grauballe Man's entire body was analysed and underwent a process of conservation by the conservator at Moesgaard Museum in Silkeborg, Lange-Kornbak, who noted that the bog began "an incipient tanning process which it was my task to complete" (Strehle 2007, 42 in Giles 2020, 63). The body was kept wet and disinfected to prevent the growth of mould, and was preserved for 18 months in water and 875kg of oak bark chips to complete the tanning process, followed by the application of Turkish Red Oil

(Asingh & Lynnerup 2016, 86). The choice to preserve Grauballe Man in this way has ensured that his body remains in a stable preservation state today and, after undergoing initial post-excavation analyses in the 1950s, he has continued to be studied in the early 2000s and beyond, using technological developments and newer techniques and methods to bring a new perspective to previously analysed remains (Asingh & Lynnerup 2016, 86; Lynnerup 2015; Lynnerup & Villa 2012; Lynnerup 2010; Lobell & Patel 2010).

General analysis

For the analysis of Grauballe Man, the blank template containing the previously discussed intrinsic, extrinsic, cultural and post-excavation analyses and treatment factors to be considered (see Appendix 5) was completed using information collated from various sources of bog body research (see Appendix 6).

Intrinsic factors

Grauballe Man was found as the remarkably well-preserved body of a male, with his skin preserved and tanned dark from the natural geochemical conditions of the bog environment. Additionally, the full head of hair that was also preserved had also been coloured from a light brown to a rather bright red due to the bog itself, rather than the male naturally having this shock of red hair (Lobell & Patel 2010). The bones of Grauballe Man were in place but were demineralised due to the forensic taphonomic process of diagenesis, calcium-leaching from the bones in the bog environment.

Grauballe Man was estimated to have been around 30±5 years old at the time of his death by the majority of sources consulted in the process of this work. The estimated age ranged from 25-30 years old due to the presence of fused clavicles and an ossified sternum (Frederiksen & Glastrup 2007) up to around 34 years old resulting from CT scanning of the iliac crest (Warner Boel et al 2007). The remains have been dated as being from the early Iron Age (Lynnerup & Villa 2012) which in Denmark is c.400BC-AD100, with Grauballe Man's death dated at c.2300 years ago (Lobell & Patel 2010).

With maximum measurements of the demineralised but present tibia and femur, Grauballe Man has been estimated to have been around 5ft 7 in height, i.e. 170cm tall, noticeably smaller than the skeletal remains of similar Iron Age individuals found in non-bog burial sites (Lobell & Patel, 2010). Lynnerup also challenges this estimation, as diagenesis could cause a general reduction in the bone size of the tibia and femur, and thus give an inaccurate representation of his height. The estimated weight of the individual during his lifetime was not specified in the research literature consulted for this work. Blackened teeth were found in-situ or loose in the oral cavity after falling loose due to taphonomic change, with some showing signs of periodontal disease in the form of caries (Lobell & Patel 2010). Other than this, the overall analyses of his remains and the small-yet-present internal organs found that he was generally in good health, with no disease detected beyond the oral cavity.

Grauballe Man is regarded as a "crown jewel" and one of the most highly regarded pieces of Denmark's prehistory (Moesgaard Museum, 2021). No aDNA analysis was possible to investigate his genetic background, as DNA could not be extracted from the dentine of the remaining teeth. Enamel was not present in many of the teeth and the exposed dentine was exposed to the wet and acidic environment of the bog itself, meaning that DNA extraction was not possible (Lynnerup 2015). However, early analysis of the fingerprints of the well-preserved hands found that Grauballe Man had both double and ulnar loop fingerprints, which are present in 11.2% and 68.3% of the modern Danish population respectively (Lynnerup 2015; Asingh & Lynnerup 2007; Asingh & Lynnerup 2016).

Extrinsic factors

Fig. 24 - Grauballe Man: Moesgaard Museum (2021) - Nebelgaard Mose, central Jylland - location of deposition

Grauballe Man was found in Nebelgaard Mose in the village of Grauballe in central Jylland, Denmark, less than 10km north of the modern city of Silkeborg (fig.24). He was uncovered in April 1952 by peat cutters extracting the rich soil for fuel (Lobell & Patel 2010; Lynnerup 2015) and was excavated 26 April 1952.

According to the FAO-UNESCO (1974; 1981), Denmark's climate is regarded as 7.6. Marine 'cool temperate' (1981, 28) overall, a climate which is characterised by "moderate rainfall spread across the year or portion of the year with sporadic drought, mild to warm summers and cool to cold winters" (Kazemi & Mohorko, 2017). Since records began in 1874, the average annual temperature of Denmark is recorded as around 7.7°C, with central Jylland generally falling just below this annual average at around 7.4°C (DMI, 2013). Moesgaard

Museum notes that “the time in which Grauballe Man lived was characterised by a marked climate change with wetter and colder conditions than before” (Moesgaard Museum 2021 [2]). As regards humidity, Denmark is regarded as ‘ever humid’ to ‘humid, but with drier periods’ (FAO-UNESCO 1981, 29) with an average annual humidity of 79-82% since records began in 1874. Additionally, the central Jylland area of Denmark is noted as having over 900mm of rainfall each year, with a nationwide annual average of 745mm (DMI, 2014).

The UNESCO 1974 Soil Classification denotes the area of Jylland in which Grauballe Man was found as being largely Po ‘Orthic podzols’ and/or Pp ‘Placic podzols’ soils. However, there was no specific information about soil type and its impact on the decomposition and preservation of Grauballe Man, in the research papers consulted as part of this work. Soil type and its impact on the decomposition and preservation of bog bodies in general was discussed by Nielsen et al (2020), where the soil type was discussed in reference to fleshed bog bodies vs. bog skeletons, with the latter largely understudied in comparison (Nielsen, Christensen & Frei, 2020). Additionally, there was no specific information in the research papers for Grauballe Man discussing the presence or absence of entomological activity in the remains during the time spent in the bog, but plant growth was noted as being present inside the remains (Glob 1969; Lynnerup 2015).

Cultural factors

As regards cultural factors and the proposed cause of death before deposition into the bog, Grauballe Man was found with his throat having been cut from ear to ear and severe damage to both his cranial and tibial bones (Lobell & Patel 2010). He was found naked in the bog without any clothing either on his person or buried with him externally to his remains. His body therefore received 100% exposure to the bog environment without any clothing to retain some coverage. An analysis of the stomach contents of the Grauballe Man was carried out during the investigations of the 1950s and was also reassessed during the 2001-2002 reanalysis. His last meal was suggested to have been a mix of many types of plants and weeds, including barley, grasses, wheat and herbs, with a small amount of pork (Lobell & Patel, 2010; Lynnerup 2015). After his excavation, Grauballe Man was kept wet in the bog water he was found in and resting upon a block of peat in which he rested since his deposition. He was almost immediately exhibited to an excited public (Asingh & Lynnerup 2016, 85) where 18,000 visitors quickly attended the Forhistorisk Museum in Aarhus (fig.25). He is now one of the key permanent exhibitions at the Moesgaard Museum in Aarhus.

Fig. 25 – Grauballe Man: Moesgaard Museum (2021) - Sunday queue for the Grauballe Man in his first exhibition

Asingh and Lynnerup additionally note that, though Glob was cautious to ensure that Grauballe Man was preserved in his entirety unlike the Tollund Man, he “clearly considered him as both a scientific object and a precious museum object” rather than preserving his remains as those of a human being who deserved dignity and respect (2016, 85).

Post-excavation analyses and treatment

During 1952-54, an autopsy, analysis of gut contents and teeth were completed (Asingh & Lynnerup 2016, 85; Glob 1965, 1969) as discussed above, as well as fingerprint analysis, CT scans and radiocarbon dating. The autopsy included the inspection of the internal organs and one remaining testicle, all of which were preserved but shrunken in size due to the bog environment itself. All were analysed and there was no evidence of disease, hence the previous determination that the Grauballe Man was in generally good health (Gregersen et al 2007) other than the presence of periodontal disease and caries common during the time period in which he lived. 21 teeth remained with 12 still in-situ, several of which showed the presence of Harris lines. The enamel was largely absent with exposed dentine, as discussed. This indicates a physically challenging childhood, and a largely rough/coarse diet. Scanning electron microscopy and radiographic analyses were successful but DNA could not be extracted from the remains, thus aDNA analysis could not be performed - a common result for waterlogged remains. A transitional analysis via measurements of anatomical sutures at the pubic symphysis, auricular surface and the cranium suggest an age of 26-30, further to the ossification of the sternum and clavicle previously mentioned. Additional radiography suggested possible rheumatoid arthritis of some thoracic vertebrae, a rarity in those under 30

(Asingh & Lynnerup 2007). The hands were interpreted in early analyses as being those of a noble individual, as they were smooth and with finely kept nails, suspected as being the result of a lack of manual labour during the man's lifetime. However, this was later challenged by Lynnerup (2015, 1011) as also being a result of the bog environment itself, with "the desquamation of the outer epidermal layer" rather than the outcome of a lifetime devoid of manual labour. The aforementioned damage to the cranial and tibial bone were immediately obvious upon initial visual inspection and also confirmed via forensic medical and radiographic analyses to be so deep that it severed the throat, larynx and oesophagus etc. entirely (Lynnerup 2015, 1010). The initial analyses in the 1950s found the hyoid bone to be broken and this was first suggested to be evidence that this was a perimortem injury indicating that the Grauballe Man had been strangled. However, reanalysis of the remains in the early 2000s suggested that the hyoid bone, the cranial fracture and the tibial fracture were all deemed to be post-mortem taphonomic breakages as a result of the weight of the soil following deposition into the bog (Lynnerup 2015, 1010; Lynnerup & Villa 2012).

Grauballe Man was CT scanned and underwent an MRI during the more recent period of analyses in 2001-02 led by Asingh & Lynnerup, which allowed for "a morphological assessment of the tissues" and a "three-dimensional rendering of the auricular surface… which could be used for determining age-at-death" (Lynnerup 2015, 1009). The cranial dimensions were found to be c.10% smaller when compared to skeletons from non-bog environments from the same period, but Lynnerup suggests that "one should consider whether these smaller dimensions reflect that the Grauballe Man really was smaller than his contemporaries, or whether this is due to diagenesis" (Lynnerup 2015, 1008-09).

The dimensions taken did allow for a facial reconstruction to be completed by Caroline Wilkinson, a British anthropologist and specialist in forensic facial reconstruction, despite the deformation of the skull due to taphonomic change (fig.26). As discussed in the external factors, the stomach contents of the Grauballe Man were analysed by Hans Helbæk in 1958 who identified up to 66 different species of plants present, noting that the lack of fruit could be an indicator of a winter diet, where foodstuffs were perhaps more scarce (Lynnerup 2015, 1010). These results were later reassessed and confirmed in 2007 alongside isotopic analysis of the hair which still remained in place, which suggested that the Grauballe Man maintained a largely terrestrial diet rather than marine, and the majority of his protein sources were from animal rather than plant-based sources (Harold et al, 2007; Lynnerup 2015; Moesgaard Museum 2021).

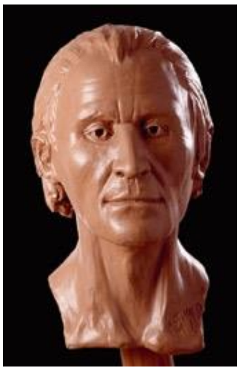

Fig. 26 – Grauballe Man: Moesgaard Museum (2021) - facial reconstruction of Grauballe Man by Caroline Wilkinson

The use of a forensic scoring method

For the case studies, the adapted scoring method by Heaton et al (2010) was used (see fig. 29 below) as this was specifically adapted from the method developed by Megyesi et al (2005) for use in relation to aquatic depositional environments. The forensic scoring method uses three sections: the face, body and limbs.

'FADS' relates to the descriptive stages for decomposition observed in the face and the assigned facial aquatic decomposition score; 'BADS' relates to the descriptive stages for decomposition observed on the torso and the assigned body aquatic decomposition score; and 'LADS' relates to the descriptive stages for decomposition observed in the limbs and the assigned limbs aquatic decomposition score.

FADS - analysis of the face and head

Fig. 27 – Grauballe Man: Moesgaard Museum (2021) - Grauballe Man's head (colour)

The Grauballe Man would not fit into any of the later categories for the FADS as he was overall very well preserved (fig.27). 8 would not apply as the skull was not disarticulated from the body but was laid in a somewhat awkward position due to the injury to the neck and the falling back of the head. There is no adipocere formation mentioned in the research literature used for this work.

Both 7 and 6 would not apply as the cranium did not see any skeletonisation, nor did the mandible and/or maxilla. 5 could not be applied to the Grauballe Man as the head hair remained in place and was not sloughing off. Although the skin is tanned dark, it could not be said that a green/black discolouration would be applicable to these remains. 4 could not apply as the skin of the face was present and well preserved (fig.28).

Fig. 28 – Grauballe Man: Moesgaard Museum (2021) - Grauballe Man's head (in situ, black & white)

3 could not apply here as there were no signs of animal activity or predation as the body was deposited into the bog where no such activity could take place. No entomological activity was

discussed in the research literature. Overall, the face and head retain their skin which was tanned a darker shade due to the long period of time in which the remains were present in the bog, plus the additional tanning as a result of the preservation processes.

The remains of the face/head do not show any sloughing off of skin and bones are not exposed through the process of decomposition. The deformative change seen in the skull and any bone exposed through that was determined to be taphonomic change as a result of the weight of the soil above the remains, not via decomposition. For this reason, the Grauballe Man was given a FADS score of 2 or 3, as there were found to be visible changes so 1 could not be applicable, but there were generally minimal changes to his appearance attributable due to the process of decomposition, other than the tanning process of the skin due to geochemical composition of the bog and some clear change to the areas of the eyes and nose.

	Points	Description
FADS	1	No visible changes.
	2	Slight pink discolouration, darkened lips, goose pimpling.
	3	Reddening of face and neck, marbling visible on face. Possible early signs of animal activity/predation - concentrated on the ears, nose, and lips.
	4	Bloating of the face, green discolouration, skin beginning to slough off.
	5	Head hair beginning to slough off - mostly at the front. Brain softening and becoming liquefied. Tissue becoming exposed on face and neck. Green/black discolouration.
	6	Bone becoming exposed - concentrated over the orbital, frontal, and parietal regions. Some on the mandible and maxilla. Early adipocere formation.
	7	More extensive skeletonisation on the cranium. Disarticulation of the mandible.
	8	Complete disarticulation of the skull from torso. Extensive adipocere formation.

Fig. 29 – Grauballe Man: FADS or facial aquatic decompositional score, as per the forensic scoring method of Heaton et al (2010)

BADS - analysis of the body/torso

Fig. 30 – Grauballe Man: Moesgaard Museum (2021) - Grauballe Man torso 1 (black & white)

Similarly to the FADS analysis, the later point stages of the scale could not be applied to the remains of the Grauballe Man. 8 would not be applicable as the body was not completely skeletonised nor disarticulated. 7 could not be applied as the organs were still present, even if shrunken, adipocere formation was not discussed in the literature and bone was not exposed through the skin (fig.30 & 31).

There are some areas of the body section of Grauballe Man where the bone is very visible through the layer of skin, but it is not exposed. 6 could also not apply here as organs and bones were not found to be exposed. 5 could also not apply as the one testicle still present was not found to be swollen but rather shrunken somewhat as per the internal organs. Fat and tissues were not exposed.

Fig. 31 - Grauballe Man: torso 2 (colour)

4 would not be applicable to the Grauballe Man as no skin slippage was present. Skin on the left side of the torso is noticeably different from the way the skin would appear during life, but this is not regarded as skin slippage as the skin is still present throughout the entire body area, with a leather-like appearance. 1 could not be applicable as there were clear marked visible changes throughout the torso. All skin is present with some minor changes in the appearance, but the torso is clearly caved in and the organs were noted as shrunken and preserved, vastly reduced in size. As such, Grauballe Man was given a BADS score of 2-3.

	Points	Description
BADS	1	No visible changes.
	2	Slight pink discolouration, goose pimpling.
	3	Yellow/green discolouration of abdomen and upper chest. Marbling. Internal organs beginning to decompose/autolysis.
	4	Dark green discolouration of abdomen, mild bloating of abdomen, initial skin slippage.
	5	Green/purple discolouration, extensive abdominal bloating - tense to touch, swollen scrotum in males, exposure of underlying fat and tissues.

	6	Black discolouration, bloating becoming softer, initial exposure of internal organs and bones.
	7	Further loss of tissues and organs, more bone exposed, initial adipocere formation.
	8	Complete skeletonisation and disarticulation.

Fig. 32 – Grauballe Man: BADS or body aquatic decomposition score, as per the forensic scoring method of Heaton et al (2010)

LADS - analysis of the limbs, hands and feet

Fig. 33 - Grauballe Man: hand (black & white)

Again, similar to the FADS and BADS sections, the later stages of the Heaton et al (2010) forensic decomposition scale could not apply to the remains of the Grauballe Man. Both 9 and 8 could not apply as there was no skeletonisation and the limbs were not at all disarticulated. The bones in the upper limbs were not at all exposed (fig.33). 7 would not be applicable as muscles, tendons and small areas of bone were still covered by the well-preserved skin.

6 on the scale could also not apply as neither the hands nor feet were in the process of degloving - the skin was present, and 5 could not apply as no skin slippage is present. 4 would also not apply in this case as the skin still appears tight to the remains and is certainly not presenting as soggy or loose.

Fig. 34 - Grauballe Man: foot (colour)

Fig. 35 - Grauballe Man: foot (black & white

As per these results, the Grauballe Man would be given a LADS score of 3 due to changes being seen but being relatively minimal, with some wrinkling of the skin on the hands, feet and lower leg areas and the skin on some areas the feet/ankle areas in particular appearing to taking on an appearance of being somewhat thickened. Although the skin on the top of the foot appears thinner and the tendons and bones beneath are clearly visible beneath the layer of skin (fig.35), the skin wrinkling and thickening is particularly visible on the sides of the feet as the foot curves towards the sole around the point of the 5th metatarsal base, and the wrinkling of the thenar eminence area of the thumb/hand (fig.33).

	Points	Description
LADS	1	No visible changes.
	2	Mild wrinkling of skin on hands and/or feet. Possible goose pimpling.
	3	Skin on palms of hands and/or soles of feet becoming white, winkled, and thickened. Slight pink discolouration of arms and legs.
	4	Skin on palms of hands and/or soles of feet becoming soggy and loose. Marbling of the limbs - predominantly on upper arms and legs.
	5	Skin on hands/feet starting to slough off. Yellow/green to green/black discolouration on arms and/or legs. Initial skin slippage on arms and/or legs.
	6	Degloving of hands and/or feet - exposing large areas of underlying muscles and tendons. Patchy sloughing of skin on arms and/or legs.
	7	Exposure of bones of hands and/or feet. Muscles, tendons, and small areas of bone exposed in lower arms and/or legs.
	8	Bones of hands and/or feet beginning to disarticulate. Bones of upper arms and/or legs becoming exposed.
	9	Complete skeletonisation and disarticulation of limbs.

Fig. 36 – Grauballe Man: LADS or limbs aquatic decomposition score, as per the forensic scale of decomposition by Heaton et al (2010)

Results

The forensic scoring method recommends that, when the category is unclear between two, to take the lowest score from the scale. As this is the case for each of the FADS, BADS and LADS, the lowest scores will be used. Additionally, the method denotes that “very rarely does a case show all or even the majority of the descriptions in a scoring category” and that “assigning a score relies on the investigator making an educated assessment of each individual case to select a category that can be described as ‘best fit’” (Heaton et al 2010, 303).

Using data from DMI, the Isenvad station was used for the data, as the closest to Grauballe. This station was set up in October 2002 and data is available from 17 October 2002 (DMI, 2021) as daily, weekly and monthly. The data shows the maximum temperature, minimum temperature and the middle temperature - it is the mean temperature of the monthly which will be used in this case. The overall average daily temperature in central Jylland in Denmark is 7.4°C (DMI 2021; 2014). According to Megyesi et al (2005) “ADD accounts for approximately 80% of the variation in decomposition” and that “decomposition is best modelled as dependent on accumulated temperature, not just time” and Heaton et al note that this seems to be the same for terrestrial decomposition as it is for aquatic decomposition when the temperatures and days are normalised, i.e. comparing a terrestrial burial at 20°C for 5 days to that of an aquatic burial at 5°C for 20 days - “both equate to 100 ADD” (2010, 304).

In the case of the Grauballe Man:
FADS - 2   BADS - 2   LADS - 3

Out of a maximum potential TADS of 25, for the Grauballe Man: FADS 2 + BADS 2 + LADS 3 ∴ TADS = 7

Grauballe Man was dated c.390BC - i.e. 2410 years old.
2410 years * 12 = 28,920 months
2410 years * 365 = 879,650 days

ADD = ADT - base temperature
ADD = 7.41 - 4 ∴ ADD = 3.41

3.41 * 879.650 days
ADD = 2,999,606, i.e. = 2.999606×10^6, i.e. 3.00×10^6

These results and the associated ADD number will be discussed in the following section in regard to the other case studies and the wider results of this study.

3.2.2. England: Worsley Man

Background

Worsley Man was found on 18 August 1958 by a local employee of the peat industry in the Astley Moss area of Manchester in north-west England (fig.37), the surrounding area of which would have been characterised by pastureland, seasonal use of wetter grazing and an “exploitation of the bogs” (Giles 2020, 236). Where the bog body of the Grauballe Man was similarly found by peat cutters just a handful of years prior, the Worsley Man was found as a partially fleshed skull only and is therefore perhaps better termed a ‘bog head’, rather than a bog body. The local police were informed of the find and an extensive search of 252 surrounding acres, just over $1km^2$, was immediately carried out in order to determine if further remains would be located. However, no additional remains were uncovered in this process (Giles 2020, 217).

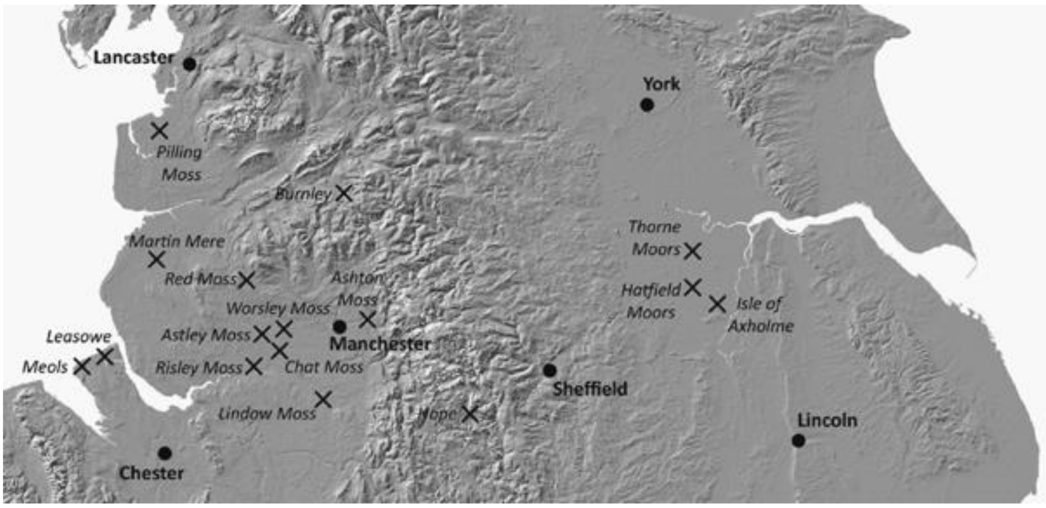

Fig. 37 – Worsley Man: Giles (2020, 237) - the north-west English landscape, showing sites of importance in the late Iron Age and early Roman period sites, with Worsley Man's location of Astley Moss marked 10 miles to the west of Manchester

The remains were taken to the University of Liverpool for initial analysis which was carried out initially by Dr A. St Hill the following day post-excavation (Giles 2020, 217). The remains were assessed as being those of a young adult male of around 20-40 years old of Asian ancestry "due to the breadth of the nasal bones" (Giles 2020, 217) and were regarded as having been buried in the ground for "less than a year" (Garland 1995, 104). Following this, the remains were then assessed by a forensic pathologist, Dr. G. Manning, at the Bolton Home Office on 24 August 1958. He reported his findings in October 1958, where he noted "a portion of skull, an upper and lower jaw, the first two and a half cervical vertebrae, some skin above the right ear, a two-inch section below the right ear, a one-inch strip of skin on the right side of the neck and a separate tooth" (Garland 1995, 104) with the bone being noted as having undergone diagenesis as well as being stained a dark brown. Hair was still present on some of the partially fleshed remains, and this was noted as grey and light brown on the front section of the bog head and red in colour toward the back. The jaw was reported as wide with a clear fracture. Following a process of microscopic visual analysis and chemical testing, the shrunken yet preserved brain was found to still be inside the preserved skull of the Worsley Man. Garland also notes (1995, 104) that Dr. Manning's coroner report stated that "some bodies which were 2000 years old, yet in a good state of preservation, had been found in peat bogs on the Continent" and yet he still made his final determination that the remains were in fact somewhere between 100-150 years old (Giles 2020, 219). The result from the coroner reported that, although the remains were 'just' a preserved head without any torso and so on, "in law the remains counted as a body" and he returned an open verdict with the cause of death unknown (Garland 1995, 104-05). Due to the age being determined as at least 100 years old, the remains were regarded as an archaeological find rather than a case to be further processed by the police or require any further involvement by the wider judicial system. As such, the head of the Worsley Man was returned to the original forensic pathologist, Dr. Manning, who donated the find to the Manchester Medical School's Pathology Museum for preservation and storage as an archaeological relic (Giles 2020, 219).

General analysis

Again, as per the Grauballe Man's analysis, the Worsley Man was analysed using the same factors with the aim that the result of each case study would be more directly comparable with one another when the analysis was complete. Descriptions from published material were used for the analysis, with support from climate information from the UK's MetOffice. Descriptive detail from published material and the associated photographs of the remains were used for the forensic analysis.

Intrinsic factors

Generally, the remains of the Worsley Man were found to be in a somewhat preserved state, with flesh and hair remaining on some parts of the skull and missing on others with the bone completely exposed. The hair retains its original colouring in some areas of the remains and has been stained a red colour in others, due to taphonomic change of the bog environment. Some teeth are present, others are not and the right ear is present where the left one is missing, presumably decomposed due to exposure in the bog (Garland 1995, 104-107).

The Worsley Man has been estimated as being around 24-40 years old according to the first pathologist who inspected the remains soon after discovery in 1958. Garland later concluded the remains to be of a young to middle-aged adult male (1995) and the man has most recently been estimated as being aged 26-45 years old, based on the overall dentition and the closed sagittal suture (Giles 2020, 224). In normal adult development, the sagittal suture is the first cranial suture to close, typically at around 22 years of age, followed by the coronal suture at around 24 years old. The lambdoid and squamosal sutures close at around 26 and 60 years respectively (Idriz et al, 2015). Without the remainder of the body with which to build a more complete profile, e.g. through a consideration of the pelvis, it is via the consideration of the Worsley Man's complete dentition and the closure of these various sutures with which he receives his approximate age at death.

Despite having first been estimated as being in the bog for no longer than 100-150 years in the first coroner's report in October 1958, the remains have since received a couple of different dates based on radiocarbon dating. In the first period of analysis from 1987 to the early 2000s, the preserved facial tissue on the right-side of the skull of the Worsley Man was used to find a radiocarbon date of 1800 +/- 70 years BP, i.e. remains from the Romano-British era. Unlike the majority of the bog bodies found in Northern Europe, the Worsley Man was therefore not an example from the Iron Age and was certainly not 100-150 years old as first interpreted (Garland 1995; Denton 2003; Giles 2020, 221). The Worsley Man has been interpreted as biologically male based on osteological analysis of morphological features such as defined brow ridges, a robust and square chin and large nuchal crest (Giles 2020, 222-223), and of Caucasian descent, with Giles noting that “there is no reason to believe we are looking at the remains of anything other than a northern European skull though whether he came from an indigenous population or arrived as a Roman auxiliary or immigrant, we cannot yet tell” (Giles 2020, 223). No discussion of aDNA or isotopic analysis of hair was discussed in the literature, to suggest these interpretations are backed by genetic or isotopic data.

The consulted literature for this case study did not provide any detail or information as to the proposed weight or height of the Worsley Man during his lifetime, but such a determination would be difficult to suggest with any confidence beyond general averages, without any knowledge of, for example, the long bones, with which to make a possible interpretation and a general indication of height. As regards the general degree of health of the Worsley Man, it is noted in the literature that he had complete dentition at the time of death, but only two teeth were recovered during his recovery from the bog (Giles 2020, 220), and a bone sample subjected to histological analysis showed healthy average collagen growth, suggesting an average healthy male at the time of death (Denton 2003; Giles 2020, 221).

Extrinsic factors

The head of the Worsley Man was found on 18 August 1958 in Astley Moss in the Salford area of Greater Manchester, which sits in the north-west of England. Astley Moss is around 10 miles to the west of central Manchester and approximately 6 miles south of Bolton. The area is characterised as moorland and is comprised of naturally wet raised bog peat soils (LANDIS, 2021). The area is today regarded as an SSSI, a Site of Special Scientific Interest, managed by the Lancashire Wildlife Trust as a protected area for conservation purposes. The site is not only archaeologically significant due to the find of the Worsley Man, but also an important site for many heathland, woodland and acidic grassland species and communities including many species of birds, and is one of the last remaining fragments of Chat Moss, an ancient peatland and lowland raised mire (Wigan Council, 2021).

The nearest station for environmental monitoring and temperature recording is Rochdale, just to the north of Manchester. Previously, the UK Met Office maintained a recording station closer to the site at the Manchester airport but this has now closed. Data has been collected in the Rochdale station from 1981, with an average annual temperature of 9.41°C and an average annual humidity of 82.3% (MetOffice, 2021). With England's national average temperature ranging from 8°C in the north to 11°C in the south (MetOffice, 2007), the average annual temperature in this area of Greater Manchester is in the lower end of the spectrum but still within the general national annual average and average for a more northern area. The annual average rainfall from the Rochdale station is 1118mm and, with the average annual rainfall for England sitting just below 1000mm, this is generally slightly above average but quite common for the north-west area of England (MetOffice, 2021 [2]).

The presence of clear entomological activity in the remains of the Worsley Man was not specifically discussed in any of the research literature considered for this case study. Giles does discuss that the first period of analyses from 1987 noted the skin analysed had "significant microbial damage" but it is unclear as to whether this microbial damage stems from entomological activity in the soil, or from the bog environment itself (Giles 2020, 221). As a result, it cannot be easily stated what impact entomological activity could have played a role in the general decomposition of the head of the Worsley Man. The soil type in this area was again not discussed specifically in the research literature for this area in which Worsley Man was located. Peatland is of course generally high in sphagnum moss, but nothing is discussed in the literature regarding soil type. According to LANDIS, an online GIS-based service developed by the University of Cranfield and sponsored by DEFRA (Department for Environment, Food and Rural Affairs, the part of the government responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities), the Astley Moss area is regarded as 'Soilscape 26' "Raised bog peat soils" which are defined as high carbon soils with a surface layer that is dominantly organic, are naturally wet and which have very low levels of fertility. These low levels of fertility are characterised by very acidic to highly acidic soils which have very low numbers of organisms within them, and which support heathland and acid woodland habitats (LANDIS, 2021).

Cultural factors

As regards cause of death, the investigations found a fracture on the right side of the mandible, progressing downwards into an empty socket of the lower right canine tooth. The CT scan analysis was unable to identify if this injury was ante-, peri- or post-mortem. Fractures are visible in the frontal and parietal bones, with a depressed fracture in the bregma region with displaced fragments of skin and bone, indicative of a fracture to the top of the head from a harsh blow. Other injuries will be discussed in more detail within the following subsection on post-excavation analyses and treatment, but generally the cause of death has been interpreted in the research literature as a murder carried out by one or several individuals, delivering several sharp-point blows to the individual followed by beheading, before the deposition of the head into the bog. It is unclear what became of the remainder of the Worsley Man's remains as the head was the only part of the body found. The head appears to have been deposited into the bog alone, without any grave goods and without any clothing or coverage. Thus, the head was 100% exposed to the environmental conditions of the bog itself from its deposition until its discovery in 1958. As only the head was located, there were no further remains to consider, e.g. no last meal could be inferred due to the lack of a stomach with which to assess its contents, and no other wounds, disease or defensive/parry injuries could be inferred or discussed.

Post-excavation analyses and treatment

4 different periods of post-excavation analysis have been identified by Giles (2020) after the initial investigations carried out when Worsley Man was discovered in 1958. It is clear from the descriptions and the photographs considered for this work that metal pins have been inserted into the Worsley Man's head in order to maintain its structural integrity, but it is unclear from the literature exactly when this was completed.

The first period of investigations is noted as taking place from 1987, led by histological specialist J. Denton and forensic pathologist A.N. Garland. During these analyses, samples of skin, hair and the suspected cord from around the neck of the Worsley Man were subjected to biochemical analysis (Garland 1995). The skin indicated peaks for chlorine, calcium and lead, and the suspected cord indicated peaks for chlorine, sodium, silicone and sulphur, but not iron or copper (Garland 1995, 107; Giles 2020, 221). It was during these analyses that the skin indicated "significant microbial damage" (Giles 2020, 221) but it is unclear from the literature if this microbial damage is inferred as caused by the acidic environment of the bog, potential entomological activity or some combination of both. Histological analysis carried out on the suspected cord around the neck of the Worsley Man was found to consist of "thick collagen bands" akin to human and animal tendons. Therefore, at this stage, this 'cord' was interpreted as being of animal origin as a ligature (Giles 2020, 221; Denton et al 2003, 49; Garland 1995, 107).

The surviving cervical vertebrae, CV1 and CV2, were sampled and "revealed normal lamellar collagen orientation indicating that this was a healthy adult at the time of his death" (Giles 2020, 221). Additionally, it is noted that the immediate cessation of decay leading to the level of preservation seen indicates the head of the Worsley Man was placed into the bog very soon after the decapitation took place, if not immediately after the event (Denton 2003; Giles 2020, 221). Radiocarbon dating during this period of investigation indicated that the remains were 1800 years old ± 70 years, with the Worsley Man then being dated during the Romano-British period era, not Iron Age as is common for most Northern European bog bodies, and certainly not the 100-150 years old indicated during the first coroner's report in October 1958.

The next phase of analyses were led by Richard Neave and John Prag from the Unit of Art in Medicine at the University of Manchester during 2000-01, with the main aim of creating a facial reconstruction of the Worsley Man, similar to the Grauballe Man over in Denmark as previously discussed. To do so, the Worsley Man's head was subjected to a CT scan whereby it was indicated that not only did the man receive a severe head trauma, a wound behind his remaining right ear and the eventual decapitation, but there was evidence of prior serious injury to the man's face before the blows that killed him. The Worsley Man received an ante-mortem injury to his face "comprising a major 'step fault' at the tooth line and a misplaced but healed piece of bone in the nasal septum with a fracture line defect in the left orbit" (Giles 2020, 221; Denton et al 2003, 49). This was suggested as evidence of a blow to the face from the right side in an upwards direction, through the nose and into the eye socket which had healed but which resulted in chronic sinusitis "visible in the deformation of the right front nasal bone" (Giles 2020, 221).

A third period of analysis began in 2010 led by specialists from both the University of Manchester and the University of Nottingham, to give more insight into the death of the Worsley Man via the latest non-invasive and non-destructive methods. Further CT scanning revealed a loose piece of bone embedded in the neck tissue with an irregular profile, suspected as a shard of bone sheared off during decapitation (Giles 2020, 223).

The latest period of analysis began very recently in 2018, with Giles noting (2020) that much of the work is ongoing and as yet unpublished, with this text being the only reference point for these analyses. The latest work has included specialists from the Manchester University and Manchester Museum research teams and a proteomics expert, a specialist from the Henry Moseley X-Ray Imaging Facility, a hair isotope specialist from the University of Bradford and a forensic expert from the University of Bournemouth. A radiocarbon date has been suggested as AD131-251 at 95.4% probability (Giles 2020, 223), reiterating the dating of the Worsley Man to the early to mid-Romano-British period and is thus comparable in date to the much more ‘famous’ Lindow Man. The work confirms his assessment as an adult male of around 26-45 years old, based on the defined brow ridges, a robust and square chin, and a large nuchal crest, i.e. where muscles attach to the base of the skull which is usually smoother in biological females and more prominent and/or hooked in appearance in biological males. With these features, the ancestry of the Worsley Man has been determined as Caucasian, with the research teams noting “there is no reason to believe we are looking at the remains of anything other than a northern European skull” but also noting that this does not differentiate as to whether the man would have been an indigenous individual to the British Isles at the time, a Roman soldier, an immigrant or an ‘other’ (Giles 2020, 223; fig.38).

Fig. 38 – Worsley Man: Giles (2020, 223) - facial reconstruction of the Worsley Man, University of Manchester

Giles notes much more detail surrounding the injuries sustained by the Worsley Man; a significant sharp-wound trauma sustained to the top of his skull causing fractures to the left parietal bone and the bregma of approximately 6cm in length, which is suspected as causing the breakage of the lower right first molar (Giles 2020, 224; fig.39). Additionally, there are additional fractures radiating from the foramen magnum on both sides of the skull, with linear fractures of the occipital bone and the sphenoid (fig.40) which Giles et al note as subsidiary fractures resulting from the sheer force of the blow to the top of the skull, from an axe or other heavy wide-bladed weapon (Giles 2020, 224).

Fig. 39 – Worsley Man: Giles (2020, 225) - injuries sustained to the top of the cranium

Fractures to the nasal cavity, cheek and right jawline which were initially interpreted by Denton et al (2003) as ante-mortem and healed fractures have been interpreted by this latest work as “post-depositional compression and fracture caused by the bog” and thus are interpreted as taphonomic rather than the result of further injury.

Further to these reinterpretations, Garland (1995) interpreted an exterior flesh injury of 28mm long around the remaining ear of the Worsley Man. This latest work (Giles 2020) measures the injury at 5.75cm but notes this could be the result of damage to the remains resulting from post-excavation handling and treatment. Beneath this flesh wound is a very fine 14mm length sharp-force cut to the right mastoid process, with a damage ratio of 2:1 external flesh to bone which "may be the first time that the forensic examination of an external/internal wound site has been possible for a bog body" (Giles 2020, 226; fig.41).

Fig. 40 – Worsley Man: Giles (2020, 225) - subsidiary fractures from the foramen magnum, resulting from the force of the injury seen above in fig.30

Fig. 41 – Worsley Man: Giles (2020, 226) - 2:1 flesh:bone injury resulting from sharp-force cut to the right mastoid process

The decapitation itself is noted as leaving a small 5mm wide and 10.55mm deep gash in the left-side of the mandible, suggesting a sword or axe was used to decapitate the Worsley Man, and with the discoloured and sharp-edged unhealed bone marking this injury as perimortem. It is the decapitation which caused the small piece of bone to become embedded into the neck tissue (fig.42 & 43) which was revealed fully by a 3D scan of the head.

This additional scan confirmed that both the initial 1950s forensic assessment and the previous work in the 1990's (Garland 1995) were indeed correct, with decapitation taking place at CV3, slicing the third vertebrae in 2 and leaving CV1 and CV2 whole. Giles notes the interpretation of this final injury as evidence the Worsley Man faced two attempts at decapitation, the first injuring his jaw, the second successful in its attempt (2020, 227).

Fig. 42 – Worsley Man: Manchester Evening News (2014) - 3D scan at the Manchester X-Ray Imaging Facility revealed a sharp, pointed object hidden deep within Worsley Man's neck

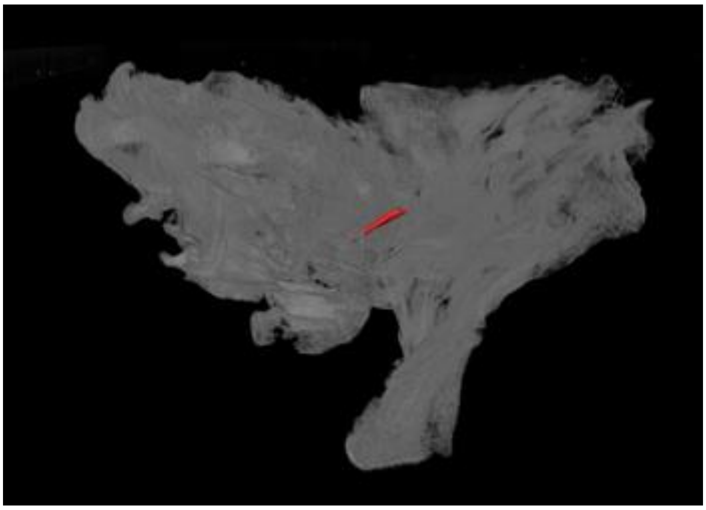

Fig. 43 – Worsley Man: Manchester Evening News (2014) - 3D scan at the Manchester X-Ray Imaging Facility revealed a sharp, pointed object hidden deep within Worsley Man's neck

The suspected 'cord' around the Worsley Man's neck was interpreted as a ligature, and underwent additional CT scans during 2013 (MXIF, 2013) and during the latest period of work (Giles 2020, 228) whereby it was also analysed via proteomic analysis. This latest analysis found the 'cord' to not be a ligature similar to animal or human tendon, but was actually a piece of the man's own neck tissue "torn from the wider flesh of the neck, which is why it appears to pass high up into the anterior flesh below the right ear" (Giles 2020, 228). Thus, the 'cord' is not a cord at all, but simply just a piece of the man's own anatomy, incorrectly interpreted as another act of peri-mortem violence as is common in other bog body finds (Garland 1995, 106). Beyond the work of Giles (2020) and the associated research papers noted within her work, and several local newspaper reports, it appears that there is actually very little information regarding the Worsley Man in the public sphere. This is especially pronounced and notable when compared to the attention received by other English bog body finds, such as the Lindow bog bodies, particularly Lindow II or 'Lindow Man'.

The use of a forensic scoring method

As per the Grauballe Man, the forensic scoring method by Heaton et al (2010) was used due to its adaptation from the Megyesi et al (2005) scale for assessing decomposition in an aquatic environment.

FADS - analysis of the face and head

Fig. 44 - Worsley Man: head, anterior view

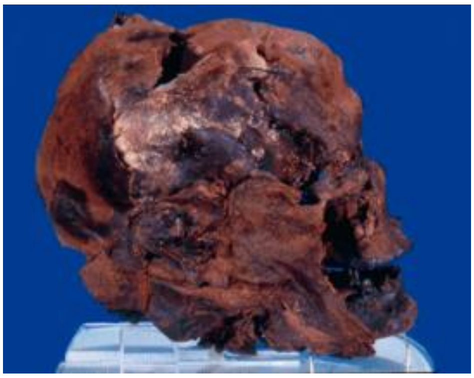

Fig. 45 - Worsley Man: head, right-lateral view

For the case study of the Worsley Man, the facial score is the only section that it is possible to complete using the Heaton et al (2010) scale due to the limited remains found (fig.44). Although skin does remain on the skull (fig.45), it is noted that it is just 20% of the surface and that “all of the bone has been decalcified by the action of the organic acids in the peat bog” (MXIF, 2013). Any of the scores regarding sloughing off of skin and discolouration would not apply here, as the cranium and mandible is 80% skeletonised. For this reason, a score lower than 7-8 would seem unreasonable to assign to these remains.

However, it must be noted that the mandible is not disarticulated as per 7, and the disarticulation of the skull from the torso as per 8 is due to decapitation and not decomposition or taphonomy specifically. Additionally, there is no adipocere formation discussed in the literature.

	Points	Description
FADS	1	No visible changes.
	2	Slight pink discolouration, darkened lips, goose pimpling.

	3	Reddening of face and neck, marbling visible on face. Possible early signs of animal activity/predation - concentrated on the ears, nose, and lips.
	4	Bloating of the face, green discolouration, skin beginning to slough off.
	5	Head hair beginning to slough off - mostly at the front. Brain softening and becoming liquefied. Tissue becoming exposed on face and neck. Green/black discolouration.
	6	Bone becoming exposed - concentrated over the orbital, frontal, and parietal regions. Some on the mandible and maxilla. Early adipocere formation.
	7	More extensive skeletonisation on the cranium. Disarticulation of the mandible.
	8	Complete disarticulation of the skull from torso. Extensive adipocere formation.

Fig. 46 - Worsley Man: FADS or facial aquatic decomposition score, as per the forensic scale of decomposition by Heaton et al (2010)

BADS - analysis of the body/torso

This is not possible to complete due to the head being the only body part present.

	Points	Description
BADS **NOT APPLICABLE**	1	No visible changes.
	2	Slight pink discolouration, goose pimpling.
	3	Yellow/green discolouration of abdomen and upper chest. Marbling. Internal organs beginning to decompose/autolysis.
	4	Dark green discolouration of abdomen, mild bloating of abdomen, initial skin slippage.
	5	Green/purple discolouration, extensive abdominal bloating - tense to touch, swollen scrotum in males, exposure of underlying fat and tissues.
	6	Black discolouration, bloating becoming softer, initial exposure of internal organs and bones.
	7	Further loss of tissues and organs, more bone exposed, initial adipocere formation.
	8	Complete skeletonisation and disarticulation.

Fig. 47 - Worsley Man: BADS or body aquatic decomposition score, as per the forensic scale of decomposition by Heaton et al (2010)

LADS - analysis of the limbs, hands and feet

This is not possible to complete due to the head being the only body part present.

	Points	Description
LADS NOT APPLICABLE	1	No visible changes.
	2	Mild wrinkling of skin on hands and/or feet. Possible goose pimpling.
	3	Skin on palms of hands and/or soles of feet becoming white, winkled, and thickened. Slight pink discolouration of arms and legs.
	4	Skin on palms of hands and/or soles of feet becoming soggy and loose. Marbling of the limbs - predominantly on upper arms and legs.
	5	Skin on hands/feet starting to slough off. Yellow/green to green/black discolouration on arms and/or legs. Initial skin slippage on arms and/or legs.
	6	Degloving of hands and/or feet - exposing large areas of underlying muscles and tendons. Patchy sloughing of skin on arms and/or legs.
	7	Exposure of bones of hands and/or feet. Muscles, tendons, and small areas of bone exposed in lower arms and/or legs.
	8	Bones of hands and/or feet beginning to disarticulate. Bones of upper arms and/or legs becoming exposed.
	9	Complete skeletonisation and disarticulation of limbs.

Fig. 48 - Worsley Man: LADS or limbs aquatic decomposition score, as per the forensic scale of decomposition by Heaton et al (2010)

Results

The forensic scoring method recommends that, when the category is unclear between two, to take the lowest score from the scale. In this case, this can only apply to the FADS score, which was assessed at 7 or 8. As the FADS score is the only one of the three scores possible to assess when using the Heaton et al (2010) forensic scoring method since only the head remains, the score of 7 would be used.

Using data from the UK's Met Office (2021) the nearest station is Rochdale, as discussed. From this station, there is an average annual temperature of 9.41°C (MetOffice, 2021). It is this temperature which will be used to calculate the proposed ADD.

In the case of the Worsley Man:
FADS - 7   BADS - n/a   LADS - n/a

Out of a maximum potential TADS of 25, for the Worsley Man: FADS 7 + BADS n/a + LADS n/a ∴ TADS = 7

Worsley Man was dated AD131-251 - c.1889-1769 years old - mean = 1829
1829 years * 12 = 21,948 months
1829 years * 365 = 667,585 days

ADD = ADT - base temperature
ADD = 9.41 - 4 ∴ ADD = 5.41

5.41 * 667.585 days
ADD = 3,611,634, i.e. = 3.611634×10^6, i.e. 3.61×10^6

Despite the fact that only one of the three scores could be used for this case study of the Worsley Man, there is still a very similar result in terms of the ADD number when compared to the Grauballe Man case study which used all three scores (FADS, BADS and LADS). These results will be discussed in the following section in relation to the other case studies and the wider results of this study.

3.2.3. Ireland: Clonycavan Man

Fig. 49 – Clonycavan Man: Kelly (2012, 223) - Clonycavan Man, Co. Meath, found in the debris of a peat-screening machine in February 2003

Background

The Clonycavan Man was found unexpectedly and by accident in Clonycavan in Ballivor, in the west of Co. Meath, Ireland, in February 2003 (Kelly 2006, 2012; Villa & Lynnerup 2012). Clonycavan is located just 40 miles north-west of the city of Dublin, and just 25 miles from where another bog body, Old Croghan Man, was found in Co. Offaly 4 months later in June 2003. The remains were found by a member of staff at a peat extraction facility, having been torn apart by a peat cutter and having dropped out of a piece of machinery before being found in the waste peat there (Irish Times, 2006). As a result, the exact place of the Clonycavan Man's deposition into the bog environment is unknown (Kelly 2006, 26). Clonycavan Man was found as a head, torso and the majority of the arms but no hands (see fig.49), the rest having been torn away by the machinery of the peat extraction facility. Post-abdominal remains were not located after the recovery of the torso from the waste peat location, similar to the case of the Worsley Man's head. The Bog Bodies Research Project was set up by the Museum of Ireland after finding Clonycavan Man in Co. Meath and Old Croghan Man in Co. Offaly. Initially the police (An Garda Síochána, known as the Gardaí) and the forensic pathologist were called in response to finding the human remains, but it quickly became clear this was a case for archaeological investigation. As a result, the Clonycavan Man remained with the Museum of Ireland and 35 specialists, many with extensive experience working within bog body research, worked together with staff from the Irish Antiquities Division and the Conservation Department of the Museum itself. The post-excavation work took place over a period of 18 months and involved many different analyses, including CT scanning, MRI scanning, palaeodietary analysis, fingerprinting and fingerprint analysis, histological sampling and assessment, pathological analysis, etc (Museum of Ireland, 2020). During this time, the remains of Clonycavan Man were kept in wet peat in refrigerated storage, at a stable and consistent temperature of 4°C (Villa & Lynnerup 2012, 138).

General analysis

As per the Grauballe Man and Worsley Man, the remains of the Clonycavan Man were analysed using the same factors, with the aim that the result of each case study would be more directly comparable with one another when the analysis was complete. Descriptions from published material were used for the analysis, with support from climate information from Met Éireann (The Irish Meteorological Service). Descriptive detail from published material and the associated photographs of the remains were used for the forensic analysis using the forensic scoring method of Heaton et al (2010).

Intrinsic factors

As discussed above, the remains of the Clonycavan Man were found as just the torso, head and the majority of the arms without hands, having been torn apart by peat cutting machinery and found in the waste peat at the site in Clonycavan, Co. Meath. The remains were found to consist of leather-like skin and red hair, both tanned by the chemical conditions of the bog environment. The skull was deformed and flattened by the weight of the soil in the depositional environment. The remains were completely mummified, with the remains of the limbs shrunken in size and with completely decalcified bones via the process of diagenesis, again from the environmental conditions of the bog itself. No post-abdominal remains were found; no hands were attached to the remains of the Clonycavan Man and the forearms were ripped open - the position of the rip across the body and the forearms suggests that the peat cutting machinery was responsible for the tears/separation. Despite the damage from the torso down, it is noted in the research literature that “the internal organs were preserved partially”. The head, though deformed in shape, was intact with “clearly distinguishable face and a very distinctive hairstyle”, the latter of which consisted of the back of the hair cut down to approximately 2.5cm long, with the top section grown to around 20cm, with the longer hair gathered up into a bundle on top of the man’s head (Kelly 2006 [3], 57; 2012, 234).

There was no indication of an age range for the Clonycavan Man specified in the literature. The remains were described as an adult male, a young adult male, etc. but no actual age specified. For example, in Kelly (2007, 28) we find the description that “workers discovered the preserved body of a young man in a peat-screening machine”, yet ‘young man’ does not specify an estimated age bracket for the remains of the Clonycavan Man. In a separate interview piece, Kelly is noted as commenting that “all the ritually killed bog bodies from the Bronze and Iron Ages in Ireland were young males aged, say, 25 to 40” (Kelly 2015, 36) and therefore we can presume that Clonycavan Man as a ‘young male’ could fit into this bracket.

There is, again, nothing specific in the research literature denoting what analyses were carried out to denote the remains as male specifically, but as the pelvis, genitalia and the long bones are missing due to the damage caused by the peat extraction machinery, we can presume that sex estimation was carried out based on a combination of the preserved facial features and the morphological and/or anthropometric osteological analyses of the skull (e.g. Buikstra & Ubelaker 1994). In the absence of the pelvis and long bones, alternative or additional sex estimation methods could involve the assessment of the sternum (e.g. Bongiovanni & Spradley 2012) and/or humeri (e.g. Ali & Elbaky 2016) but the use of such methods is not clarified in the literature for this case study.

The remaining teeth of the Clonycavan Man were radiocarbon dated as 392BC to 201AD (Kelly 2006 [2] & [3]), placing him in the time period of an Iron Age bog body find. From the remains, the Clonycavan Man is estimated as having a height of around 5ft 2 inches and “of slight build and diminutive stature” (Kelly 2007, 78; 2012, 234) and, as there is no discussion of DNA extraction and analysis in the literature, it is assumed that Clonycavan Man could be, as Kelly suggests (2007, 2015) a member (or deposed leader) of an indigenous Irish tribe.

Although it was found to be suggested that “like Grauballe Man and Lindow Man, both men [Clonycavan Man and Old Croghan Man] were young, showed few signs of physical labour during their lives, and were healthy at the time of their deaths” (Lobell & Patel 2010), this has since been proved to be misleading by Lynnerup (2015) who suggested that the lack of clear physical labour in the hands is a result of the desquamation process of the outer skin layers of the hands as a result of the chemical conditions in the bog, and should not be interpreted as evidence of a lack of clear physical labour during their lifetime.

Extrinsic factors

As previously mentioned, the remains of the Clonycavan Man were found in the waste peat of a peat extraction facility at Clonycavan in Ballivor, in Co. Meath, having been dislodged from their original depositional environment. The area is located around 40 miles north-west of central Dublin. Although Co. Meath is a densely populated area, the area of Ballivor is sparsely populated, with a population of just 1809 in the most recent census data (Central Statistics Office - An Phríomh-Oifig Staidrimh, 2016) and the area in which Clonycavan Man would have been found is marked by agricultural land and peat extraction.

The closest station to Clonycavan for environmental monitoring is Rathwire which sits just 9 miles to the west of the peat extraction facility. However, this station records only the average temperature. The closest station to the location which records temperature, humidity, rainfall and soil temperature is the station of Mullingar, which is located 18 miles from the site of Clonycavan in Ballivor. Here, the long-term average (LTA) mean temperature is recorded as 9.2°C, with an LTA soil temperature of 9.9°C. The LTA for humidity in the area is 73%, with an annual LTA rainfall of 970mm (Met Éireann (The Irish Meteorological Service), 2021).

There was no information found and discussed in the research literature as regards the presence of evidence indicating any entomological activity in the remains of the Clonycavan Man. Additionally, there was no discussion surrounding the soil type in the area, beyond brief discussion of the bog environment itself in general terms. There is no information on whether soil type was considered as part of the overall analyses relating to Clonycavan Man, as no information was found to indicate this one way or another.

Cultural factors

According to the research literature, the Clonycavan Man was on the receiving end of some very serious and brutal antemortem and perimortem violence, before his eventual deposition into the bog in Co. Meath. It is noted that “the victim was struck in the face with a blunt object before his head was struck with an axe and his abdomen cut” (Kelly 2019; 2015, 36). The man is reported to have received not just one, but several blows to the head and the cut in the abdomen measured around 40cm, which was interpreted as suggestive of disembowelment (Kelly 2006 [3], 58). Similarly to the other case studies included in this work, there was no clothing found with the remains of the Clonycavan Man, nor was any coverage found such as a cloak or blanket, etc. With this, it is presumed the body would have faced 100% exposure to the bog environment itself.

There are a few additional factors to note in the case of the Clonycavan Man. As previously discussed, the man was short in stature with a distinctive hairstyle, somewhat similar to the modern ‘top-knot’, with long hair piled on top of his head in a tidy bundle. The Clonycavan Man kept his distinctive hairstyle in place using what could be described as an early form of fixing hair gel, and analysis of this gel-like substance indicated that it was produced from a vegetable plant oil mixed with resin sourced from pine trees which were only found in areas of Spain and south-west France (Kelly 2007, 78; National Geographic, 2015). This was interpreted as being a clear sign of the man’s high status, and the ability to command the necessary resources to obtain such luxurious foreign imported goods (Kelly 2007, 78; 2014).

A further additional factor is the nipple mutilation described by Kelly (2012, 336) which is interpreted as a clear sign of the man being demoted from a high-status rank which would render them ineligible for kingship due to the fact that “the suckling of a king’s nipples was an important gesture of submission by subordinates” (Kelly 2012, 239). Interestingly, the same nipple mutilation is seen in the Old Croghan Man found just 25 miles away from the Clonycavan Man in 2003.

Post-excavation analyses and treatment

Since Clonycavan Man was found in February 2003, both his remains and the remains of Old Croghan Man found in June 2003 have undergone many analyses together as part of a long-term research project named the ‘Bog Bodies Research Project’. These findings of this project have resulted in an exhibition titled ‘Kingship and Sacrifice’ at the National Museum of Ireland in Dublin which displays both sets of preserved human remains, two further bog bodies from Ireland and “items of royal regalia, horse trappings, weapons, feasting utensils, boundary markers and votive deposits of butter known as bog butter” (National Museum of Ireland, 2021). In this exhibition, the museum pushes a narrative of bog bodies being the result of sacrificial ritual related to kingship and sovereignty, which in itself continues to perpetuate the common ‘overkill’ theory related to bog bodies (Glob 1965, 1969) some now argue against (Lynnerup 2015; Asingh & Lynnerup 2007). Although the Museum and the research papers published discuss the outcome of the various analyses, there was very little specific information published regarding the process of the analyses themselves. It is noted that “CT scans, MRI scanning, palaeodietary analysis, fingerprinting, histological analysis, pathological assessment, facial reconstruction and so on” was conducted (Kelly 2006 [3], 57) but it seems that there was not a great deal of detail regarding the actual analyses in the published literature for this case study. It is further noted by Kelly (2012, 233) that “a detailed analysis is being prepared as part of a larger review of all the dated Irish Iron Age bog bodies and their European background” but at this date, this is still denoted as ‘forthcoming’. Similar to the Grauballe Man and the Worsley Man, two different facial reconstructions were completed for the Clonycavan Man, one with the University of Dundee (fig.50) and another bust which features in the presentation material at the exhibition in the National Museum of Ireland (fig. 51).

Fig. 50 – Clonycavan Man: Wilkinson et al (2006) - digital facial reconstruction of Clonycavan Man at the University of Dundee

Fig. 51 – Clonycavan Man: Bog Body Research Network - the facial reconstruction bust of Clonycavan Man, part of the National Museum of Ireland exhibition ‘Kingship and Sacrifice’

However, regarding the actual results coming out of the analyses, the result of the pathological assessment has already been discussed in terms of the violence and injuries inflicted on the man, and the radiocarbon dating analysis was able to date the Clonycavan Man to 392BC – 201AD (Kelly 2006 [2] & [3]; Villa & Lynnerup 2012, 131). Chemical analysis of the preserved hair and fingernails were able to show that the Clonycavan Man's diet was rich in vegetables. The final meal itself did not survive, thus stomach contents could not be analysed, however the hair analysis "indicated that for four months prior to his death he had a plant-based diet, suggesting that he may have died in the autumn before the onset of a meat-rich winter diet" when the consumption of fresh vegetables would not have been possible (Kelly 2014; 2006 [3], 58). The Clonycavan Man's CT scan, and the scans of other Irish bog bodies, were perhaps less revealing in terms of the types of tissues that survived, compared to other bog bodies which underwent the same analysis, for example in finds from Denmark. Where the scans of the latter were able to clearly reveal different types of tissues during the CT scans of their remains, the scans of Clonycavan Man resulted in a homogenous grey colour for all tissues in the output of the analyses, even in the case of teeth (Villa & Lynnerup 2012, 143; fig.52), revealing very little of the type of tissues which were actually preserved and present in the remaining material.

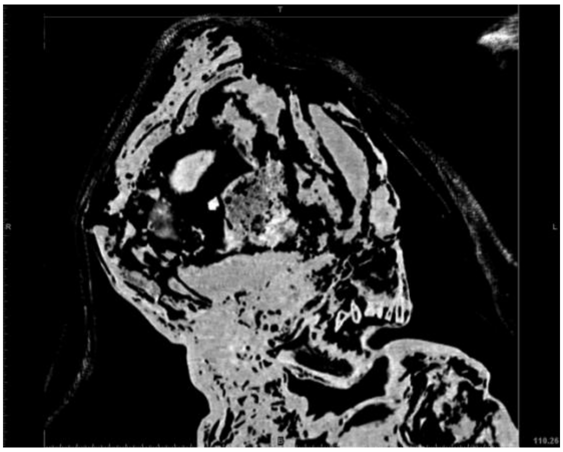

Fig. 52 - Clonycavan Man - Villa & Lynnerup (2012, 13) / Coronal view of a CT-scan

Finally, it is noted that both the Clonycavan and Old Croghan men were found along ancient tribal boundaries, with "up to forty probable Iron Age bog bodies in total that appear to fit the same pattern… suggesting that some bodies were dismembered for internment at a number of different places along tribal boundaries" which has been interpreted as protective in nature, and/or sacrificial ritual killing associated with new kingship (Kelly 2006 [3], 58). Although too much a consideration of 'why' the bodies were deposited into the bog is beyond the scope of the research aims and research questions of this work specifically, it is interesting to note this interpretation of the material on a minor scale, for later consideration of the archaeological narratives which are constructed and perpetuated, in relation to bog bodies, which will follow in the next chapter.

The use of a forensic scoring method

As per the preceding case studies of the Grauballe Man and the Worsley Man, the forensic scoring method by Heaton et al (2010) was used to assess the remains of the Clonycavan Man due to its specific adaptation from the Megyesi et al (2005) scale for assessing decomposition in remains recovered from an aquatic environment.

FADS - analysis of the face and head

Fig. 53 - Clonycavan Man: Kelly (2014) – head, left-lateral view

For the analysis of Clonycavan Man according to Heaton et al (2010)'s decomposition scale, the deformation of the skull to a flattened shape (fig.53) can quite clearly be interpreted as a result of taphonomic factors, with the weight of the soil causing non-decompositional change. The face is well preserved, with ears, eyes, nose and mouth with a strong jawline clearly present and distinguishable. The skin on the face is well preserved, with changes beyond the tanning of the skin present around the eyes, nose and mouth especially. It is unclear if this is a result of taphonomic factors, or whether this could be the result of tissue predation from an entomological source. Due to the physical nature of the bog, this seems unlikely, but it is not discussed in the literature consulted. For the FADS score, 8 could not be assigned to these remains as the skull remains attached to the torso and no adipocere formation is visible nor is it discussed in the research literature. 7 could not be assigned to the Clonycavan Man as the mandible is not disarticulated from the cranium and there is no general skeletonisation of the head.

Fig. 54 - Clonycavan Man: Kelly (2014) - top of head, deformation

Fig. 55 - Clonycavan Man: National Museum of Ireland

The only part of the cranium visible is as a result of the perimortem injuries and due to taphonomic factors resulting from the weight of the soil (fig.54). A score of 6 could not be associated with the remains as bone is not present in the orbital, frontal or parietal bones, nor the mandible and/or maxilla; all bones retain their skin coverage. 5 was interpreted as an inappropriate score due to the hair remaining present and the tissue remaining in place on the face and neck area. 4 was also deemed an inappropriate score as the skin was not found to be sloughing off. Visible changes were obviously present, as discussed (fig.55) therefore a score of either 2 or 3 was deemed Clonycavan Man. This was deemed appropriate due to the overall tanning of the skin, thickening of the skin around the neck and clear visible change around the facial orifices.

	Points	Description
FADS	1	No visible changes.
	2	Slight pink discolouration, darkened lips, goose pimpling.
	3	Reddening of face and neck, marbling visible on face. Possible early signs of animal activity/predation - concentrated on the ears, nose, and lips.
	4	Bloating of the face, green discolouration, skin beginning to slough off.
	5	Head hair beginning to slough off - mostly at the front. Brain softening and becoming liquefied. Tissue becoming exposed on face and neck. Green/black discolouration.
	6	Bone becoming exposed - concentrated over the orbital, frontal, and parietal regions. Some on the mandible and maxilla. Early adipocere formation.
	7	More extensive skeletonisation on the cranium. Disarticulation of the mandible.
	8	Complete disarticulation of the skull from torso. Extensive adipocere formation.

Fig. 56 – Clonycavan Man: FADS or facial aquatic decomposition score, as per the forensic scale of decomposition by Heaton et al (2010)

BADS - analysis of the body/torso

Fig. 57 – Clonycavan Man: Healey (2011) - Clonycavan Man at the National Museum of Ireland, Dublin

Fig. 58 – Clonycavan Man: BBC (2021) – 4,000-year-old cold case

Fig. 59 – Clonycavan Man: Kelly (2014) 40cm cut to abdomen

The torso area is generally well preserved, though obviously very damaged in the lower area as a result of the peat extraction machinery in which the Clonycavan Man was discovered (fig.57 & 58). Overall, the skin is extensively tanned and thickened due to deposition in the bog environment, but is present throughout all of the torso/body area other than the areas torn in the machine. The remains are completely mummified, with thick, leather-like skin coverage and a flattened appearance due to taphonomic factors and the process of diagenesis. The 40cm cut to the abdomen (fig.59) is visible with its rough edges on the left anterior side of the Clonycavan Man's lower torso (fig.57). The cut appears roughly edged but otherwise clean, with no sign of decomposition along what would have been a substantial open wound.

As regards a BADS score, 8 could not be assigned to the remains of Clonycavan Man as there was no sign of visible skeletonisation on the torso, either front or back. 7 could not be assigned as there was no visible or discussed adipocere formation, nor any exposed bone. Additionally, the research literature denotes that the organs were preserved intact. For the same reasons as 7, it was not appropriate to assign a score of 6 or 5 as organs and bones were not exposed in the body/torso. 4 was also not assigned as the BADS score as no skin slippage was visible, nor was it mentioned in the literature. Visible changes were present, with what appears to be some degree of marbling, though it is unclear if this marbling is a result of decomposition or the tanning process. There is a thickening of the skin throughout the torso/body on both front and back of the Clonycavan Man's remains. For this reason, a score of 2-3 was deemed appropriate to assign from the Heaton et al (2010) scale.

	Points	Description
BADS	1	No visible changes.
	2	Slight pink discolouration, goose pimpling.
	3	Yellow/green discolouration of abdomen and upper chest. Marbling. Internal organs beginning to decompose/autolysis.
	4	Dark green discolouration of abdomen, mild bloating of abdomen, initial skin slippage.
	5	Green/purple discolouration, extensive abdominal bloating - tense to touch, swollen scrotum in males, exposure of underlying fat and tissues.
	6	Black discolouration, bloating becoming softer, initial exposure of internal organs and bones.
	7	Further loss of tissues and organs, more bone exposed, initial adipocere formation.
	8	Complete skeletonisation and disarticulation.

Fig. 60 – Clonycavan Man: BADS or body aquatic decomposition score, as per the forensic scale of decomposition by Heaton et al (2010)

LADS - analysis of the limbs, hands and feet

No additional images were deemed to provide any further information or visual aid to the assessment of the Clonycavan Man in terms of the LADS score, other than the images already used above. As the remains were just an intact head, torso and some partial arm remains, the hands and feet could not be considered as factors for inclusion in this section. As can be seen in fig.57 & fig.58, the remaining arms are preserved in terms of their skin coverage but withered from diagenesis in terms of the bone content. Additionally, the forearms have been ripped across above the wrist due to damage caused by the peat extraction machinery. As a result, it is difficult to assign an appropriate score for the remains when the damage caused by the machinery causes only half of the limbs to be present, and the limbs that do remain are also missing the hands and lower arm. A score of 9 was not assigned as there was not a complete skeletonisation of the limbs nor a disarticulation. A score of 8 was not assigned as bones were not exposed. 7 was deemed an inappropriate score as muscles and tendons were also not exposed. 6 was not assigned as there did not appear to be any sloughing off of skin from the remaining sections of arms, rather the skin appeared to be as well preserved as the rest of the remains other than the damage caused by the machinery. 5 was not assigned as no skin slippage was present, nor was it discussed in the research literature. A score of 4 was not deemed fitting as marbling was not noted on the remains, nor mentioned in the research. Visible changes were clearly present and noted, beyond that of a score of 2 which appeared too minimal for the remains presented, as the changes were deemed more extensive than just mild wrinkling. Due to the decomposition state of the remains, it was deemed appropriate to assign a score of 3, with the skin clearly thickened throughout the area of consideration.

	Points	**Description**
LADS	1	No visible changes.
	2	Mild wrinkling of skin on hands and/or feet. Possible goose pimpling.
	3	Skin on palms of hands and/or soles of feet becoming white, winkled, and thickened. Slight pink discolouration of arms and legs.
	4	Skin on palms of hands and/or soles of feet becoming soggy and loose. Marbling of the limbs - predominantly on upper arms and legs.
	5	Skin on hands/feet starting to slough off. Yellow/green to green/black discolouration on arms and/or legs. Initial skin slippage on arms and/or legs.
	6	Degloving of hands and/or feet - exposing large areas of underlying muscles and tendons. Patchy sloughing of skin on arms and/or legs.
	7	Exposure of bones of hands and/or feet. Muscles, tendons, and small areas of bone exposed in lower arms and/or legs.
	8	Bones of hands and/or feet beginning to disarticulate. Bones of upper arms and/or legs becoming exposed.
	9	Complete skeletonisation and disarticulation of limbs.

Fig. 61 – Clonycavan Man: LADS or limbs aquatic decomposition score, as per the forensic scale of decomposition by Heaton et al (2010)

Results

The forensic scoring method recommends that, when the category is unclear between two, to take the lowest score from the scale. As this is the case for the FADS and BADS of the Clonycavan Man, the lowest scores will be used for each of those. Additionally, the method denotes that “very rarely does a case show all or even the majority of the descriptions in a scoring category” and that “assigning a score relies on the investigator making an educated assessment of each individual case to select a category that can be described as ‘best fit’” (Heaton et al 2010, 303) and it is therefore deemed appropriate to choose the best fit for categorisation of each case. Using data from Met Éireann, the Irish National Meteorological Service, the Mullingar station was used for the data, as the closest station to the Clonycavan area in Ballivor, which records all relevant data. As discussed previously, the Irish National Meteorological Service provides publicly accessible data showing annual long-term average or ‘LTA’ figures for temperature, rainfall and humidity, which are used in the process of this work. Here, the long-term average (LTA) mean temperature is recorded as 9.2°C, with an LTA soil temperature of 9.9°C. The LTA for humidity in the area is 73%, with an annual LTA rainfall of 970mm (Met Éireann (The Irish Meteorological Service), 2021). According to Megyesi et al (2005) “ADD accounts for approximately 80% of the variation in decomposition” and that “decomposition is best modelled as dependent on accumulated temperature, not just time” and Heaton et al note that this seems to be the same for terrestrial decomposition as it is for aquatic decomposition when the temperatures and days are normalised, i.e. comparing a terrestrial burial at 20°C for 5 days to that of an aquatic burial at 5°C for 20 days - “both equate to 100 ADD” (2010, 304).

In the case of the Clonycavan Man:
FADS - 2   BADS - 2   LADS - 3

Out of a maximum potential TADS of 25, for the Clonycavan Man: FADS 2 + BADS 2 + LADS 3 ∴ TADS = 7

Clonycavan Man was dated to 392 - 201BC in 2003 - i.e. between 2395 and 2204 years old
∴ mean age = 2299.5 = 2300 years old
2300 years * 12 = 27,600 months
2300 years * 365 = 839,500 days

ADD = ADT - base temperature
ADD = 9.20 - 4 = 5.20

5.20 * 839,500 days
ADD = 4,365,400, i.e. 4.365400×10^6, i.e. 4.37×10^6

3.3. Using a forensic scoring method for bog bodies

This work aimed to use an established forensic scoring method in order to assess three case studies of bog bodies from the case study regions of Denmark, England and Ireland. The case studies were selected at random from all instances of bog bodies deemed to have published research material. As a result of random selection, each of the bog bodies were completely different in their state, with one presenting as a fully preserved body, one presenting as a preserved torso and head, and one presenting as a preserved head alone, in a much more skeletonised state than the other selected case studies. Although the case studies were similar in terms of all being remains recovered from the bog environments of northern European countries, the bodies were very different in nature; not only in terms of being from different countries and from different bogs, but also in terms of the amount of actual 'body' remaining and being left to assess. Despite this, the resulting TADS or 'total aquatic decomposition score' has interestingly been found to be the same in each case, with each resulting in a TADS of 7 out of a maximum TADS of 25, irrespective of location, temperature, soil type, injuries, taphonomic factors or the amount of the body actually remaining for assessment and analysis (fig.62). Where Worsley Man was just analysed as just a bog head and therefore the BADS and LADS could not be assessed, his FADS score was considerably higher due to his considerably more decomposed state. In comparison, Clonycavan Man and Grauballe Man were found to have the same FADS or 'facial aquatic decomposition score', BADS or 'body aquatic decomposition score' and LADS or 'limbs aquatic decomposition score' despite Grauballe Man presenting as a fully preserved body and Clonycavan Man presenting as just a torso and head, with his post-abdominal remains missing and no hands as a result of damage due to the peat extraction machinery in which he was found.

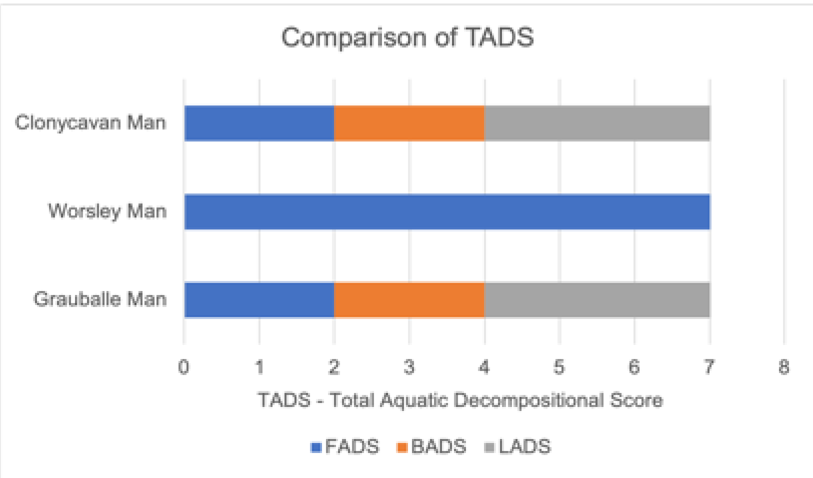

Fig. 62 – Results: A comparison of TADS - total aquatic decomposition score of the three case studies

When comparing each of the case studies in terms of the number of years spent in deposition within the bog with their respective ADT, TADS and ADD, there appears to be a correlation in the data. Where TADS always remains the same at 7 due to the respective FADS, BADS and LADS scores from the first stage of the forensic scoring method seen above (fig.62) a higher ADT seems to correlate to some degree with a higher ADD when considered alongside the length of time spent in the bog. Heaton et al note that "bodies in the water for a prolonged length of time in cooler temperatures and those subjected to warmer temperatures for a shorter time showed similar rates of decomposition" (2010, 306) and this appears to be confirmed in this small, qualitative study and dataset (fig.63). For example, Clonycavan Man's result of a higher number of ADD than Grauballe Man, despite having spent a similar length of time in their respective bog environments, seems to correlate with Grauballe Man's deposition taking place in a location where the average temperature is around 2°C lower on average than that of Clonycavan Man. Similarly with Worsley Man, his ADD number was higher than Grauballe Man despite having spent less time in his bog burial location, as he was buried in an area with a higher ADT. These results appear to, at least qualitatively, confirm Heaton et al's assertion above.

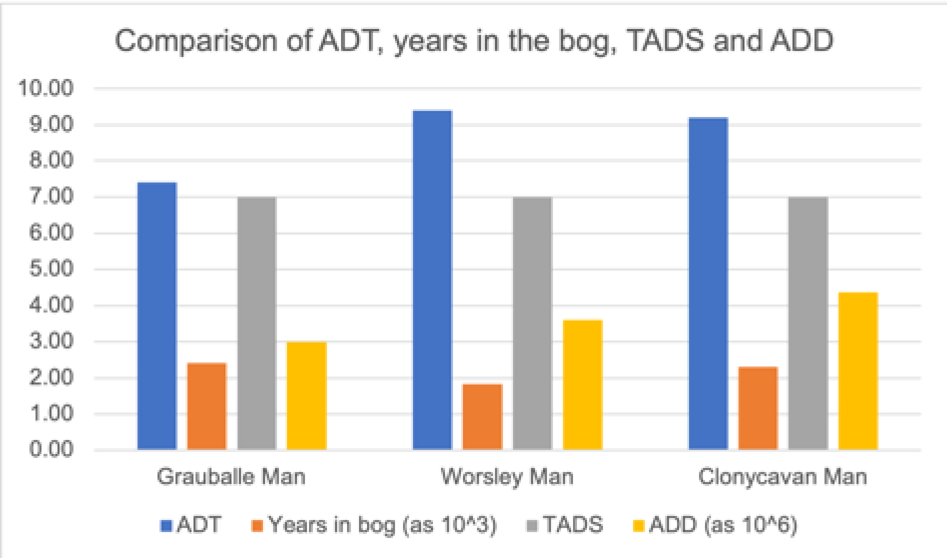

Fig. 63 – Results: A comparison of ADT - average daily temperature, years in the bog, TADS - total aquatic decomposition score and ADD – accumulated degree days

It is deemed appropriate to note that, though these results may not necessarily reflect a statistically significant result in terms of this small and qualitative dataset of just three case studies, there does appear to be a noticeable pattern within the resulting data from the case studies which could warrant further investigation, on a larger-scale quantitative basis.

4. DISCUSSION

4.1. Introduction to discussion

This chapter aims to expand further on the results of the previous chapter and to enter into discussion of those results in relation to the specific research questions of this work. This chapter will discuss the general outcome of the work itself in terms of the methods used and a discussion of the three case studies in general. Further to a discussion of the specific research questions, this final chapter aims to expand further into wider-scale legal and ethical considerations deemed directly relevant to this study, as well as reflections on the process and outcome of this work and some suggestions and considerations for future further research in this topic area. This chapter aims to answer the below research questions in the subsequent subsections, which were:

(1) Using three case studies from within the bog body research history, one each from Denmark, England and Ireland, how has deposition into the bog affected the overall human decomposition and preservation process? How does decomposition in the bog compare to burials in soils, water or the open air?

(2) How is taphonomic change and/or loss differentiated from change resulting from deliberate human action, if at all?

(3) Does a forensic scoring method used for assessing human remains in forensic cases have any potential benefit for archaeology, e.g. if appropriately adapted for implementation in bog body research? Could the field as a whole benefit from increasing forensic knowledge in general, especially in relation to human decomposition/taphonomy, as we work to uncover the buried human past which often includes the finding and recovery of human remains?

4.2. Depositional environment and decomposition: comparison to other environments

As per the introductory chapter of this work, this study was carried out with the basic premise that different depositional environments will inevitably result in different levels of preservation and decomposition of human remains. As the human body is by its very nature an organic entity, it is subject to the natural decomposition process after death of the organism occurs. In order to answer the first of the research questions, it was imperative to not only consider the three chosen case studies in order to understand how the bog environment impacted the process of decomposition there, but to also consider other environments in which human remains may decompose, for effective comparative analysis of the impact of the depositional environment to the variation in the human taphonomic process after death.

In the generally accepted stages of decomposition, the body enters the stage of early post-mortem changes and begins to cool after death in the stage of algor mortis. As the body's natural processes have ceased to function and the cardiovascular system is no longer active, the contents of the body become subject to hypostasis. This is the gravitational pooling of blood in the areas in which the body rests on the ground after death, also known as lividity or livor mortis. It is notable that there can be a lack of livor mortis if the individual has faced a severe antemortem or perimortem trauma or injury, which resulted in considerable blood loss, whereby "the complete absence of livor necessitates a blood loss of at least 65% of the circulating blood volume in adolescents and 45% in infants" (Tsokos & Byard 2016). The body will enter a period of rigor mortis, with all of the body becoming rigid and stiff due to a natural build-up of ATP or adenosine triphosphate, which the body is no longer able to clear due to the lack of oxygen. This stage can be highly variable, with the onset and development dependent on a number of both intrinsic and extrinsic factors which are assessed on a purely case by case basis (Tsokos & Byard 2016; Hayman & Oxenham 2016) but that in general, both extremes of high and cold temperatures can initiate the onset and intensity of this stage, high ambient temperatures accelerate the onset and intensity of rigor mortis. The body would then enter the stage of putrefactive decomposition, where all soft tissues, organs and other materials would begin to decay through bacterial degradation, breaking down proteins and lipids which become energy sources for the bacteria, and with the body progressing towards liquefaction and skeletonisation.

Post-mortem changes and the onset of decomposition is a highly variable process dependent on so many factors. It is noted by Tsokos & Byard that there are general factors which can speed up the onset and the extent of these post-mortem changes, including but not limited to, death in a warm and/or moist environment, the location of the death, any trauma/injury sustained ante- or peri-mortem, the amount of clothing or other body coverage and the presence of arthropods/insects and bacteria. There are similar factors for the deceleration of the onset and extent of the post-mortem changes including, but again not limited to, death in a cool/cold and drier environment, the level of coverage of the body and the absence of arthropods/insects and bacteria, where it is also noted that these factors may slow the rate of post-mortem changes but, in general, do not completely alter the underlying post-mortem biologic processes (Tsokos & Byard 2016). In other words, in the majority of circumstances, the environment will affect the speed of the onset of decomposition and the extent of it, but will not stop the processes entirely.

Decomposition of the body in bog environments

The generally established stages of human decomposition noted above are clearly considerably altered by the very conditions of the bog itself; a generally cool, wet, humid and anaerobic environment, devoid of much entomological activity which can speed up the process. Additionally, as the body is immersed in the bog, any chemicals and odours which would usually be released as part of the decomposition process are unable to attract predators or scavengers to the body (Tsokos & Byard 2016) as they would perhaps be in the case of, for example, a partial submersion in water or a body decomposing in an open air environment, which could leave the body open to possible scavenger activity. In the case of a body submerged into the bog, the normal decomposition process is generally 'paused', so to speak, as a result of the anaerobic conditions of the bog itself. Where the speed of decomposition would usually be increased by bacterial and entomological activity, where such organisms breakdown human proteins which become their energy source, this is suppressed in the anaerobic conditions. The assessment and analysis of the three case studies of this work made it quite clear that the individuals who after their deaths became known as Grauballe Man, Worsley Man and Clonycavan Man must have been placed into the bog very soon, if not immediately, after death occurred. Particularly in the case of Grauballe Man where the whole body is preserved intact (compared to just the head of Worsley Man and the damaged remains of Clonycavan Man) there does not appear to be any sign of decomposition which would suggest the body remained outside of the bog for long after death, according to the stages of decomposition and forensic scoring methods (Hayman & Oxenham 2016; Tsokos & Byard 2016; Magyesi et al 2005; Heaton et al 2010; Gelderman et al 2018 - see Appendices 2-4). The remains clearly retain their skin, with no signs of any washerwoman's hands, any skin slippage or skin sloughing off, which are regarded as some of the earlier stages of decomposition to occur beyond discolouration which, in the cases of the bog bodies, would be extremely difficult to identify due to the general tanning of the skin as a result of the tannins of the peat moss. This seems to also be the case for Clonycavan Man, but the damage from the peat extraction machinery prevents any analysis of post-abdominal remains which could, potentially, have shown a different result. In contrast, in the case of Worsley Man, there was very little skin remaining, at just 20% of the surface (MXIF, 2013). It is also notable that these remains were found to have been in their depositional environment for the least amount of time out of the three case studies, but were from a location with the highest ADT. As was discussed in the Results, the skin analysis showed "significant microbial damage" but it is unclear as to whether this microbial damage stems from entomological activity in the soil, or from the acidic geochemical bog environment itself (Giles 2020, 221). It is also notable that these bog/moss areas in Greater Manchester were often partially drained, and used as areas to dump the city's 'street waste' and sewage, the mixture of natural peat moss combined with natural fertiliser resulting in fertile ground suitable for arable farming and peat extraction, as in the case of Clonycavan Man (Breward 2003). So, although the Astley Moss site was marked as an SSSI or 'site of special scientific interest' in 1989 meaning that the site is now protected, this earlier use of the land for farming and the regular turning over the soil prior to it being discontinued in the 1950s (Breward 2003) could perhaps to some extent explain the Worsley Man's exposure to different depositional conditions, oxygen and the microbial damage which resulted in just 20% skin coverage.

It is suggested in a number of sources (Krompecher 1981; Kobayashi et al 2001; Hayman & Oxenham 2016) that both the environmental temperature and the humidity level are two of the most important contributing factors in determining the onset of early post-mortem changes and the subsequent extent of human decomposition, with both playing "a central role in the colliquation of human tissue after death" (Cockle & Bell 2019, 332). Colder temperatures can result in the slower onset of early post-mortem changes followed by a delayed progression towards the putrefactive stage, if this stage is reached at all, as seen in the cases of bog bodies in general. Cockle & Bell showed that traumatic perimortem injuries resulting in considerable blood loss may impact the progression of decomposition. As blood is composed of 55% liquid, "the loss of fluid from the body may impact the humidity levels of the tissue… [and] the absence of blood within the body may promote mummification of tissues and delay colliquation" (2019, 332), the data from their study showing that blood loss was indeed determined to be a significant contributing factor when it came to assessment of the body and analysis of the forensic decomposition score, suggesting that "increased blood loss may retard the progression of decomposition" (2019, 334) and that the impact of blood loss *must* be taken into account during the assessment of human decomposition. When assessing the cases of Grauballe Man and the considerable blood loss that would have occurred after his throat injury, the case of Worsley Man and his catastrophic head injuries and decapitation, and the Clonycavan Man and the blood loss that would have followed his 40cm abdominal cut, it can be argued that the preservation level of all three cases could have been assisted not only by the geochemical conditions of their depositional environment in the bogs and their generally high humidity levels (at an average of 79-82%, 82.3% and 73% respectively annually), but also by the significant blood loss from their ante- and perimortem injuries, resulting in an overall decelerated process of autolysis and general progression of decomposition.

Where it is clear from both the assessment of the three case studies and wider source analysis that, for the most part, a combination of temperature and humidity plus the cold, damp and anaerobic bog environment itself prevents the progress of the decomposition process of much of the human remains, with the presence of sphagnum and the absence of arthropods or other organisms that could commonly move along decomposition, this is certainly not the case in other burial or depositional environments, which are exposed to varying extrinsic factors.

Decomposition of the body in soil

Similarly to bodies buried in the bog, the level of human decomposition in soil depositions can vary depending on a number of intrinsic and extrinsic factors, including but not limited to temperature, humidity, the level of trauma and injuries, as well as the characteristics of the soil type itself and entomological factors. It is noted by Janaway et al that, although each case is different and the process is actually very complex and variable, “the rate of decomposition of a body on the ground surface is [generally] more rapid than that of a buried body… due to the soil limiting the access by extracorporeal microorganisms and larger animals as well as reducing the rate of gaseous diffusion” (2009, 324); thereby, a buried body should be less decomposed than that of the same body left on the ground surface for an equal period of time.

An experimental qualitative study carried out by Tumer et al investigated the importance of the soil type on the process of decomposition, using 32 wild boar limbs and 4 additional control samples as proxies for human remains, in 4 different soil types in the Ankara area of Turkey - loamy, clayey, organic and sandy (2013, 150). The remains were buried at a depth of 50cm and evaluated at intervals of 3 months and 6 months post-burial to assess their state of decomposition, during the period of May to November 2010. The average temperature, humidity and rainfall readings were recorded for the duration of the study, from the national meteorological service in the study location of Turkey (Tumer et al 2013, 151). In addition to assessing the decomposition state of the limbs themselves, analysis was also carried out on soil samples from each of the burial locations, as well as an analysis of the entomologic activity in each burial location, with the results showing a considerable variation in decomposition dependent on soil type, with loamy and organic soils causing the highest degree of decomposition, leading to the conclusion that “type of soil is one of the most important factors that have affects on decomposition of any organic material in soil” (2013, 155) which, inevitably, includes buried human remains. However, the study itself noted the importance of conducting further research using human remains specifically, and not further proxies (Tumer et al 2013, 155). Although it may have been considered in the actual analyses of the cases and may just not have been written in the resulting published texts, interestingly, the importance of the soil types and textures were not found to be discussed in the research literature from the three bog bodies considered as part of this work.

Decomposition of the body outdoors on the ground surface

The only current study found during the research for this work which addresses human decomposition and the forensic-taphonomic changes outdoors in a European context is that of Alfsdotter & Petaros (2021) which assessed 94 cases in aquatic (51), surface (31), hanging (9) and buried (3) human remains. Where the three case studies in this current work were deemed to each have a TADS of 7 irrespective of the amount of body remaining, the amount of time spent in the bog or the resulting ADD, the result of Alfsdotter & Petaros' work showed TADS scores varying from 4 to 22, with variation resulting from both the amount of time the individual's remains had spent decomposing in the outdoor environment *and* the variation in environmental surroundings due to Sweden's large size. As regards decomposition of the human remains outdoors on the surface compared to the bog environment discussed in this present work, Alfsdotter & Petaros revealed that 12.9% of the surface cases were completely skeletonised, 54.8% of the cases were partially skeletonised and 42% of the surface remains showed a "combination of desiccation and putrefaction and/or saponification" (2021, 7). The desiccation was found to begin in the extremities in the cold and somewhat dry environment of the ground surface, and it is suggested that such a degree of skeletonisation is "likely due to scavenging" (2021, 7), both something which the bog bodies were not subjected to in their wet, peaty and anaerobic depositional environments. Additionally, the buried cases of the study show 100% skeletonisation in more than a year, compared to 71% skeletonisation In 1-3 months, 80% skeletonisation in 3-6 months and 100% skeletonisation in just 6-12 months in the surface environment cases (2021, 9).

Comparing these results to the present work and assessment of the three bog bodies, it is clear that the human remains assessed from the ground surface are exposed to a completely different set of extrinsic factors compared to the three case studies. Where each of the bog bodies were placed into an environment with a very low pH, consistently high in water content, high in humidity, cooler in temperature and lacking any entomological activity for the most part due to the anaerobic conditions, human remains left to decompose on the ground surface are constantly exposed to all of the factors the bog bodies were not since their deposition, including the changing air temperature, bacterial growth and the activity of scavengers and insects; although the decomposition of the Alfsdotter & Petaros study showed a generally overall slower decomposition rate compared to other studies outside of the Northern European context (Galloway 1997: Micozzi 1997) the factor of the cooler temperatures combined with the aerobic environment in which bacteria can still grow and insects are still able to colonise the human remains will simply serve to slow down the inevitable decomposition process and will not stop it altogether – compared to the bog bodies, human remains on the ground surface "eventually skeletonise completely" irrespective of the colder climate (2021, 10).

Alfsdotter & Petaros (2021) note that there has been a heavy focus on terrestrial settings in warmer or mild climates, with cooler climates and aquatic environments remaining "underrepresented in scientific literature" (Alfsdotter & Petaros 2021, 2). Their work is based in a Swedish context and uses both the Megyesi et al (2005) and Heaton et al (2010) scoring methods to assess the level of decomposition, finding that "the universal formulae that assess ADD from TBS [total body score, according to Megyesi et al (2005)] or TADS [total aquatic decompositional score, according to Heaton et al (2010)] do not perform well" (Alfsdotter & Petaros 2021, 13), and suggest more investment in quantitative research in a Northern European context, or other colder climatic environment, alongside the development of regional formulae with which to assess human decomposition or to explore the possibility of a different scoring method altogether (2021, 13). As the current research focuses on human taphonomy in warmer climates, the developed scoring methods therefore are most applicable to those settings, where early post-mortem changes are generally quicker in their onset and their progression; human remains generally decompose at a faster pace compared to the cooler climates of the north, especially if the body has been located in an anaerobic environment as we see in the cases of the bog bodies and, as Alfsdotter & Petaros highlight, additional research is essential to ensure that scoring methods, decomposition scales and the understanding of human taphonomy in general is not just mainly developed out of a focus on one environment or climate, but an array of climates and conditions, to reflect and represent the high degree of variability in which human remains can decompose.

Decomposition of the body outdoors in water

The adapted forensic scoring method of Heaton et al (2010) took Megyesi et al's (2005) decompositional scale and adapted the descriptive stages and scoring for use in an aquatic environment. Heaton et al note that the UK sees around 400 cases of drowning on average each year, stwith the possibility of additional bodies in the waterways resulting from suicides, disposal of bodies after murders, boating disasters and so on, and that despite this, "there has been little investigation carried out in this area of forensic taphonomy" (2010, 302). The adapted method came from an initial visual assessment of the remains via the Megyesi et al methods, whereby decompositional trends were identified and appropriately incorporated into the descriptive stages initially laid out by Megyesi et al (2005). Where the bog preserves the soft tissues and decalcifies the bones over time due to the acidic environment of the peat moss, with the result being tanned skin but otherwise (generally) well preserved but mummified remains, Heaton et al (2010) note that the aquatic environment generally shows changes in the face, neck and extremities quite soon after deposition in the water, with changes to the hands as soon as 1-2 hours (2010, 304) and washerwoman's hands resulting from very swift soft tissue modification (Heaton et al 2010, 304; see also fig.8). The work confirmed that bodies recovered from all of the waterways sampled for the study resulted in human remains going through the same phases of decomposition, in the same sequence, at the same rate (2010, 305). However, De Donno et al (2014) found that the type of aquatic environment can cause variation in the progression of decomposition, with the marine environment's high salinity reducing both bacterial action and predation by insects and scavengers (both similar to the bog environment) (De Donno et al 2014, 439), and thus developed a further adaptation of the forensic scoring method of Heaton et al to suit this purpose (De Donno et al 2014, 442: Table 2). Similar to the depth of burial affecting the level of scavenger activity and insect activity in burial in soils, the depth of the water was also found to be a key factor in the level of decomposition in marine environments – bodies found floating in the deep high seas showed lower TADS of 8-9 with washerwoman's changes to the extremities, compared to higher TADS at depths of 10-20m resulting in skin slippage, and those close to the land in shallower waters showing high TADS, adipocere formation or total saponification with disarticulation of bones despite clothing coverage, with biomass loss due to natural decomposition (De Donno et al 2014, 441 & 445).

Although the two environments are of course very different, with the bog environment being acidic with a pH of around 3.2 to 4.0 (Clymo 1984, 487) and the high salinity of the marine environment providing an alkaline environment of around 8.1. (NOAA, 2021), the consideration of using forensic scoring methods to assess decomposition in both environments result in a similar conclusion; the forensic scoring method(s) used to assess the decompositional state of the human remains in question, whether those remains are recent or ancient, *must* be specifically adapted to the specificities of the environment in which the human remains were found. Without appropriate adaptation of the methods, the scoring method could fail to capture and appropriately assess the factors which are so specific to each environment.

Decomposition of the body indoors

Although the decomposition process of human remains in an indoor environment is a completely different environment to the environment the bog bodies were subjected to, a consideration of the decomposition of such remains serves to further highlight the variation in human taphonomy as a highly environmentally dependent process. According to the UK's Nuffield Trust, on average 35% of deaths took place in the individual's usual place of residence in 2004, whether that is in their home, a care home, a hospital, etc., compared to 47% in 2019 (Nuffield Trust 2021). Recent work by Ceciliason et al (2018) notes that few studies have been done to investigate deaths and decomposition in such indoor environments, despite those dying indoors being exposed to potentially fewer insects, scavengers and other extrinsic factors, compared to bodies decomposing outdoors. The work reviewed 140 indoor cases using Megyesi et al's (2005) forensic scoring method, revealing only 9 cases in the later advanced stages of decomposition and that the cases subject to insect infestation were much more progressed in their decomposition compared to those without, irrespective of the time passed since death or their ADD. Again, this work highlights that the method developed by Megyesi et al can be used, but many aspects of the scoring method do not apply (e.g. some of the descriptive stages are tailored towards outdoor decomposition) and overall, using the method results in poor precision when assessing the decompositional stage. Despite this, Ceciliason et al conclude that "a scoring method still could be the most practical way to describe and quantify the rate of decomposition" but would need to be appropriately adapted to suit the specific environment the remains decompose within (2018, 187).

When comparing this to the results of this current study and the assessment of the bog body case studies, the result reflects a very similar output. Although the established methods of Megyesi et al (2005) and the adapted scoring method of Heaton et al (2010) for aquatic environments can help to assess the decompositional stage of human remains in forensic settings, they are only able to do effectively if the descriptive stages effectively describe the actual stages human remains progress through, the actual state the human remains could be expected to present in, and take into account the specific environmental variables of the environment the remains decompose within. The concept of this is directly applicable to the field of archaeology whereby excavation is constantly unearthing glimpses into the human past via the human remains and material culture left behind, the survival of which is entirely dependent on the depositional environment in which it is found, combined with anthropogenic behaviour since its deposition, and where a degree of knowledge regarding the possible impacts of the environments in which we as archaeologists unearth these glimpses of our shared human past is deemed essential.

4.3. Identifying taphonomic change and using proxies for human remains

The second research question this work aimed to answer was to what extent taphonomic change and/or loss was differentiated from change resulting from deliberate human action, if at all, in the case studies used for this work. Using the specific template to assess the intrinsic, extrinsic and cultural factors and the post-excavation and treatment and analyses for each case study, the consideration of taphonomic change vs. deliberate human action was a central part of the overall analysis and was interwoven with all considered aspects of the decompositional state of the remains of the three bog bodies.

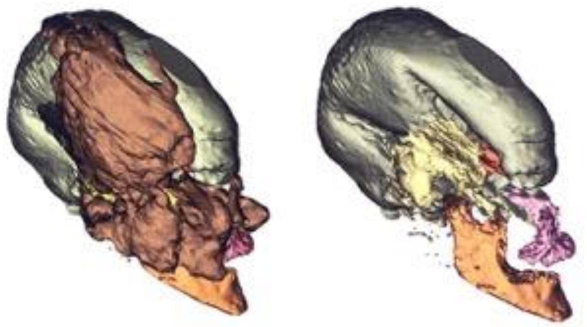

Fig. 64 - Grauballe Man - 3D imaging of skull

In the case of the Grauballe Man, for instance, the documentary analysis found that earlier work suggested his fractured tibia and skull were perimortem injuries sustained as part of his death, yet later work (Villa & Lynnerup 2012; Lynnerup 2015 etc) found via CT scans and 3D models (fig.64 & 65) that these 'injuries' were not injuries at all, but were rather the result of taphonomic change from the weight of thick peat layers of the bog itself, bearing down its weight on human remains which had undergone a process of diagenesis, resulting in softened, weakened and decalcified bones which were easier to squash and deform, leaving noticeable indentations particularly in the parietal bone (see fig.65).

In the case of the Worsley Man, as with the majority of bog bodies, the remaining preserved hair was stained red from the environmental conditions of the bog, and although one ear remained preserved attached to the 20% of skin that remained on the head, the other ear was missing and was deemed to have been lost to due taphonomic change, resulting from exposure to the bog environment. And finally, in the case of the Clonycavan Man, his head, though greatly preserved, was flattened and deformed in shape (fig.53 & 54) due to similar circumstances of the Grauballe Man – diagenesis and decalcification of cranial bones and taphonomic change due to the weight of the soil of the bog itself.

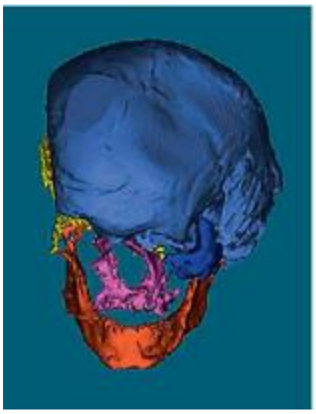

Fig. 65 - Grauballe Man - noticeable indentation on the parietal bone due to diagenesis and soil pressure

The use of animal carcasses as proxies for human remains can be beneficial for developing understanding of the decomposition process of organic remains in lieu of human bodies, but it has been brought into question as to how much that understanding can be transferable to understanding human taphonomy specifically. The issue of using animal proxies for studying the decomposition of human remains has been somewhat heavily debated in forensic literature (Connor, Bagent & Hansen 2017; Keough et al 2017; Dautartas et al 2018; Williams, Rogers & Cassella 2019; Bisker et al 2021) with Alfsdotter recently noting that “studies of animal proxies can complement, but not substitute, human decomposition research” (2021, 14). It is generally pig or boar remains which are commonly used in lieu of human remains (Tumer et al 2013; Janaway et al 2003; Janaway et al 2009; Dautartas et al 2018), the use of which resulted from a recommendation in the 1980s to use domestic pig cadavers as analogues in forensic entomology studies (Matuszewski et al 2020). Yet, when research has been carried out to see if this is actually beneficial and a whether pigs are indeed a sound replacement when looking into human decomposition and other forensic investigations, it has been noted that “systematic studies that directly validate animals as proxies for human decomposition are lacking” (Dautartas et al 2018), with the few studies that have been done indicating that “significant differences are observed during early decomposition between the carcasses of pigs and of humans remains (Keough, Myburgh & Steyn 2016) and that, quite simply, “pigs are not an adequate proxy for human decomposition studies” (Connor, Bagent & Hansen 2017).

Unlike in Scandinavia and in other countries utilising proxies for human remains in studies, many countries *do* use human remains for taphonomic research. The USA has been carrying out human taphonomic studies using actual human remains since 1972 (Gelderman 2019, 125) with seven human taphonomy research facilities (HTRF) or ‘body farms’ being run as part of universities, spread out across the nation. This includes the world’s “first and most famous” which opened in 1981 in Knoxville as part of the University of Tennessee (FAC 2021; Adam 2019). Other countries to have such facilities include Australia at a facility known as AFTER - the Australian Facility for Taphonomic Experimental Research which is part of the University of Technology Sydney (UTS, 2017) and, more recently, a facility in the Netherlands known as ARISTA - the Amsterdam Research Initiative for Sub-surface Taphonomy and Anthropology, which was opened after the establishment of a Masters programme in forensic science in 2010 (Oostra et al, 2020) as Europe’s first ever human taphonomic research facility. Such facilities provide a specific facility to research and further understand the general human decomposition process in controlled, observable and repeatable environments, as well as develop the knowledge, skills and training opportunities required to work not only in forensic crime scene investigation, but also specific training regarding the appropriate forensic anthropological and archaeological excavation of human remains (Oostra et al, 2021).

4.4. Forensics in archaeology and bog body research

This work aimed to answer three research questions related to how human decomposition and preservation varies in different depositional environments, and how identifying and differentiating taphonomic change from deliberate human action is done through more developed technologies. The latter is seen in the case study of Grauballe Man where, as discussed in the previous section, the presumed fracture to his tibia and skull as perimortem injuries were later found to be the result of taphonomic change his remains sustained over time, resulting from the weight of the peat against his softened, weakened, decalcified bones resulting from diagenesis in the bog (fig.56).

The final research question that this work aimed to answer was whether a forensic scoring method used for assessing the decomposition state of human remains in forensic cases has any potential benefit for archaeology, and whether archaeology as a whole could benefit from an increased general knowledge of forensic techniques, especially in relation to human decomposition / human taphonomy. It is unquestionable that many analyses and techniques are utilised in the field of archaeology. These techniques are highly varied, with many involving the incredible care, knowledge and experience of highly trained specialists, whether those specialists come from within the field itself or are working in an interdisciplinary and/or transdisciplinary manner to assist in an archaeological investigation. Archaeology employs this experience and skill from initial desk-based research, pre-excavation analyses, throughout the entire process of an excavation itself and at all stages of post-excavation work, analysis, publication of research and presentation to peers and the public alike.

Although this work was able to successfully analyse the three chosen case studies via the forensic scoring method of Heaton et al (2010) using a combination of documentary analysis of written research literature and published photographs of the preserved human remains of Grauballe Man, Worsley Man and Clonycavan Man, it is somewhat unclear from such a small qualitative study if such a forensic scoring method would have an additional benefit to the field of archaeology, beyond the knowledge that can already be gained using the vast range of current techniques and methods archaeology can have at its disposal, as required. What has become abundantly clear through the research for this paper is that each individual forensic investigation assesses the specifics of the case itself and determines whether the method that most closely meets the demands of the case would need to be appropriately adapted to the circumstances and requirements of the human remains they are assessing. This can be seen through Megyesi et al's (2005) developing the stages of decomposition of Galloway et al (1989) into a forensic scoring method for assessing decomposition, Heaton et al (2010) taking the adapted methods of Megyesi et al to meet the specific decompositional stages of the aquatic environment rather than having a focus on terrestrial decomposition, and De Donno et al (2014) then taking the Heaton et al aquatic method and adapting it for their own requirements when looking at decomposition in the highly saline marine environment.

Forensic scoring methods aim to assess the scale of decomposition in human remains and they are used alongside ADD to assess the PMI (post-mortem interval) or TSD (time since death). Assessing the PMI is not a requirement of archaeological cases and instead, estimating the TSD is done as part of the overall dating of the human remains, usually C14 most recently via AMS or accelerator mass spectrometry (Nielsen, Philippsen, Kanstrup & Olsen 2019) in conjunction with other interpretative post-excavation analyses. It is difficult to interpret from this small quantitative study of three bog bodies whether the forensic scoring method could have some potential benefits for assessing human remains in archaeology in general. Although the majority of bog bodies are found to be from the Iron Age, we see examples ranging from the Mesolithic (e.g. Koelbjerg Man in Denmark) through to modern times (e.g. bodies preserved after WWII in Poland; Glob 1969, 101). A wider-scale quantitative study of available bog bodies from the many different locations, environments and time periods should be able to indicate whether such a method could be appropriately adapted for specific use in bog body research. Such a method must be appropriately adapted to take into account the specific stages bog bodies will progress through, as all of the forensic scoring methods have adapted their own, as this study highlights that many of the factors described in the Heaton et al (2010) aquatic method do not apply to the specific presenting stages of the bog bodies in their process of decomposition and preservation. A potential scoring method must be able to take into account these stages and the specific geochemical composition of the bog environment itself. De Donno et al (2014) noted that Heaton et al's (2010) method needed to be adapted to their study, as the method did not take into account the changes to decomposition resulting from the higher saline levels; in the case of bog bodies, an adaptation would need to take into account the acidic and anaerobic conditions of the bog environment in which human remains are deposited and preserved to the extent presented in this work.

As highlighted in chapter 1.4. there is a considerable variation in the content of archaeological education programmes and considerable variability in adequate training opportunities in the areas of forensic archaeology. Although an archaeology student can choose to specialise in human osteology within their degree programme, through personal experience navigating the world of academia and via research for this work, it is clear that there are few opportunities to gain experience working with preserved human remains such as bog bodies, compared to skeletal remains.

Our field constantly strives to develop knowledge of the human past and to build on our understanding and interpretations of the lives of past peoples. These lives also inevitably include the eventual process of death, along with any associated burial practices and/or other mortuary traditions. It is hereby proposed in the conclusion to this work that, to effectively excavate, analyse and develop interpretations from human remains, all practicing archaeologists should have at least a basic understanding of the physical human bodies through which those lives (and deaths) took place and how the preservation and decomposition of those bodies and the material culture they leave behind can vary considerably dependent on the depositional environment. Many looking to build a career in archaeology may not be necessarily interested in building specialist knowledge regarding human remains, whether skeletal, fleshed or anywhere in between, but, when excavation still remains a central tenat of the field and when the unearthing of human remains is potentially always a possibility when we dig downwards towards the buried human past, some essential knowledge of human anatomy, human decomposition and knowledge regarding the potential taphonomic processes of the soil in which excavation is taking place seems like beneficial and logical information with which an archaeologist can be guided during their excavations. This suggestion does not erode the need for specialists, whether those are human osteologists, forensic archaeologists or other, but rather gives the opportunity for an excavating archaeologist to appropriately assess any uncovered human remains immediately. An appropriately adapted forensic scoring method could potentially have a benefit at this stage, to allow an archaeologist with some basic training in human taphonomy to immediately assess human remains prior to a specialist's arrival. Archaeology is a highly international field, with excavations often having many different nationalities on site; when the content of degree programmes and the training opportunities are so variable and when the lines blur between different fields, specialisms and job roles, ensuring that *all* archaeologists are trained in the basics of human anatomy, the stages of human decomposition and the impact of the depositional environment on human taphonomy can ensure that future archaeologists are appropriately equipped with knowledge to be able to deal with the uncovering of human remains in an archaeological excavation.

4.5. Conclusion and future research

This work concludes that a wider-scale quantitative study of all available bog bodies could aid in the development of a bog body-specific forensic scoring method, which could be known as a bog body scoring method or ‘BBSM’ for use in future bog body research. The study is intended to be completed as a future PhD project and should aim to assess the common decompositional traits for each area (face, body and limbs) and to assess how the descriptive stages of the forensic scoring method of Heaton et al (2010) could be appropriately adapted to be able to reflect the common decompositional traits seen during the assessment. Doing so would ensure that any such BBSM would be applicable to bog body research specifically and based on a comprehensive analysis of the stages of decomposition and preservation bog bodies progress through. Any future studies should ensure that a physical visual inspection of each of the bog body remains could take place, to the extent that is possible and permissible. Taking new high-quality and detailed photographs would be beneficial, alongside the development of 3D models, perhaps via photogrammetry or laser scanning, which could be used both within the study itself to support further understanding and interpretation when no longer in physical contact with the remains, but which could also support further dissemination of the details of the bog bodies to the public via in-museum displays and via their websites.

Finally, this current work concludes that the future research should aim to collate information regarding the bog bodies to create a comprehensive and accessible database of bog body research, that could be accessible both by academics and the public alike. As each case of bog bodies has been treated so differently, both in terms of when and how the bodies were excavated, the post-excavation treatment, preservation methods, the analyses that were undertaken and the level of published research material, some information was found to be detailed in one case and sporadic or non-existent in others. Some bog bodies have received a great deal of research interest (e.g. Tollund Man) and others may not seen publication at all (e.g. the bog skeletons, as discussed in Nielsen, Christensen & Frei 2020.) An additional analysis via the proposed specific and appropriately adapted BBSM, in combination with the various analyses specific to the case, could not only make cases easier to compare and contrast, but could also aid understanding and interpretation of the bog bodies via a more standardised method.

4.6. Reflections on this work

This thesis aimed to answer three research questions:

- *Using three case studies from within the bog body research history, one each from Denmark, England and Ireland, how has deposition into the bog affected the overall human decomposition and preservation process? How does decomposition in the bog compare to burials in soils, water or the open air?*

- *How is taphonomic change and/or loss differentiated from change resulting from deliberate human action, if at all?*

- *Does a forensic scoring method used for assessing human remains in forensic cases have any potential benefit for archaeology, e.g. if appropriately adapted for implementation in bog body research? Could the field as a whole benefit from increasing forensic knowledge in general, especially in relation to human decomposition/taphonomy, as we work to uncover the buried human past which often includes the finding and recovery of human remains?*

This work was able to provide answers to the majority of the intended aims and research questions set out above, using the chosen method of documentary and comparative analysis to assess the three case studies of bog bodies with specific template developed to consider key intrinsic, extrinsic and cultural factors alongside post-excavation treatment and analyses, followed by an assessment of the case studies using the forensic scoring method of Heaton et al (2010). In light of the circumstances in which this thesis took place, in the midst of a global COVID-19 pandemic with multiple long-term lockdowns, using a retrospective documentary and comparative analysis generally worked well overall. Each of the chosen case studies had a substantial amount of published material which was (for the most part) sufficient enough to analyse the key factors. Using published photographs, whether as part of the published research literature or via the museums which are responsible for the remains now, ensured that visual analysis could take place for each of the bog bodies without having to be physically present with the human remains. Some of the published research material did not discuss some of the factors which were included in the analytical method. The study here acknowledges that this does not necessarily mean those factors were not considered at all during the process of analysis and developing the results, but the details of which were simply just not included in the resulting published literature itself. This included the material regarding e.g. the pH level and geochemical specifics of any soil samples taken from each of the three bogs which, as the study concludes, is vital information. An additional factor to consider is that one of the three case studies considered was of course from Denmark, which may have resulted in some published research material being negated from literature searches due to the language differences, which could have otherwise contributed further details to the work.

The study could have benefitted from travel opportunities to visit a body farm in the US (e.g. in Texas or Tennessee) and/or visiting the first European taphonomic research facility in the Netherlands, to support the wider understanding and context regarding human taphonomic research in general. This study hopes that European taphonomic research facility may be just the first of its kind in this continent, and that future human taphonomic research will expand into Scandinavia in the future, especially when forensic-specific training currently requires individuals to explore pathways of education across borders.

Being able to undertake a physical visual inspection of the three bodies would have been preferable when carrying out a study of this nature but, in light of the COVID-19 pandemic, this was not possible. In different circumstances without a global pandemic, where travel would been possible from Denmark to England and to Ireland, and where museums in Denmark would have been open during the research period, an in-person assessment of the bog bodies could have been able to reveal more detail than some of the photographs that were available for use. The photographs were of course only available for certain angles of the remains, and it is hereby acknowledged that these angles may influence the overall interpretation that can be made when analysing the physical state of human remains. However, the study also has been successful in showing that an analysis can be completed using non-invasive, distance methods and that, in the majority of cases, the published research literature can be sufficient with which to continue to build upon previous work.

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APPENDIX 1: Galloway et al (1989) stages of decay

Fresh	• Fresh no discolouration or insect activity • Fresh burned
Early decomposition	• Pink-white appearance with skin slippage and some hair loss • Gray to green discolouration, some flesh relatively fresh • Discolouration to brownish shades particularly at fingers, nose, and ears; some flesh still relatively fresh • Bloating with green discolouration • Post-bloating following rupture of the abdominal gases with discolouration going from green to dark • Brown to black discolouration of arms and legs, skin having leathery appearance
Advanced decomposition	• Decomposition of tissues producing sagging of the flesh, caving in of the abdominal cavity, often accompanied by extensive maggot activity • Moist decomposition in which there is bone exposure • Mummification with some retention of internal structures • Mummification of outer tissues only with internal organs lost through autolysis or insect activity • Mummification with bone exposure of less than one half the skeleton • Adipocere development
Skeletonisation	• Bones with greasy substances and decomposed tissue, sometimes with body fluids still present • Bones with desiccated tissue or mummified tissue covering less than one half the skeleton • Bones largely dry but still retaining some grease • Dry bone
Extreme decomposition	• Skeletonisation with bleaching • Skeletonisation with exfoliation • Skeletonisation with metaphyseal loss with long bones and cancellous exposure of the vertebrae

APPENDIX 2: Megyesi et al (2005) decomposition scoring method

Categories and stages of decomposition for the head and neck:

A. Fresh
1 pt - Fresh, no discoloration

B. Early decomposition
2 pts - Pink-white appearance with skin slippage and some hair loss.
3 pts - Gray to green discoloration: some flesh still relatively fresh.
4 pts - Discoloration and/or brownish shades particularly at edges, drying of nose, ears and lips.
5 pts - Purging of decompositional fluids out of eyes, ears, nose, mouth, some bloating of neck and face may be present.
6 pts - Brown to black discoloration of flesh.

C. Advanced decomposition
7 pts - Caving in of the flesh and tissues of eyes and throat.
8 pts - Moist decomposition with bone exposure less than one half that of the area being scored.
9 pts - Mummification with bone exposure less than one half that of the area being scored.

D. Skeletonization
10 pts - Bone exposure of more than half of the area being scored with greasy substances and decomposed tissue.
11 pts - Bone exposure of more than half the area being scored with desiccated or mummified tissue.
12 pts - Bones largely dry, but retaining some grease.
13 pts - Dry bone.

Categories and stages of decomposition for the torso:

A. Fresh
1 pt - Fresh, no discoloration.

B. Early decomposition
2 pts - Pink-white appearance with skin slippage and marbling present.
3 pts - Gray to green discoloration: some flesh relatively fresh.
4 pts - Bloating with green discoloration and purging of decompositional fluids.
5 pts - Post-bloating following release of the abdominal gases, with discoloration changing from green to black.

C. Advanced decomposition
6 pts - Decomposition of tissue producing sagging of flesh; caving in of the abdominal cavity.
7 pts - Moist decomposition with bone exposure less than one half that of the area being scored.
8 pts - Mummification with bone exposure of less than one half that of the area being scored.

D. Skeletonization
9 pts - Bones with decomposed tissue, sometimes with body fluids and grease still present.
10 pts - Bones with desiccated or mummified tissue covering less than one half of the area being scored.
11 pts - Bones largely dry, but retaining some grease.
12 pts - Dry bone.

Categories and stages of decomposition for the limbs:

A. Fresh
1 pt - Fresh, no discoloration

B. Early decomposition
2 pts - Pink-white appearance with skin slippage of hands and/or feet.
3 pts - Gray to green discoloration; marbling; some flesh still relatively fresh.
4 pts - Discoloration and/or brownish shades particularly at edges, drying of fingers, toes, and other projecting extremities.
5 pts - Brown to black discoloration, skin having a leathery appearance.

C. Advanced decomposition

6 pts - Moist decomposition with bone exposure less than one half that of the area being scored.
7 pts - Mummification with bone exposure of less than one half that of the area being scored.

D. Skeletonization
8 pts - Bone exposure over one half the area being scored, some decomposed tissue and body fluids remaining.
9 pts - Bones largely dry, but retaining some grease.
10 pts - Dry bone.

Take each point value and sum them to find the total body score (TBS).
For example: 5 (head) + 5 (torso) + 5 (limbs) = 15 TBS

If an area of the body has differential decomposition or different features (such as brown to black discoloration on relatively fresh skin on the torso) record both numbers. For the total body score, average the two numbers before totalling the body score.

Total body score is supposed to represent overall decomposition progression, so if unsure about where to fit a section of the body into a category, either go for the lowest score or an average score.

APPENDIX 3: Heaton et al (2010) aquatic decomposition scoring method

	Points	Description
FADS	1	No visible changes.
	2	Slight pink discolouration, darkened lips, goose pimpling.
	3	Reddening of face and neck, marbling visible on face. Possible early signs of animal activity/predation - concentrated on the ears, nose, and lips.
	4	Bloating of the face, green discolouration, skin beginning to slough off.
	5	Head hair beginning to slough off - mostly at the front. Brain softening and becoming liquefied. Tissue becoming exposed on face and neck. Green/black discolouration.
	6	Bone becoming exposed - concentrated over the orbital, frontal, and parietal regions. Some on the mandible and maxilla. Early adipocere formation.
	7	More extensive skeletonisation on the cranium. Disarticulation of the mandible.
	8	Complete disarticulation of the skull from torso. Extensive adipocere formation.
BADS	1	No visible changes.
	2	Slight pink discolouration, goose pimpling.
	3	Yellow/green discolouration of abdomen and upper chest. Marbling. Internal organs beginning to decompose/autolysis.
	4	Dark green discolouration of abdomen, mild bloating of abdomen, initial skin slippage.
	5	Green/purple discolouration, extensive abdominal bloating - tense to touch, swollen scrotum in males, exposure of underlying fat and tissues.
	6	Black discolouration, bloating becoming softer, initial exposure of internal organs and bones.
	7	Further loss of tissues and organs, more bone exposed, initial adipocere formation.
	8	Complete skeletonisation and disarticulation.
LADS	1	No visible changes.
	2	Mild wrinkling of skin on hands and/or feet. Possible goose pimpling.
	3	Skin on palms of hands and/or soles of feet becoming white, winkled, and thickened. Slight pink discolouration of arms and legs.
	4	Skin on palms of hands and/or soles of feet becoming soggy and loose. Marbling of the limbs - predominantly on upper arms and legs.

	5	Skin on hands/feet starting to slough off. Yellow/green to green/black discolouration on arms and/or legs. Initial skin slippage on arms and/or legs.
	6	Degloving of hands and/or feet - exposing large areas of underlying muscles and tendons. Patchy sloughing of skin on arms and/or legs.
	7	Exposure of bones of hands and/or feet. Muscles, tendons, and small areas of bone exposed in lower arms and/or legs.
	8	Bones of hands and/or feet beginning to disarticulate. Bones of upper arms and/or legs becoming exposed.
	9	Complete skeletonisation and disarticulation of limbs.

Where:

Points - score given

FADS - descriptive stages for decomposition observed in the face and the assigned facial aquatic decomposition score

BADS - descriptive stages for decomposition observed on the torso and the assigned body aquatic decomposition score

LADS - descriptive stages for decomposition observed in the limbs and the assigned limbs aquatic decomposition score

Heaton, V., Lagden, A., Moffatt, C. and Simmons, T. (2010). Predicting the Post-mortem Submersion Interval for Human Remains Recovered from UK Waterways. *Journal of Forensic Science.* March 2010. Vol.55. No.2. http://doi.org/10.1111/j.1556-4029.2009.01291.x

APPENDIX 4: Gelderman et al (2018) indoor decomposition scoring method

	Points	Description
FDS	1	1.1. No visible changes
	2	2.1. Livor mortis, rigor mortis and vibices
		2.2. Eyes: cloudy and/or tache noir
		2.3. Discolouration: brownish shades particularly at the edges. Drying of nose, ears and lips
	3	3.1. Grey to green discolouration
		3.2. Bloating of neck and face is present and/or skin blisters, skin slippage and/or marbling
		3.3. Purging of decompositional fluids out of ears, nose and mouth and/or brown to black discolouration
	4	4.1. Caving in of the flesh and tissues of eyes and throat. Skin having a leathery appearance
		4.2. Partial skeletonisation, joints still together
	5	5.1. Gross skeletonisation, some joints disarticulated
	6	6.1. Complete skeletonisation
BDS	1	1.1. No visible changes
	2	2.1. Livor mortis, rigour mortis and vibices
	3	3.1. Grey to green discolouration
		3.2. Bloating with green discolouration and/or skin blisters, skin slippage and/or marbling
		3.3. Rectal purging of decompositional fluids
		3.4. Post-bloating: release of abdominal gasses with discolouration changing from green to black
	4	4.1. Decomposition of tissue producing sagging of flesh. Caving in of the abdominal cavity
		4.2. Skin having a leathery appearance
		4.3. Partial skeletonisation, joints still together

	5	5.1. Gross skeletonisation, some joints disarticulated
	6	6.1. Complete skeletonisation
LDS	1	1.1. No visible changes
	2	2.1. Livor mortis, rigour mortis and vibices
		2.2. Discolouration: brownish shades particularly at the edges. Drying of fingers and toes.
	3	3.1. Skin blisters and/or skin slippage and/or marbling
		3.2. Grey to green discolouration
		3.3. Brown to black discolouration
	4	4.1. Skin having a leathery appearance
		4.2. Partial skeletonisation, joints and tendons still together
	5	5.1. Gross skeletonisation, some joints disarticulated
	6	6.1. Complete skeletonisation

Where:

Points - score given to the stadia

2.1, 2.2, 2.3 etc - the different phenomena

FDS - facial decomposition score

BDS - body decomposition score

LDS - limbs decomposition score

APPENDIX 5: Template for assessing case studies

Factors			**Results from research**
Intrinsic	Taphonomy	Decomposition stage	
	Individual profile	Estimated age	
		Estimated date of death	
		Sex	
		Weight & height	
		Ancestry	
		General degree of health	
Extrinsic	Context	Bog location	
		Surroundings	
		Date found	
	Environmental	Temperature	
		Humidity & rainfall	
		Entomological activity	
		Soil type in area Is soil type discussed in literature?	
Cultural	Cause of death	Trauma and/or injury? Poisons? Natural? Unknown/unclear?	
	Burial	Clothing or coverage on the individual & ergo. % exposure to environment	
		Clothing with individual	
		Other items with individual	
	Other	Additional factors specific to case	
		Last meal if known	
Analyses and post-ex treatment			

APPENDIX 6: Denmark - Grauballe Man results table

Factors to consider for bog body decomposition: Grauballe Man

Factors			
Intrinsic	Taphonomy	Decomposition stage	Skin present, full head of hair (Lobell & Patel 2010) Bones demineralised / diagenesis due to forensic taphonomy in the bog environment. Smooth hands inc. fine nails – suspected GM was noble and showed no sign of manual labour in his hands, but this was actually a result of the bog environment; “the desquamation of the outer epidermal layer” (Lynnerup 2015, 1011) Must be deposited prior to rigor mortis – lack of decomposition in an awkward supine position with head bent backwards as if flopped back when throat was cut
	Individual profile	Estimated age	c.30s (Lobell & Patel 2010) Fused clavicles suggest age of 26-30 (Frederiksen & Glastrup 2007) Ossified sternum suggests 25-30 y.o. Iliac crest CT scan suggests 34 y.o. (Warner Boel et al 2007)
		Estimated date of death	c.2300 years ago (Lobell & Patel 2010) Early Iron Age 400BC-AD100 (Lynnerup & Villa 2012)
		Sex	Male (Lobell & Patel 2010)
		Weight & height	5ft 7 (Lobell & Patel 2010) – this was estimated by max. lengths of tibia and femur Notably a little shorter than his contemporaries but Lynnerup argues this could just as well be the result of diagenesis due to bog environment
		Ancestry	Danish – at least by modern terminology (will be discussed re: narratives) No specific genetic info because aDNA extraction was not possible from the dentine - wet and acidic environment of the bog itself (Lynnerup 2015). Fingerprint analyses = double (11.2% of modern DK population) and ulnar loops (68.3% of modern DK population).
		General degree of health	Generally healthy but with some periodontal disease (Lobell & Patel 2010) – blackened teeth but many either still in situ or in the oral cavity. Light facial stubble. Generally in good health, no disease detected.
Extrinsic	Context	Bog location	Grauballe (Lobell & Patel 2010) Nebelgaard Mose, central Jutland.
		Surroundings	Peat bog, found by peat cutters in 1952 (Lobell & Patel 2010)
		Date found	1952 (Lobell & Patel 2010) Excavated 26 April 1952.
	Environmental	Temperature	Info from DMI - Danmarks Meteorologiske Institut (http://research.dmi.dk/ and WMO https://public.wmo.int/en

			Records only began 1874 but - "Average annual temperature for the entire country is 7.7°C (average 1961-90), ranging from 7.4°C in central Jutland to 8.4°C degrees at some coasts." https://web.archive.org/web/20140507045225/http://www.dmi.dk/en/klima/klimaet-frem-til-i-dag/danmark/temperatur/ Moesgaard Museum: https://www.moesgaardmuseum.dk/en/exhibitions/permanent-exhibitions/grauballe-man/the-bog/the-bog-as-a-landscape-archive/ "the time in which Grauballe Man lived was characterised by a marked climate change with wetter and colder conditions than before. Similarly, bog sequences demonstrate that a more open landscape was created at the time as people cut down trees for timber, fuel and to create more space for arable fields."
		Humidity & rainfall	Average annual humidity = 79-82% - again records only began 1874. Average annual precipitation over land (normal 1961-90) is 712 mm but varies significantly from year to year and from place to place. The most rainy part of Denmark is central Jutland, which gets over 900 mm of rainfall a year. The lowest annual precipitation for the whole country was 464 mm in 1947. The highest was 905 mm in 1999. Since 1990, the average annual precipitation in Denmark has been approx. 745 mm and has increased by approx. 100 mm since systematic measurements were introduced in 1874. https://web.archive.org/web/20140507045647/http://www.dmi.dk/en/klima/klimaet-frem-til-i-dag/danmark/nedboer-og-sol/
		Entomological activity	Not specified
		Soil type in area Is soil type discussed in literature?	From UNESCO 1974 Soil Classification - Grauballe area is Po - Orthic podzols and/or Pp - Placic podzols. Did not find any of the literature referring to the soil type specifically, other than in Nielsen et al 2020 which discussed bog skeletons simply being a product of their burial environment vs fleshed bog bodies. Janaway et al 2003 discussed soil type in reference to an experimental study on archaeology/taphonomic change to buried bodies in the UK - used pig carcasses as proxies for humans; cannot find any Grauballe Man info re: soil type.
Cultural	Cause of death	Trauma and/or injury? Poisons? Natural? Unknown/unclear?	Throat slashed ear to ear (Lobell & Patel 2010) Throat cut – found via forensic medical and radiographic analyses (Lynnerup 2015, 1010) Noted as having an expression of pain/terror unlike the peaceful Tollund Man - subjective! Suspected that GM was also strangled due to hyoid bone broken but this was later thought to be due to taphonomic change - see below from Lynnerup & CT scans. Suspected blow to the head & leg = initially suspected as perimortem cranial & tibial # but CT scan gave much more detail and later found changes were post-mortem taphonomic breakages as a result of the weight of the soil – the skull was squashed in its depositional environment rather than it being a blow to the head (Lynnerup 2015, 1010)
	Burial	Clothing or coverage on the individual and therefore % exposure to enviro'	Found naked i.e. 100% exposure to the bog environment for decomposition
		Clothing with individual	None
		Other items with individual	None
	Other	Additional factors specific to case	None

		Last meal if known	Barley, grass, wheat and herbs with a small amount of pork (Lobell & Patel 2010)
Analyses and post-ex treatment	Exhibited to the public soaked in bog water and resting on the block of peat in which he was found, mere days after his discovery by PV Glob – very problematic!! (Asingh & Lynnerup 2016, 85) – 18,000 visitors (!); initially interpreted as a fertility sacrifice. “Glob clearly considered him as both a scientific object and a precious museum object” (Asingh & Lynnerup 2016, 85) – not a human body? Now on display in Moesgaard Museum, Aarhus		
	Autopsy, gut contents, teeth analysed in the first few years after discovery 1952-54 (Asingh & Lynnerup 2016, 85) Fingerprints taken, radiography, first CT scans, C14 and autopsy in 1952 Fingerprint analyses = double (11.2% of modern DK population) and ulnar loops (68.3% of modern DK population) Plant growth within the bog body due to the bog environment Autopsy of internal organs inc. one testicle suggested no evidence of disease (Gregersen et al **) Throat cut was so severe, death would have taken max. few mins due to blood loss Teeth – 21 remained, 12 in situ – harris lines = difficult childhood; periodontitis = tooth disease inc. inflammation and some caries. Enamel absent and exposed dentine = a rough/coarse diet. SEM scanning electron microscopy and radiographic analyses successful but could not extract DNA from exposed dentine. Transitional analysis suggested age 26-30 based on measurements of anatomical sutures at the pubic symphysis, auricular surface and the cranium X-ray done in 1955 (Lynnerup 2010) and additional radiography in 1956 – see Asingh & Lynnerup 2007 Suggested rheumatoid arthritis of some thoracic vertebrae, rare in those under 30		
	CT scanned and MRI in 2001 (led by Asingh & Lynnerup 2010) and noted as CT scanner ‘Siemens/Somatom plus’ at 120 KV (Lynnerup & Villa 2012, 143) Colour-coded for specific structures, “allows for a morphological assessment of the tissues” and “three-dimensional rendering of the auricular surface could be made which in turn could be used for determining age-at-death” (Lynnerup 2015, 1009)		
	Post-excavation preservation in oak bark as tanning agent – “the body was kept for 18 months in a mixture comprised of one third fresh oak and two thirds oak bark, plus a 0.2% of toxinol as disinfectant” and “immersed for months in a bath of 10% Turkish-red oil in distilled water to avoid shrinkage after the evaporation of the moisture” – keeping the tissues in “original state” (Lynnerup & Villa 2012, 136) which effectively replaced bog water with tanning process (p.138) Also discussed in Lynnerup 2015 (1008)		
	Cranial dimensions – 10% smaller compared to skeletons from non-bog environments from the same period (Lynnerup 2015, 1009) “one should consider whether these smaller dimensions reflect that the Grauballe Man really was smaller than his contemporaries, or whether this is due to diagenesis” (1009) Cranial dimensions allowed for a facial reconstruction to be carried out by Caroline Wilkinson – difficult process due to taphonomic deformation of cranial bones!		
	Stomach contents – assessed by Hans Helbæk in 1958, an archaeobotanist able to identify plant species in the gut. He identified 66 different species – weeds, grasses, small animal bones, barley, wheat, chaff, oats, some rye-grass, etc. Noted that the lack of fruit indicates he was eating foods during the winter, where things were more scarce. Reassessed by Harild et al in 2007 “In the case of the Grauballe Man this was mostly weed seed with some grain and meat” (Lynnerup 2015, 1010)		
	aDNA – not possible for Grauballe Man; “no DNA was recoverable (from dentine)” due to the wet and acidic bog environment (Lynnerup 2015, 1010) He suggests this could be possible in the future if/when the detection of shorter DNA chains is possible Acidic bog environment = calcium leeched from bones = demineralisation of the bony tissues.		

	This means that x-rays usually result in bones being poorly visualised (Lynnerup 2010, 444) “The demineralisation is not necessarily uniform, but may differ within the skeletal system or the single bone due to the diagenetic microenvironment” = patchy Diagenesis = softening of the bone due to demineralisation, causing bending under soil pressure

APPENDIX 7: England - Worsley Man results table

Factors			
Intrinsic	Taphonomy	Decomposition stage	Only skull found - partially fleshed, some skin present. Some hair present - some its original colour of grey and brown, some has been stained red by the bog environment. Shrunken but preserved brain matter present. Some teeth present. Right ear present, left not. (Garland 1995, 104-107)
	Individual profile	Estimated age	Aged 24-40 according to the first pathologist inspecting the remains soon after discovery in 1958. 1995 - Garland concluded the remains to be of a young to middle-aged adult male.
		Estimated date of death	Estimated as no older than 100-150 years old by the first coroner's report in 1958.
		Sex	Male - see post-ex section for extra detail on this interpretation
		Weight & height	Nothing present in the literature - hard to interpret without long bones to give indicative measurements of height
		Ancestry	Interpreted as generally Caucasian, with no inference that the WM was anything other than northern European. No aDNA testing carried out and as yet no reported isotopic analysis on hair etc - forthcoming as a result of currently still ongoing research from 2018 onwards.
		General degree of health	Complete dentition at time of death but only two teeth recovered (Giles 2020, 220)
Extrinsic	Context	Bog location	Astley Moss, Greater Manchester - in the area of Wigan, around 10 miles to the west of central Manchester
		Surroundings	Moorland, bog. It is today regarded as a SSSI - site of special scientific interest in the UK and is managed by the Lancashire Wildlife Trust, designated as a protected area for conservation purposes as it is not only an important site for certain species, but also as one of the last remaining fragments of Chat Moss, an ancient peatland / lowland raised mire https://www.wigan.gov.uk/Resident/Leisure/Greenheart/SSSI/Astley-Moss-SSSI.aspx
		Date found	18 August 1958 (Giles 2020, 218)
	Environmental	Temperature	Nearest station for temp. in UK according to the Met Office was 'Ringway 'just to the south of Manchester at the airport which has now closed https://www.metoffice.gov.uk/research/climate/maps-and-data/historic-station-data Rochdale station is now the closest, just to the north of Manchester https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcw2ymd6s Data is available from Rochdale from 1981: 1981-2010 Annual max. temp 12.1 and annual min. temp 5.8 Mean average annual temp. therefore is 8.95
		Humidity & rainfall	From the Rochdale station: Rainfall average annual = 1118.6mm

		Entomological activity	Not actually discussed in the literature specifically, but Giles does mention that the period of investigation from 1987 noted that the skin indicated “significant microbial damage” (Giles 2020, 221) - not sure if this is entomological activity or just from the bog itself.
		Soil type in area Is soil type discussed in literature?	Peatland high in sphagnum moss but nothing discussed in the literature re: soil type specifically beyond a discussion of the chemical composition of the bog itself. According to LANDIS http://www.landis.org.uk/soilscapes/ Online GIS with a search for ‘Astley Moss’ Soilscape 26: Raised bog peat soils Texture: Peaty - defined as “soils that have a surface layer that is dominantly organic” Coverage: 0.3% England Area: Astley Moss is 27.0km^2 Drainage: Naturally wet - defined as “permeable soils [that] are often affected by high ground water that has drained from the surrounding landscape” Fertility: 1/5 - Very low - defined as “very acid, have low numbers of soil-living organisms and support heathland and acid woodland habitats” Habitats: Raised bog communities Landcover: Bog; grassland and some arable Carbon: High Soil descriptions: http://www.landis.org.uk/soilscapes/soilguide.cfm LANDIS is developed by Cranfield University and sponsored by DEFRA Linked with LANDIS SiteReporter, an online tool for detailed information on soil descriptions etc. Cannot be accessed without an ac.uk email address - my student.lu.se address is not valid as an academic email
Cultural	Cause of death	Trauma and/or injury? Poisons? Natural? Unknown/unclear?	# downwards on the right side of the mandible into an empty socket of the lower right canine tooth. CT scan unable to determine if this was ante, peri or post-mortem. # seen in the frontal and parietal bones and depressed # in the bregma region where skin and bone fragments were displaced, indicating a # to the top of the head. The preserved CV1 and CV2 show evidence of sharp-force transection, interpreted as evidence of beheading (Giles 2020, 220; Garland 1995, 106). c.28mm laceration found leaning up to the remaining preserved right ear - microscopic examination showed “irregular wound edges and displacement of hair follicles into the wound” (Giles 2020, 220) See the section on post-ex analyses and treatment for more info here - it’s comprehensive due to 4 periods of detailed analysis
	Burial	Clothing or coverage on the individual and therefore % exposure to enviro’	Head only - nothing else found clothing-wise) No head coverage/hat etc. - 100% exposure to the chemical composition of the bog environment.
		Clothing with individual	n/a
		Other items with individual	None - a twisted ‘cord’ was thought to be present, embedded in the remaining preserved neck tissue - extended upwards from the soft tissue toward the right side of the face but this was recently found to be a piece of WM’s own anatomy, in position due to decapitation (Giles 2020, 221; Garland 1995, 106)

<table>
<tr><td></td><td>Other</td><td>Additional factors specific to case</td><td>n/a</td></tr>
<tr><td></td><td></td><td>Last meal if known</td><td>No stomach to interpret stomach contents or any such similar</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Analyses and post-ex treatment</td><td colspan="3">Giles (2020) denotes 4 different periods of post-ex analysis after the initial work done after WM was discovered.

Pins were put into the remains to keep the bog head together post-ex - could not find date in the literature as to when this was done specifically but was in 1950s post-ex.

1. 1987 led by John Denton (histological specialist) and A.N. Garland (forensic pathologist) (Denton et al 2003; Garland 1995)

Skin, hair and ‘cord’ from neck - biochemical analysis by Garland (1995).
“the skin showed peaks for ‘chlorine, calcium and lead’ whereas the cord indicated chlorine, sodium, silicon and sulphur (but not iron or copper)” (Garland 1995, 107)
The skin indicated “significant microbial damage” (Giles 2020, 221) - entomological activity?

Histological analysis on the cord - “thick collagen bands” akin to human and animal tendons, interpreted as being of animal origin (Giles 2020, 221; Denton et al 2003, 49; Garland 1995, 107); still interpreted as a cord at this stage.

CV bone sample - “revealed normal lamellar collagen orientation indicating that this was a healthy adult individual at the time of his death” (Giles 2020, 221) and that the immediate cessation of decay indicates the head was placed into the bog very quickly post-decapitation (Denton 2003; Giles 2020, 221)

C14 - R-side of the preserved facial tissue = 1800 +/- 70 years i.e. Romano-British era not Iron Age, and certainly not 100-150 years old as first interpreted!

2. 2000-01 led by John Prag and Richard Neave (Prag & Neave 1999; Denton et al 2003)

Main purpose was to create facial reconstruction from the skull to present in the Manchester Museum - this was done by the Unit of Art in Medicine, University of Manchester with J. Prag.

CT scan - “in addition to the head trauma, the wound behind the ear and decapitation, identified by Garland, there was evidence of an ante-mortem injury to the face comprising a major ‘step fault’ at the tooth line and a misplaced but healed piece of bone in the nasal septum with a fracture line defect in the left orbit” (Giles 2020, 221; Denton et al 2003, 49) - a blow to the face from the R-side up through the nose into the eye socket, healed but “led to chronic sinusitis visible in the deformation of the right front nasal bone” (Giles 2020, 221)

Fredengren 2018 argued marginalised individuals were ostracised in societies or treated differently - Giles suggests (2020, 221) that this facial trauma, healing and clear deformation would have held some significance; “this might be an individual already caught up in inter-/intra- group violent episodes”

3. Began 2010 led by J. Bourke, B. Pyatt and P. Bradley from the University of Nottingham, and J. Denton and J. Adams from University of Manchester.

Coordinated by Manchester curator Bryan Sitch - aim: to use the latest x-ray technology and CT scanning to give more insight into his death, via non-invasive and non-destructive methods. CT scan - loose, sharp fragment of bone embedded in neck tissue; “its irregular profile means that this can now also be dismissed as the fractured end of the temporal styloid process from the right-hand side of the head… sheared off during decapitation” (Giles 2020, 223)

4. Latest began in 2018 (!) very recent research - presented here in Giles 2020 but will later be published in more detail elsewhere, just not yet!

Manc. Uni and Museum research team - M.Giles, B.Sitch, S.Sportun, I.Narkiss, E.Tollefsen and C.Jones
Proteomics expert - M. Buckley
Henry Moseley X-ray Imaging Facility - T.Lowe</td></tr>
</table>

Uni of Bournemouth forensic expert - M.Smith
Uni of Bradford hair isotope specialist - A.Wilson

New C14 date - AD131-251, at 95.4% probability (Giles 2020, 223) i.e. early to mid-Roman period

Adult male - based on defined brow ridges, robust and square chin and large nuchal crest

Ancestry - determined as Caucasian based on these features; “there is no reason to believe we are looking at the remains of anything other than a northern European skull though whether he came from an indigenous population or arrived as a Roman auxiliary or immigrant, we cannot yet tell” (Giles 2020, 223)

Age - 26-45 based on his dentition and sagittal suture but Giles notes (2020, 224) that “he suffered from some notable osteoarthritis even at this stage of life”

WM is early Roman thus comparable in date to Lindow II i.e. Lindow Man aka Pete Marsh.

Violence & injury - most significant is sharp-force wound to top of skull on the left parietal bone and bregma, c.6cm in length - “the ‘clenching’ of the jaw and shock of this cranial trauma seems to have caused the breakage of the tooth surface of the lower right first molar” (Giles 2020, 224). Linear # in occipital bone, radiates out from foramen magnum bilaterally; # extends anteriorly from foramen magnum to the sphenoid. - these are interpreted as additional subsidiary #s from the initial injury due to the sheer force of the blow itself. Top of head suggests WM was perhaps kneeling and has been interpreted as perhaps from an axe or other heavy wide-bladed weapon (Giles 2020, 224)

#s mentioned earlier to the left nasal cavity, cheek and R-jawline which were interpreted as antemortem healed #s (Denton et al 2003) - “have a softer, more ragged and irregular appearance and we interpret these here as post-depositional compression and fracture caused by the bog” - taphonomic rather than injury.

Sharp force trauma to the remaining ear - noted as exterior flesh injury 28mm long (Garland 1995); measured at 5.75cm by the newer investigation but this could be a result of post-ex handling and treatment. Beneath this wound = sharp-force cut to right mastoid process, very fine and 14mm in length - damage ratio of 2:1 external flesh/tissue to internal bone. “This is important, as James (forthcoming) has recently argued that we significantly underestimate the scale and character of violence based solely on skeletal evidence… this may be the first time that the forensic examination of an external/internal wound site has been possible for a bog body, permissible here only by the fact that the surviving facial tissue can be ‘taken off’ the underlying bone” (Giles 2020, 226) - suggestive of a sword wound wielded from behind to R-side of head while standing and “this may have been the first major blow” (Giles 2020, 226) - perhaps knocking him to his feet before the top of head injury was inflicted.

Decapitation - small 5mm wide and 10.5mm deep nick in L-side mandible; bone discoloured and sharp edge = perimortem. Suggestive of sword or axe, catching on the mandible during decapitation. Another blow shaved off some of the surface of the R-side of the mandible by the chin area. Thyroid bone severed, R-side styloid process was then embedded in the neck tissue as discussed above.

CT scan - 1950s forensic assessment was correct! Decapitation at CV3, slicing V in 2 - took 2 attempts to decapitate WM, the first clipped the jaw, the second was successful. (Giles 2020, 227)

No post-cranial body or neck tissue to interpret if WM had any other wounds, injuries, defensive wounds etc.

‘Cord’ around his neck - “has now been evaluated using proteomic analysis by M.Buckley; unfortunately, it has proved to be human… a mere piece of his own neck tissue, torn from the wider flesh of the neck, which is why it appears to pass high up into the anterior flesh below the right ear” (Giles 2020, 228).

Interpretation: 3 ‘moments’ of violence:

1. Bloody but non-fatal sword blow behind R-ear
2. Splitting axe wound to top of skull
3. Final decapitation of the head

All blade trauma - “It suggests, in keeping with several other bog bodies, the involvement of at least two to three armed figures… participating in the termination of this life” (Giles 2020, 229)

	Very little to find regarding WM beyond Giles 2020 and the papers used within that; WM received much less widespread attention than the Lindow bodies, esp. Lindow II / Lindow Man aka Pete Marsh. There are some news articles e.g. BBC and some info from Manchester Museum etc of course but considerably fewer published resources for consideration of this case study, but the published papers were very thorough in their explanations of the investigative processes and analyses carried out so it doesn't really matter… also, there was a TV show regarding WM in the early 2000s in which Melanie Giles participated and led - "Murdered: Bodies in the Bog" on UK's channel 5.

APPENDIX 8: Ireland - Clonycavan Man results table

Factors			
Intrinsic	Taphonomy	Decomposition stage	Only the torso and head was recovered having been torn apart by a peat cutter - post-torso remains not found. Tanned leather-like skin, red hair, deformed skull from taphonomic causes. Completely mummified remains, limbs shrunken in size, decalcified bones via diagenesis resulting from the environmental conditions of the bog. No post-torso remains, no hands, forearms ripped open - position of the rip is across the body from the arms and the torso, suspected as being all from the same peat cutting machinery. "Although damaged from the waist down due to the action of a peat-harvesting machine, the internal organs were preserved partially. The head was intact with a clearly distinguishable face and a very distinctive hairstyle. On the back of the head the hair was cut to about 2.5cm long with the rest of the hair, which was about 20cm long, gathered into a bundle on the top of his head" (Kelly 2006 [3], 57; 2012, 234)
	Individual profile	Estimated age	Nothing found in research literature - an adult male, but no actual age specified in the research literature. "workers discovered the preserved body of a young man in a peat-screening machine" (Kelly 2007, 78) - 'young man' doesn't specify estimated age bracket. But Kelly does mention in an interview piece that "all the ritually killed bog bodies from the Bronze and Iron Ages in Ireland were young males aged, say, 25 to 40" (Kelly 2015, 36)
		Estimated date of death	C14 of teeth, dated 392 B.C. to 201 B.C (Kelly 2006 [2] & [3];National Geographic, 2015) - Iron Age https://www.nationalgeographic.com/science/article/ireland-ancient-bog-men-science
		Sex	Male - can't find specifics of what this is based on, presume osteological analysis / preserved facial features.
		Weight & height	Estimated 5ft 2 (157cm) (National Geographic, 2015) Reported as "no more than about 5 foot 9 inches (1.76m) tall" by Kelly (2003 [3], 57)] Reported as "about 5 foot 2 inches tall" by Kelly (2007, 78) Which one is right? Quite a difference. Described as "of slight build and diminutive stature" (Kelly 2012, 234)
		Ancestry	No indication that any DNA testing was carried out; based on other bog bodies, perhaps no DNA extracted. Described as a possible deposed king of an Irish tribe.
		General degree of health	"Like Grauballe Man and Lindow Man, both men [Clonycavan Man and Old Croghan Man] were young, showed few signs of physical labour during their lives, and were healthy at the time of their deaths" (Lobell & Patel 2010) - this has since been proved to be misleading by Lynnerup who suggested that the lack of clear physical labour in the hands is a result of the bog's desquamation of the skin layers and not because they did no work!
Extrinsic	Context	Bog location	Co. Meath, at Clonycavan in Ballivor in the Republic of Ireland - around 40 miles north-west of central Dublin and just 25 miles from where Old Croghan Man was found in Co. Offaly the same year (PBS 2006).
		Surroundings	Found in waste peat (Irish Times, 2006) https://www.irishtimes.com/opinion/face-from-the-past-1.998884

			Found by Mick Burke, an employee of the peat industry at the Bord na Mona extraction works (Kelly 2006 [3], 57) Exact place he was recovered from is not known as the body was moved by peat cutting machinery (Kelly 2006, 26)
		Date found	February 2003 (Kelly 2006; Villa & Lynnerup 2012; Irish Times, 2006)
	Environmental	Temperature	Historical climate info from Met Éireann (The Irish Meteorological Service): https://www.met.ie/climate/available-data/historical-data https://www.met.ie/climate/available-data/monthly-data Temperatures: from Mullingar, the closest station with temperature, humidity, rainfall and soil temp recorded Met Éireann specifies the LTA - long-term average which is incredibly useful instead of having to use max. and min. temps to create the average/mean! LTA mean temp. is 9.2°C LTA 10cm depth soil temp. is 9.9°C
		Humidity & rainfall	Nearest station to Clonycavan is Rathwire, just around 9 miles to the west of where Clonycavan Man was found but the closest station recording all relevant info is Mullingar, about 18 miles from Clonycavan. Humidity: annual LTA is 73% Rainfall: annual LTA is 970mm p.a.
		Entomological activity	No information discussed in the research consulted for this work.
		Soil type in area Is soil type discussed in literature?	No soil type discussed in the literature beyond describing the conditions of the bog itself in rather general terms. No information on whether this was considered as it is not discussed in the research output consulted for this work.
Cultural	Cause of death	Trauma and/or injury? Poisons? Natural? Unknown/unclear?	"The victim was struck in the face with a blunt object before his head was struck with an axe and his abdomen cut. The body was then thrown into a bog pool. The means of killing suggests the "threefold death" that was reserved for the killing of kings" (Kelly, 2019) Clonycavan man suffered three axe blows to the head, plus one to his chest and was also disembowelled (National Geographic, 2015) Struck in the face with a blunt instrument, then killed by a series of blows to his head most likely by an axe, plus a 40cm cut to the abdomen which was interpreted as suggestive of disembowelment (Kelly 2006 [3], 58) "Clonycavan Man was hit in the face with a blunt instrument, then his skull was split with an axe and his abdomen was split open." (Kelly 2015, 36) "Multiple injuries to some of the bog bodies are consistent with the practice of ritual killing." (Kelly 2014) Interpreted as ritualistic sacrificial killing (Kelly 2007, 78)

	Burial	Clothing or coverage on the individual and therefore % exposure to enviro'	None found, suggesting 100% exposure to the bog environment (seems unlikely something could have decomposed in the environment that he was preserved so well in?)
		Clothing with individual	None, as above
		Other items with individual	None, as above
	Other	Additional factors specific to case	Nipple mutilation (Kelly 2012, 236) - interpreted by Kelly (multiple sources) as being a sign of demotion from his highly-ranked status and as an act of humiliation, but not known if this was pre- or post-mortem. "Oldcroghan Man and Clonycavan Man may have been deposed kings, as is implied by the fact that their nipples were cut, thus rendering them ineligible for kingship. This is because the suckling of a king's nipples was an important gesture of submission by subordinates" (Kelly 2012, 239) - seen in gold gorgets as far back as LBA. Perhaps to compensate for his short stature, Clonycavan man coiffed up his hair using an early hair gel. "Analysis of the substance by archaeologist Stephen Buckley from the University of York in England showed the gel was made of vegetable plant oil mixed with resin from pine trees found in Spain and southwest France." (National Geographic, 2015) Also noted in Kelly (2007, 78) The now retired Dr. Ned Kelly referred to this as an "extraordinary hairstyle" which "suggests that Clonycavan Man was a person of high status who commanded the resources necessary to obtain exotic foreign imports" (Kelly 2007, 78; 2014) Beneath his hair, which retains its unusual "raised" style, was a massive wound caused by a heavy cutting object that smashed open his skull (BBC, 2006). http://news.bbc.co.uk/2/hi/science/nature/4589638.stm
		Last meal if known	Chemical analysis of the hair showed that Clonycavan man's diet was rich in vegetables in the months leading up to his death, suggesting he died in summer (BBC, 2006). Kelly (2014) notes that the final meal did not survive but chemical analysis of the remaining hair "indicated that for four months prior to his death he had a plant-based diet suggesting that he may have died in the autumn before the onset of a meat-rich winter diet. This would have been consistent with him having been killed at Samhain." (also noted the same in Kelly 2006 [3], 58)
Analyses and post-ex treatment	Bog Bodies Research Project by the Museum of Ireland - setup 2003 after finding Clonycavan Man in Co. Meath and Old Croghan Man in Co. Offaly. Initially the police, the Gardaí, and the forensic pathologist were called - it quickly became clear this was an archaeological case. Kept in wet peat in refrigerated storage at 4°C (Villa & Lynnerup 2012, 138) "Thirty-five specialists, many of whom had vast experience in the field of bog body research, worked in conjunction with staff from the Irish Antiquities Division and Conservation Department of the Museum. A wide variety of analyses were carried out, including: CT and MRI scanning; palaeodietary analysis; fingerprinting; histological; and pathological analysis." (Museum of Ireland, 2020) - https://www.museum.ie/en-IE/Collections-Research/Irish-Antiquities-Division-Collections/Collections-List-(1)/Iron-Age/Bog-Bodies-Research-Project		

	18 months of investigation and analyses on the Clonycavan Man and the Old Croghan Man, who was found nearby in Co. Offaly. The Museum continues to perpetuate the theory that “ votive deposits and Iron Age bog bodies were related to kingship and sovereignty rituals.” Continues to follow the idea of the ‘overkill’ theory which has now been argued against. “CT scans, MRI scanning, palaeodietary analysis, fingerprinting, histological analysis, pathological assessment, facial reconstruction and so on” (Kelly 2006 [3], 57) - no specific info in Kelly’s papers. C14 = deposition date c.392-201 B.C (Kelly 2006, 2006 [2], 2006 [3] etc; Villa & Lynnerup 2012, 131) Hair and fingernail analysis = the info about his food intake in the last months (mostly plant-based diet) Pathological assessment = the info about the injuries, blows to the head, long cut to the abdomen and suspected disembowelment. CT-scanned with a Siemens / Sensation 16 scanner at 120KV voltage - “the different tissues in Irish bog bodies could be recognised only anatomically… in the CT-scan coronal view homogenous grey color of tissues, even in teeth” (Villa & Lynnerup 2012, 143) Both the Clonycavan Man and the Old Croghan Man were found along tribal boundaries - “four other dated Irish finds of Iron Age bog bodies were found to be located on significant boundaries with up to forty probable Iron Age bog bodies in total that appear to fit the same pattern… suggesting that some bodies… were dismembered for interment at a number of different places along tribal boundaries” (Kelly 2006 [3], 58) - interpreted as protective in nature, or sacrificial ritual associated with new kingship.