APPENDIX I: DESK-BASED CASE STUDIES

1. Ardmulcan-Dunmoe, Co. Meath

(after Mulrooney & van Breda 2008a)

Introduction

This case study focuses on the stretch of the Boyne River that passes through the townlands of Ardmulchan and Dunmoe, 3km northeast of Navan and 24km west of Drogheda (see Figure 11 in main text). Newgrange lies 10km to the east. Ardmulchan is situated on the Boyne's southern bank, in the barony of Skreen; Dunmoe lies on the opposing northern bank, in the barony of Lower Navan. The Boyne forms the natural boundary between the two baronies.

The name Ardmulchan is explained variously as deriving from *Árd Mullacháin* (the height of the hill of the little summit) (Fitzsimons 1978, 5), and *Árd Maelchon* – 'Mealchu's Height/Hill' (French 1986, 6). Dunmoe (*Dún mBó*) translates as 'the fort of the cows' (Fitzsimons 1978, 5). Using Ardmulchan as the central focal point, the monuments along a 5km stretch of the river, and within 2km of its banks, were analysed (Table I.i) (Fig. I.i). The Ardmulchan motte (ME025-019) is used throughout as a geographic reference point. Ardmulchan House, at the centre of Ardmulchan Demesne, lies 720m south-west of the motte.

Whilst the four extant monuments in the core of the Ardmulchan area belong to the high and late medieval periods, the provenance of the surrounding monuments ranges from the Neolithic to the post-medieval. In summary, the surviving Neolithic and Bronze Age sites indicate the banks of the Boyne were a favoured mortuary context. From the early historic period there was a fundamental shift in the way the land was utilised, with a greater emphasis being placed on intensive agricultural practices, particularly with the arrival of the Anglo-Normans to the region in the 1170s.

Prehistoric monuments

A megalithic tomb site (ME025-006) lies 1.5km downstream from Ardmulchan motte, at Broadboyne Bridge. The mound (16m x 11.50m; 1.5m high), was identified as a possible passage tomb by Eogan (1974, 146). It is situated on the top of a scarp at the 30m contour line on the south bank of the Boyne (*ibid.*). During the construction of a house in 1973, two pieces of sandstone decorated with megalithic art were found, along with two rough boulders close to a mound, interpreted as remnants of internal stones and kerbstones respectively (*ibid.* 146-149; Moore 1987, 13) (Fig. I.iii). The presence of serpentiform motifs along the edges of both stones may be of note especially given the passage tombs proximity to the Boyne. These designs may be symbolic graphic representation of the river itself.

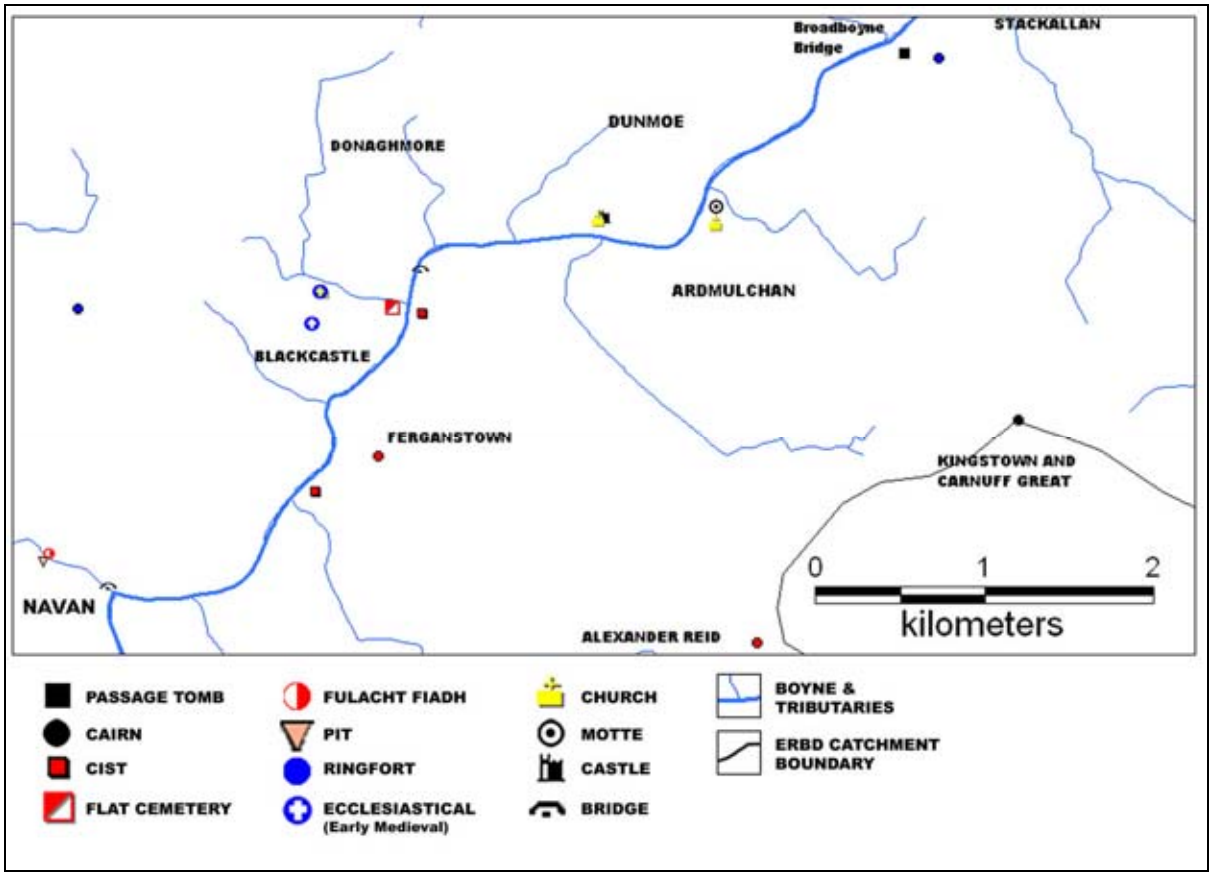


Figure I.i Distribution of the Ardmulchan-Dunmoe monuments, based on Meath County Council SMR data (also see Table I.i)

Table I.i. The SMR-listed monuments in the Ardmulchan-Dunmoe area

Monument No.	Class	Townland	Elevation (m OD)	Soil type (see text)	Distance from Ardmulchan (km)*
ME025-006	Passage tomb	Ardmulchan	30	Gls	1.50 NW
ME025-007	Ringfort	Ardmulchan	50	Rck	1.60 NW
ME025-014	Ringfort	Clonmagdan	60	Gls	3.80 W
ME025-015.01	Church	Donaghmore	>50	Rck	2.40 WSW
ME025-015.02	Round tower	Donaghmore	>50	Rck	2.40 WSW
ME025-016	Cist	Ferganstown	40	TLPSsS	1.80 WSW
ME025-018:01	Church	Dunmoe	40	Rck	0.70 W
ME025-018:02	Castle (unclassified)	Dunmoe	45	Rck	0.65 W
ME025-019	Motte	Ardmulchan	50	Rck	-
ME025-020	Church	Ardmulchan	50	Rck	0.09 S
ME025-029	Barrow (unclassified)	Fergastown	40	Made (urban)	2.60 SW
ME025-048	Flat cemetery	Blackcastle Demesne	35	Rck	1.90 WSW
ME026-007	Cairn	Kingstown	139	Rck	2.20 SE

**** Distance to the motte at Ardmulchan***

This passage tomb is noteworthy as it is the first (or last) monument of its type found along the course of the Boyne, depending on one's direction of travel. Indeed, it is the only (surviving) example of a megalithic tomb of any sort so placed in reaches of the river upstream from the Knowth passage tombs. The Ardmulchan/Broadboyne passage tomb site overlooks the river, with extensive views westwards up the river valley, and particularly of the Broadboyne stretch of the river, an area prone to flooding. In this it is somewhat reminiscent of the placement of the Brú na Bóinne tombs on a ridge overlooking the floodplain (Stout 2001, 31-32), although the topography is rather different.

Two further mounds stand in the neighbouring townlands (Fig. I.ii). A 30m diameter cairn (ME026-007) stands on the summit of Carnuff Hill at the watershed boundary. This lies in Kingstown townland, 2.2km south-east of Ardmulchan motte, on the border of the ERBD Boyne catchment area. In the townland of Alexander Reid a barrow (ME025-034) stands on the summit of Carn Hill. Both cairn and barrow are placed on exposed bedrock.

Three additional Bronze Age mounds or cist cemeteries lie in the townland of Ferganstown (Fig. I.ii). One of these is the site of a small tumulus referred to by Wilde (1849, 163) in the mid-nineteenth century, as being close to Ardmulchan, near 'the first lock' (Rowley's Lock) on the Boyne canal at *Cnoc Mionnán* (Eogan 1974). Wilde (*op. cit.*) records that a *kistvean* (cist) was discovered at Ardmulchan 'by a gentleman in removing an artificial tumulus [which] contained several skeletons, urns and some golden ornaments' (French 1986, 4). The Knockminaune cist (ME025-016) is set back 80m from the eastern bank of the Boyne, on the 40m OD contour line. It stands on Devonian/Carboniferous sandstones and shale tills. A Bowl Food Vessel and flint arrowhead are recorded from the cist (Waddell 1970, 127).

Directly opposite the Knockminaune cist, on the western bank of the Boyne, is a Bronze Age flat cemetery (ME025-048) in Blackcastle Demesne. The cemetery is set back 80m from the river. Excavations in 1990 and 1994 uncovered eight cists and two pit-burials; grave goods included Bowl Food Vessels, a worked flint and a polished stone (Roche 1990, 46-47; 1994). Crouched inhumation and cremation burials were recorded (*ibid.*); as no evidence for an overlying mound or surrounding bank was found, the site was interpreted as a flat cemetery (*ibid.*)

The second of the Ferganstown monuments, an unclassified barrow (ME025-029) lies 240m east of the Boyne (Fig. I.i). The 1m tall, 14m diameter mound was destroyed during building work in 1976 (Kelly 1977, 65). The mound covered an adult female inhumation burial within a long cist. The soil described was coarse gravel resting on boulder clay (*ibid.*).

The third Ferganstown site is also a cist burial (ME025-028; Fig. I.i). Wilde (1850) referred to a *kistvaen* uncovered upstream from Navan on the southern bank of the Boyne at '*Cnoc a' Réamuin'* (Eogan 1974, 149; French 1986, 4). This cist is set back 80m from the Boyne on the 40m OD contour line. It stands on protruding bedrock area with a thin layer of soil (BminSW, see Table 1 in main text). A vast quantity of animal remains and some sepulchral urns were found in small *kistvaens* (W.R. Wilde 1850, 163); this may have been an Early Bronze Age flat cemetery or cemetery mound (Eogan 1974, 149).

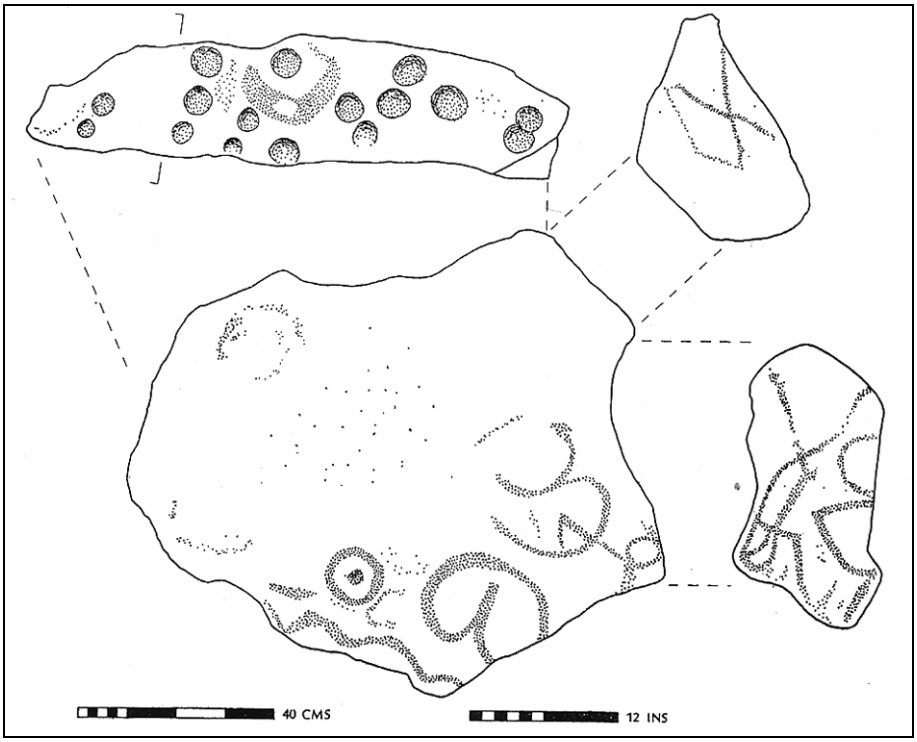


Figure I.ii Stone 1, Broadboyne Bridge, Armulchan: a decorated sandstone bearing megalithic art (Eogan 1974, 146, fig. 1).

The final prehistoric monument in the area is a standing stone in the south-west corner of Ardmulchan townland. It has only been recognised in recent years and is not yet a listed monument - it lies flat on the ground, it lay flat on the ground on its west face, but has been re-erected by the landowner in recent years (Donnelly 2001, 25). The standing stone is situated on a prominent ridge on the 100m OD contour line, on the summit of Carn Hill (Fig. I.i). The land falls sharply away northwards down to the Boyne. The stone stands 2m tall, with a further 1m below ground (Donnelly 2001, 25). Like the two decorated stones from the Broadboyne bridge passage tomb mentioned above, this stone is also sandstone. The sandstone bedrock is found north of the Boyne, although there is a chance these stones were erratics; the Ardmulchan-Dunmoe locality is predominantly limestone (*ibid.*).

Apart from the Broadboyne passage tomb and Carnuff cairn the prehistoric monuments in the Ardmulchan region are predominantly Bronze Age in date. The cluster of Early Bronze Age cists, flat cemeteries and cemetery mounds on opposing banks of the Boyne at Ferganstown/Blackcastle demesne is unique within the Boyne catchment area, especially regarding the numbers involved.

The only other known instance of a cist in such close proximity to the Boyne occurs on the southern bank at Oldbridge (ME020-002) (a distance of 22km from Ardmulchan-Dunmoe if one follows the course of the river). This segmented cist is located 110m back from the river bank, at just over 10m OD. It was discovered in a mound (18m in diameter, 1.8m high) found in the lawns of Oldbridge House in 1894 (Coffey 1895, 747). This mound is no longer extant (Moore 1987, 38). A Bowl Food Vessel, human teeth and a jet/lignite necklace were recovered (Coffey 1895, 749-

750). The Oldbridge cist is set amidst a cluster of four ring-barrows and a ditch-barrow. An unclassifed barrow (LH024-007:002) lies on the opposite northern bank in Townleyhall townland (Co. Louth). Whereas the Ferganstown/Blackcastle Demesne cluster occurs along a straight stretch of the river, the Oldbridge cluster is effectively on the apex of a significant meander in the Boyne, almost forming a 'peninsula' on a wide expanse of glacio-fluvial deposits.

Documentary and antiquarian evidence from the Oldbridge and Knockminaune cists, plus the Ferganastown barrow (unclassified) suggests that many of the cist burials on the banks of the Boyne downstream from Navan were originally covered by barrow mounds which have since been destroyed.

In addition to the three monuments placed on elevated slopes and hill summits to the south of Ardmulchan (the cairn (ME026-007), mound barrow (ME025-034) and standing stone), a similar pattern of using the high ground in prehistory is reflected in the placement of a number of prehistoric monuments on a series of hills 4-5km north of Ardmulchan. These include an embanked enclosure at Stackallan (ME018-024), the Rathcoon barrow (ME018-028), and two standing stones (ME018-018 and ME018-020) at Balsaw and Mullagha respectively (Table I.ii). The distribution of the Ardmulchan, Balsaw and Mullagha standing stones show a preference for elevated sites (90m-120m OD) within 1-4km of the two major rivers, the Boyne and Blackwater. The most upstream incidence of such standing stones along the course of the Boyne is the cluster of monoliths on the Hill of Tara (ME031-033:010 and ME031-033:019), approximately 10.7km south of the Ardmulchan motte.

Table I.ii The prehistoric monuments to the north of Ardmulchan/Dunmoe occupying elevated positions

Monument No.	Class	Townland	Elevation (m OD)	Soil type	Distance from Ardmulchan*
ME018-024	Embanked Enclosure	Stackallan	100	TLPSsS	3.75km N
ME018-028	Mound Barrow	Rathcoon	95	Rck	3.80km SE
ME018-018	Standing Stone	Balsaw	120	Rck	7.20km NW
ME018-020	Standing Stone	Mullagha	109	Rck	4.85km N
**** Distance from the motte at Ardmulchan***					

Historic monuments

The three early medieval sites in the Ardmulchan-Dunmoe area include two ringforts (ME025-014 and ME025-007) and a monastery complex at Donaghmore (ME025-015) (Fig. I.i). Donaghmore townland is said to derive its name from the monastery (*Donach-Mor-Muighe Echnach*, 'the great church of the plain of Echnach') (French 1986, 6), although there is some debate regarding the origin of the name (Moore 2008). The archaeological site consists of an ecclesiastical enclosure, church and round tower.

The distinct paucity of ringforts in the greater Ardmulchan region reflects Stout's observation (1997, 62) that, within Leinster, ringforts are least common in eastern Meath - densities fall as low as 0.04/km² in the neighbouring barony of Duleek Upper (*ibid.*) However, as the eastern area of the ERBD catchment lies within a region of significant Anglo-Norman settlement (Stout 1997, 62), which remains Ireland's

primary arable area: '…ringforts here are most likely to have been gradually removed during eight centuries of intense tillage activity…' (*ibid.*). The greater numbers of ringforts in the north-western zone of the catchment are found in a region which lay beyond the rich arable lands permanently settled by the Anglo-Normans (Graham 1975, 233).

A battle was fought in Ardmulchan in 968 AD in which the Dublin Viking king Amlaff Cuaran defeated the southern O'Neills (French 1986, 13). Early Medieval settlement is recorded at many locations in the area, including Slane and Fennor.

The catchment area incorporates much of the Liberty of Meath, comprising counties Meath and Westmeath, as well as parts of Offaly and Longford, which was granted to Hugh De Lacy by Henry II of England in 1172 AD. From that time until the late 16th century AD, the cultural and agricultural landscape of eastern Meath including the case-study areas of Ardmulchan and Brú na Bóinne, were under the continual control of the Anglo-Normans and their descendants. Following two centuries of shrinkage due to the Gaelic Resurgence, the area under the control of the old Anglo-Normans was reduced to the region officially defined in 1495 by Poyning's 34th Act as the Pale, which constituted Louth, Meath, Dublin and Kildare. The present boundary of Meath was delimited in 1542.

As part of the immediate phase of colonisation, De Lacy subdivided the Liberty of Meath into a number of smaller areas which he granted to his principal followers between AD 1172-1185. These equate with the modern baronies. These lands were then further subdivided into manors. Both Ardmulchan and Dunmoe functioned as manorial villages during the high to late medieval periods (Graham 1974, 249).

The Ardmulchan motte (ME025-019) is strategically placed overlooking the Boyne at an elevation of 50m OD (Figs. I.iii-v). As with all the other high medieval monuments in the catchment, the motte stands on a zone of exposed bedrock (Fig. I.iv). With a basal diameter of 57m north-south, the 6.8m tall mound has a flat-topped summit measuring 36 x 27m. A further four mottes are found nearby at Ardbraccan, Athlumney, Navan and Kilberry. Ardmulchan motte is one of the forty surviving mottes in Co. Meath; another nine were either destroyed or replaced during the course of the high medieval period with masonry castles on the same footprint (Graham 1974, 42).

The Ardmulchan motte fits Graham's (1974) definition of a secondary motte. These are smaller than, and lack the bailey features associated with, primary mottes (*ibid.*, 43) which were constructed during the initial sub-infeudation period of colonisation (*c.* 1175-1185). Secondary mottes such as Ardmulchan are associated with the later subdivision of those major land grants into manors (*ibid.*, 43). As well as being a defensive strong point for the local manorial lord, the Ardmulchan motte would have had a wider strategic significance; mottes were consciously sited in the area to consolidate the level of military control established over the area by the construction of the earlier primary mottes at Trim, Drogheda, Navan, Slane *et al.*, (*ibid.*, 42-44). There is a marked concentration of secondary mottes along the Boyne; further examples including Scurlogstown and Knowth (*ibid.*, 44).

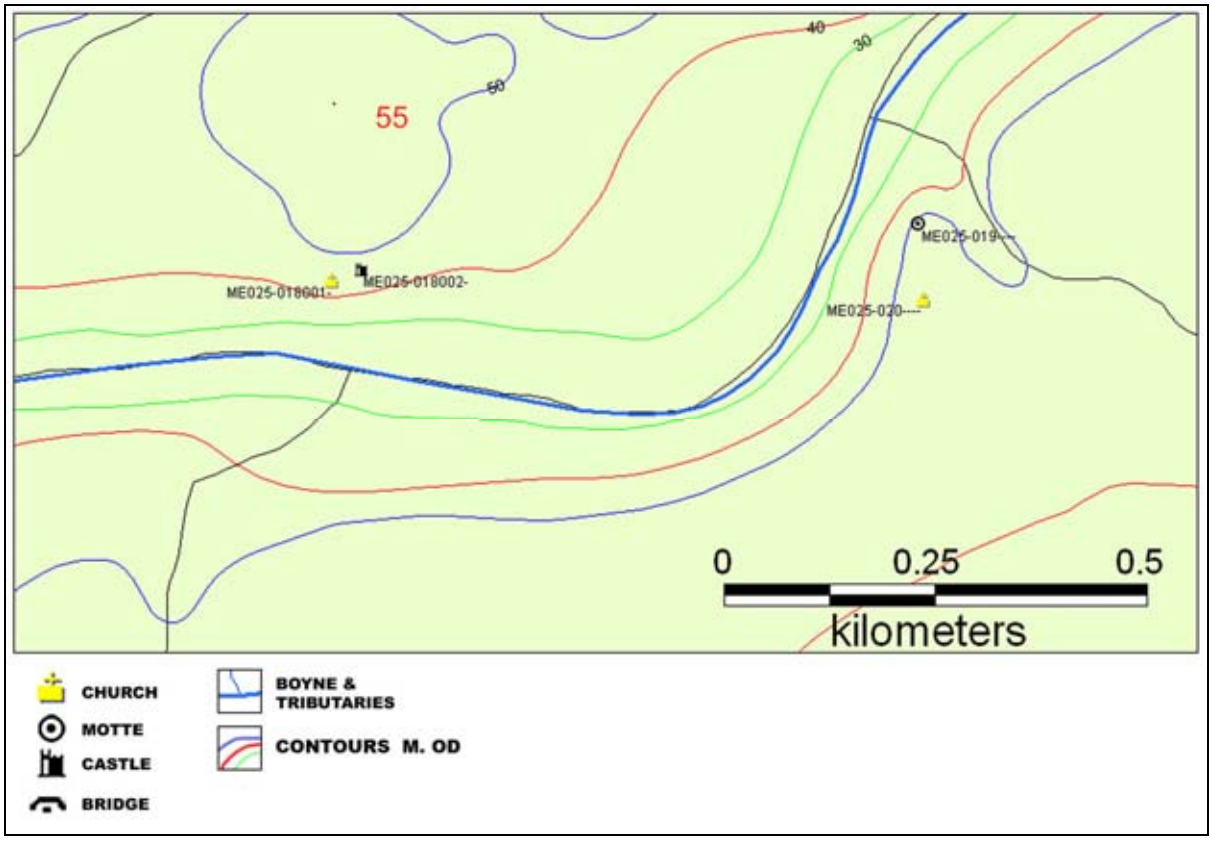


Figure I.iii The location of the four high and late medieval monuments at Ardmulchan and Dunmoe

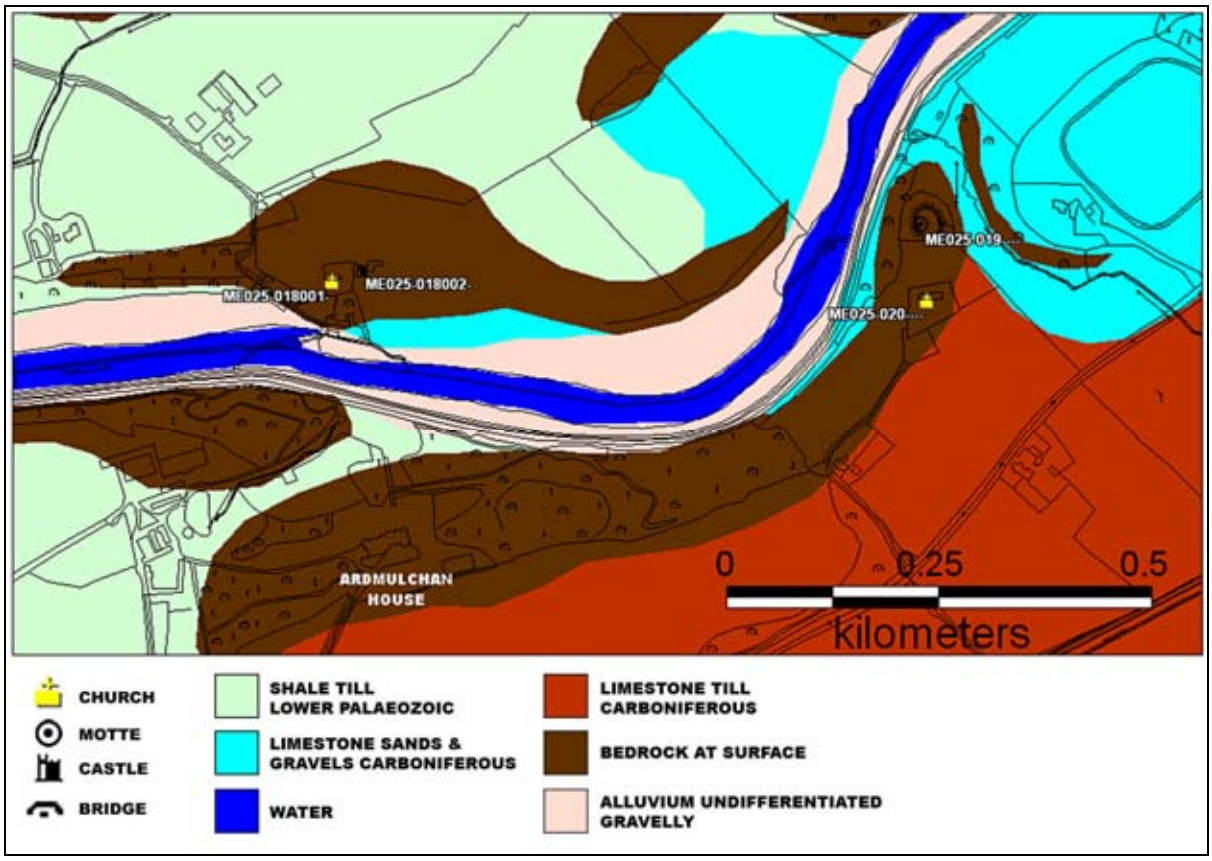


Figure I.iv The soil-types at Ardmulchan and Dunmoe

Dunmoe Castle, whilst based on the castles of the twelfth and thirteenth centuries, was not actually built until the 15th century AD (French 1986, 22). The castle was originally built by Hugh de Lacy, and was partly re-built in the 17th C, while under the ownership of the D'Arcy family (Lewis' Topographical Dictionary of Ireland 1837; French 1986, 22). It is quite an elaborate structure compared to the contemporaneous tower houses. It was rectangular with a circular tower at each corner, only two of which still stand (Moore 1987, 171).

As is the case with the majority of high medieval church ruins, both the Ardmulchan and Dunmoe churches are small simple structures (Graham 1974, 46) (Fig. I.v). Ardmulchan church (ME025-020) consists of a square, three storey bell-tower and foundations of an undivided nave and chancel, 25.6m x 7m (Moore 1987, 127). The church was probably built after the nearby motte. The church was suppressed in 1613, at which time to prevent the church bell being plundered it is said to have been taken and thrown into a deep pool in the Boyne called *Loch Gorm* (Blue Pool) (French 1986, 32). The pool is opposite Taafes Lock, 200m north of the church. The church of St. Lawrence in Dunmoe (ME025-018:001) measures 17m x 6.8m (Moore 1987, 135). A corn mill once stood on the slope below it.

Manorial village settlements such as Ardmulchan and Dunmoe were the primary form of Anglo-Norman rural settlement (Graham 1974, 48). Manorial villages would have been primarily agricultural in nature; the villagers would have created and maintained an unenclosed, open-field agricultural system (Graham 1974, 48; 1975, 228). Graham (1975) has statistically confirmed a preference in the siting of Anglo-Norman settlements and altitudinal factors. The 120m OD contour effectively marks the upper limit of high medieval settlement with 'the zone below 60m (principally composed of the lowland valleys of the Boyne and Blackwater) exerting the most powerful positive influence upon [Anglo-Norman] distribution' (Graham 1975, 237). This strongly reflects the distribution within Meath of environmental conditions favourable to arable agriculture (*ibid.*).

The erection of a motte was the primary stage in the foundation of Anglo Norman settlements (Graham 1975, 230). There is an obvious clustering of mottes along the major river valleys of the region, especially the Boyne and Blackwater (Graham 1974, 43). Mottes were strategically placed to protect river-crossing points and the main axes of movement along the river valleys (*ibid.*, 230), reflecting the necessity of ensuring stability and controlling communications within the newly settled areas (Graham 1975, 238). A statistical correlation between the placement of Anglo-Norman settlements and the distribution of crossing points of navigable rivers has been shown (*ibid.*, 1975, 239). The produce of Meath (fish, skins, hides and linen) were transported to Drogheda down the Boyne, which was navigable for small boats as far upstream as the bridge at Trim (*ibid.*, 238). By the 13th century AD Drogheda had became one of the principal Irish ports due to the flow of produce down the Boyne (*ibid.*, 235). From Drogheda the goods were exported to Chester and Liverpool (Graham 1974, 55).

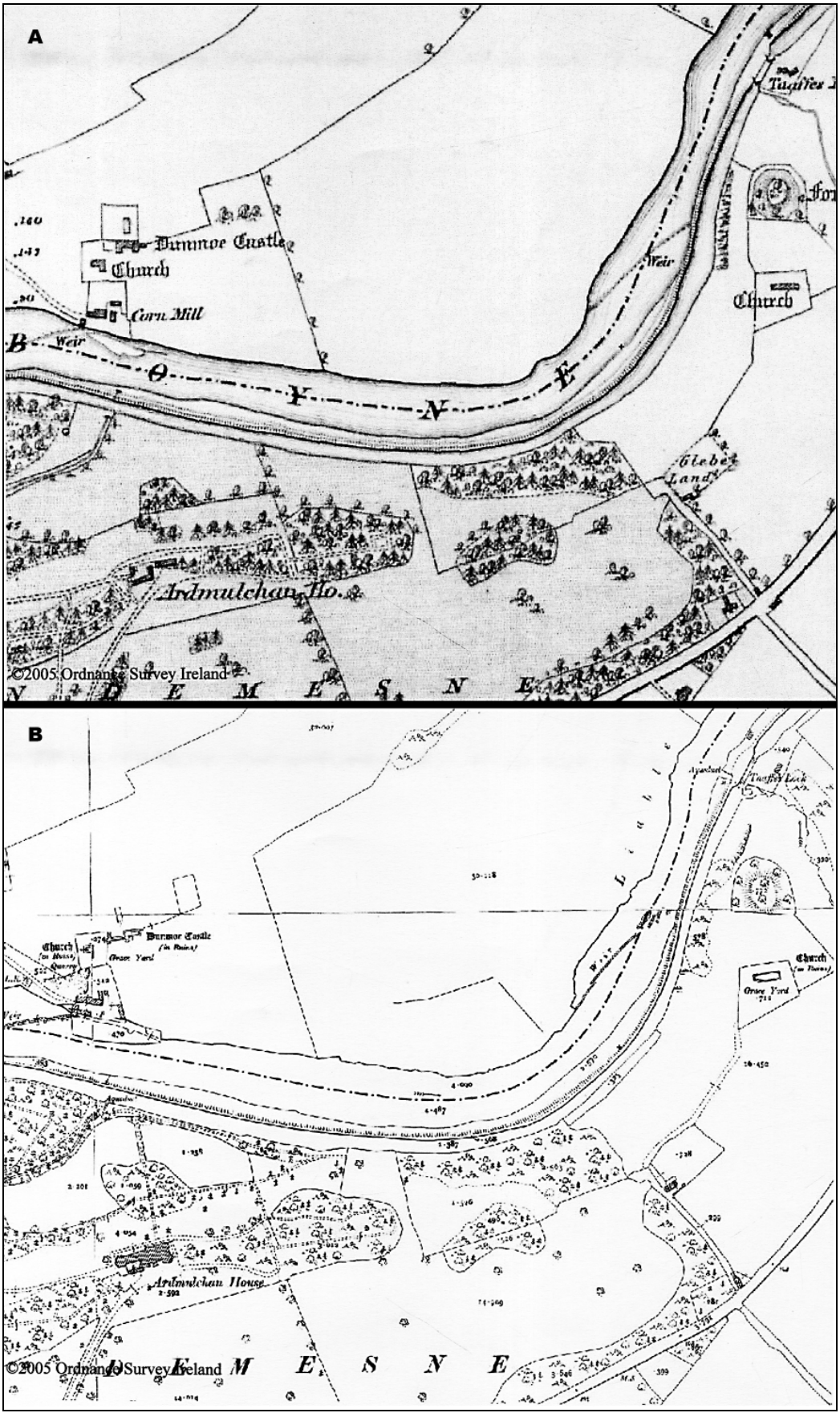


Figure I.v. A. The OS 6-inch first edition plan of Ardmulchan and Dunmoe. B. The OS 25-inch edition of 1887-1913 (OSI 2005)

Whilst there is no historical evidence of a ford or bridge existing at the fast-flowing stretch of the Boyne at Ardmulchan, the placement of a secondary motte at this venue may best be explained by the nature of the pre-existing settlement pattern, in this case the monastic site. Graham (1975, 239, 242) suggests Anglo-Norman settlements occupied or reused earlier monastic sites. There is some slight evidence for the presence of a first millennium monastic site in the area in which the high medieval church stands; an early medieval grave-slab (with a sculptured Irish cross on its face) was reused as a window lintel in the later structure (French 1986, 12) (Fig. I.vi), but the ecclesiastical foundation of Donaghmore, 2.4km upstream on the northern bank of the Boyne, must also be kept in mind as a source for the grave-slab.

As with most manorial villages, Ardmulchan and Dunmoe were eventually deserted. This occurred up to a century later than their counterparts in the west of the county, which were more exposed to the ongoing Gaelic Resurgence. Situated 12km behind the Pale boundary, the Ardmulchan area lay protected within the Anglo-Norman dominated region for centuries. It was not until the end of the 16th century AD that Dunmoe was destroyed and apparently deserted during the O'Neill rebellion in 1596 (Graham 1975, 246). A similar fate had earlier befallen Castlerickard and Killyon in 1581 (*ibid.)* Situated 30km south-west of Ardmulchan these manorial villages reflect the spatial pattern seen at Dunmoe-Ardmulcan, with one placed on each opposing bank of the Boyne, again suggesting the river could be crossed at these sites. It is possible that the two villages were united by a wooden bridge, although there is no record of such a structure existing.

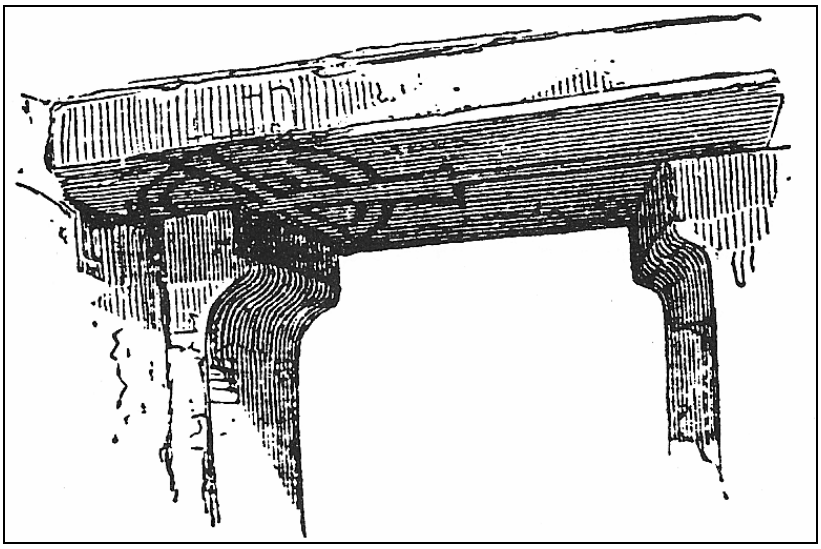


Figure I.vi The early medieval graveslab reused as a window lintel, Ardmulchan Church (ME025-020) (French 1986, 4)

The southern arch of a high medieval stone bridge (ME025-017) still stands near Donaghmore in the townland of Ferganstown (*see* Fig. 2). The upkeep of the bridge during the 15th century AD was shared between the Abbot of Navan and the Parson of Ardmulchan (Ellison 1983, 89). Known as Babe's Bridge it was variously called the Rogues' or Robbers' Bridge during later periods (Ellison 1983, 89). Babes Bridge was the only bridge on the Boyne to survive a great flood in 1330 which swept away

all the existing wooden bridges (Ellison 1983, 89). This same flood caused extensive damage in Trim and Drogheda (French 1986, 25).

Downstream from Babes Bridge is the bridge of Stackallan. The river crossing here is overlooked by high ground, but the stretch of the river just upstream was formerly prone to flooding (Ellison 1983, 91). This is the 'Broad Bay of Ardmulchan' mentioned by Markes Plunkett in 1710 (*ibid*., 10). The area marked as 'liable to flooding' on the OS 25-inch map suggests floodwaters extended as much as 150m beyond the river's southern bank between Ardmulchan and Stackallan Bridge. To this day the Stackallan Bridge is more often than not called Broad Boyne bridge, for instance on the OSI 1:50,000 series maps. The area was locally known as '*Bray*' in the 18th century – Ellison suggests this is probably a contraction of 'Broad Boyne' (1983, 91).

The mill at Ardmulchan was a tuck or fulling mill (Ellison 1983, 53).

The weir at Ardmulchan was illustrated as an intact structure in the first edition OS six-inch maps but is represented as five units in the 25-inch map series (1887-1913) and the current OS maps. The weir may have been damaged by flooding at some point in the 19th century.

2. Brú na Bóinne, Co. Meath

(after Mulrooney & van Breda 2008b)

Introduction

The Brú na Bóinne case study area lies in the lower stretch of the Boyne River, Co. Meath, and encompasses an area of 16km² (Figs. 5-7 in main text). While Brú na Bóinne is best known for its Neolithic passage tomb cemetery, the area has been utilised for at least seven millennia (Stout 2002, 2), comprising monuments of Neolithic to early modern date.

Brú na Bóinne is located just at the edge of the Central Lowlands, a landscape characterised by undulating drift-covered relief. Stout (2002, 2) noted that the Boyne provided ready access to the Irish Sea, the river system being one of the few easy avenues of access to Ireland's eastern interior. Drogheda, at the mouth of the river, would become one of the main Irish ports during the high medieval period, transporting goods and produce across the Irish Sea to western British ports such as Liverpool (Graham 1974, 55). The use of sea sand at Newgrange (the tomb's roof joints were caulked with sea sand and burnt soil) (Waddell 1998, 59), illustrates the transportation of material 15km inland (*c*. 20km upstream) during the Neolithic, possibly from the estuary in the Drogheda area,. Indeed the Boyne was navigable as far inland as Trim up to the high medieval period (Graham 1975, 238).

Landscape

The famous river bend is well understood as the product of the underlying geology, which forces the west-east flowing river to take an abrupt change of direction at Knowth, flowing southwards below the elevated Knowth ridge (Stout 2002, 2). The bend in the Boyne was formed when Boyne waters incised into the glacial mantle of tills deposited as the Drogheda ice sheet retreated to the northwest. The steep flanks of the Boyne reflect glaciofluvial erosion resulting from deglaciation processes at the end of the last Ice Age (*c.* 12000 BP) (Stout 2002, 9), of which the steep terraces on the southern bank opposite Newgrange in the townland of Roughgrange are a tangible legacy.

The Brú na Bóinne cemetery, as with most passage tomb cemeteries, is located in an area of good agricultural land (Cooney & Grogan 1994, 61). Wheat pollen found through analysis of some of the turves from the Knowth and Newgrange mounds indicates that the turves cereals were grown nearby at the time of mound construction. Areas of open pasture were also indicted from pollen of wet-loving plants, probably from the nearby river valley (Waddell 1998, 62).

By combining the Newgrange and Knowth excavations environmental evidence with the underlying geomorphology, geology and soil cover Cooney (1991) reconstructed a pattern of Neolithic land use (Fig. I.vii). This correlates well with the CORINE datasets categorisation of 'pasture' and 'non-irrigated arable' zones (Cummins 1996). This presents an agricultural model of some complexity with pastoral and arable activity 'taking place close together in conjunction' (Cooney & Grogan 1994, 41). It was proposed that soils of the region (which are now Brown Earth and Grey-Brown Podzolic soils) could have been used for either pasture or tillage, while heavier, less well-drained local soils, such as Gleys are likely to have had a more restricted agricultural use (*ibid*., 46). However, modern soil distribution and ancient land use practices are not easily correlated (see main text), and research elsewhere has demonstrated that it is necessary to actually investigate both pedogenetic history and ancient land use through studying detailed site-specific indicators before linking these aspects of landscape (French *et al*. 2007).

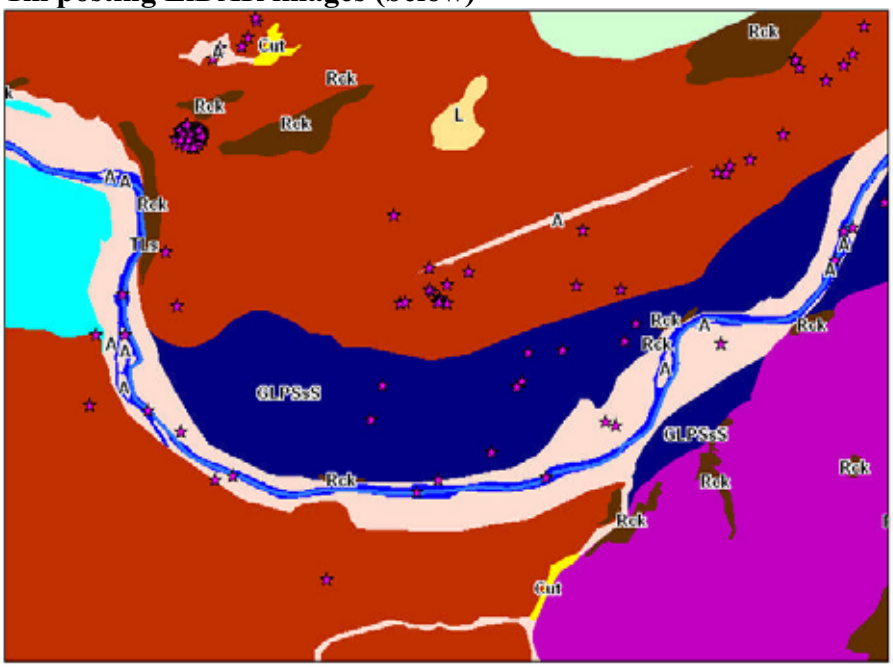
The undulating sediments of the till overlying the bedrock has a dominant influence on the geomorphological and topographical nature of Brú na Bóinne (Meehan & Warren 1999; Stout 2002). This topography appears to have been important culturally regarding the placement of the passage tombs and the siting of monuments of later date.

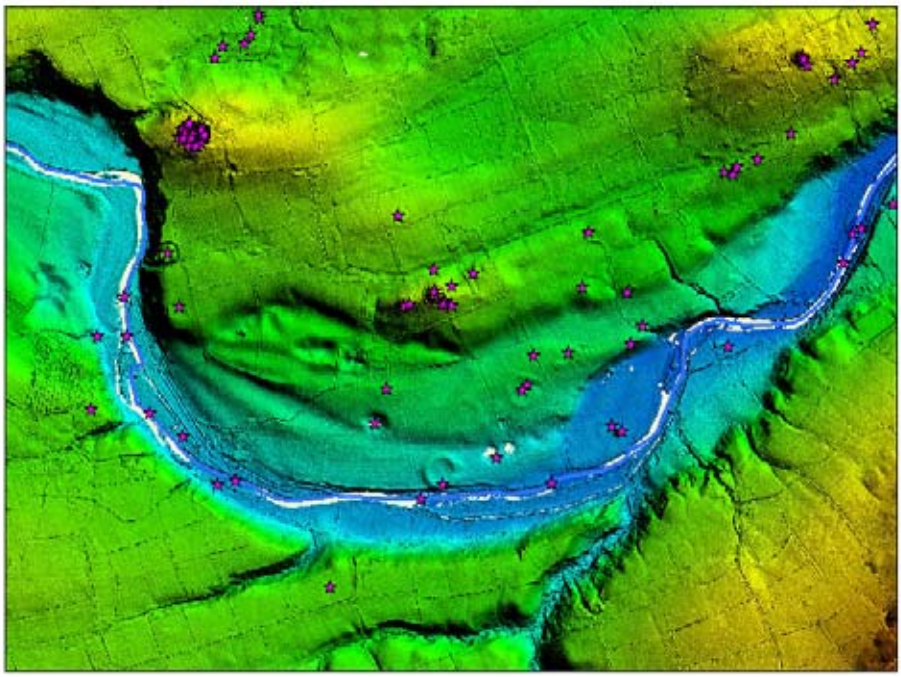
Archaeological remains

Mesolithic

Evidence of Mesolithic activity at Brú na Bóinne exists exclusively in the form of lithic finds. Later Mesolithic flakes and related forms were recovered in the assemblage from Newgrange (Lehane 1983; Stout 2002). Further Mesolithic material has been discovered to the east of Brú na Bóinne by field-walking (Cooney & Brady 1998; Cooney 2000; Brady 2007). Brady's recent campaign of systematic field-walking has sought to identify evidence for settlement in the wider Brú na Bóinne landscape (Brady 2007; Figure I.viii). Amongst the surface-collected lithics (numbering over 8,600) a single Late Mesolithic flake was recovered, but no Early

Figure I.vii Area of the World Heritage Site at Brú na Bóinne showing archaeological monuments superimposed on the 1:50,000 subsoil map (above) and the 1m posting LiDAR images (below)





Mesolithic artefacts were identified (Brady 2007, 217). The single Mesolithic artefact was recovered on the south side of the Boyne (*ibid.)*

Figure I.viii Aerial photograph of the Bend of the Boyne showing areas of potential settlement evidence (outlined). OS image 02380-C

Neolithic

Radiocarbon dates from Knowth indicate pre-tomb activity dates back to the Early Neolithic, and excavations indicate settlement activity at this time (Eogan & Roche 1997 Cooney 2000, 30). The Knowth excavations have provided clear evidence of occupation and burial activity from the Early Neolithic to the Early Bronze Age (*ibid.*; Brady 2007, 213). Six artefacts of Early Neolithic date plus a sherd of an Early Neolithic carinated bowl were recovered through field-walking on the south side of the Boyne at Brú na Bóinne (Brady 2007, 217).

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The middle Neolithic passage tombs of Brú na Bóinne have been described as the greatest architectural achievements of the passage tomb builders in western Europe (Waddell 1998, 57). The renowned Knowth, Newgrange and the Dowth tombs are the three largest passage tombs in Ireland, with all three occupying commanding positions on the summit of the ridge overlooking the course of the Boyne; Newgrange, at 61m OD, is the most elevated of the three. A possible 40 smaller passage tombs also lie in the area (Brady 2007, 213), 18 of which are the satellite tombs surrounding the central mound of Knowth, which itself has been radiocarbon dated to 3358-2932 BC and 3292-2922 BC (Eogan 1991, 126). The radiocarbon dates from the Knowth tombs as a

whole suggest that the cluster of tombs at the site were erected at much the same time, implying that the construction of the Knowth cemetery, and perhaps the Brú na Bóinne passage tomb complex as a whole, may have spanned a comparatively short period of time (Waddell 1998, 65). As the Newgrange excavations returned radiocarbon dates spanning the later centuries of the third millennium BC, the Boyne passage tombs fit into the final stage of the five stage developmental sequence of megaliths proposed by Sheridan (1986).

A marked change in the function and utilisation of Brú na Bóinne took place during the later Neolithic, towards a domestic and changed ritual role (Cooney & Grogan 1994, 78). Earlier passage tombs were now encircled, within large enclosures (e.g. Sites A and Z; Stout 1991). At least 14 structures with hearths and fireplaces were built adjacent to the southern perimeter of the Newgrange mound (Cooney & Grogan 1994, 80).

The construction of the three Brú na Bóinne hengiform enclosures is assigned to the Late Neolithic period based upon the 1971 excavation carried out at the nearby Monknewtown embanked enclosure (SMR ME019-016001), which returned a radiocarbon date of *c*. 1860 BC (Sweetman 1976; Stout 2002, 61). A total of 13 such enclosures exist in the Boyne region, including henge sites 'O' and 'A' south of Newgrange, and the Dowth henge (Stout 1991). A fifth henge at Stackallen (SMR ME018-024) lies between the Ardmulchan and Brú na Bóinne case study areas, on the southern foothills of the Collon massif.

Bronze Age

A circle of pits (SMR ME019-044002) to the south-east of Newgrange mound was built c. 2000 BC (Sweetman 1985; Stout 2002). The excavations at Newgrange indicate that this pit-circle is post-dated by 12 extant standing stones which were erected in the later third millennium BC (Early Bronze Age). These monoliths are the remnants of a stone circle enclosing the earlier Newgrange passage tomb (Stout 2002, 35). Thirty-seven lithics of Early Bronze Age date were found on the south side of the river (Brady 2007, 217), indicating continued use from the Neolithic period. A number of monuments once regarded as possible passage tombs are now designated 'barrows' of various types, e.g. 'Passage Tomb' Site B, now classified a mound-barrow (SMR 019-058001). This is the most prominent surviving monument on the floodplain today.

A number of low-relief structures also exist in this area, such as the crop-circle to the north-west of the Site P henge (Brady 2007, fig. 19.4). Analysis of the recent LiDAR survey data of the Brú na Bóinne World Heritage Site suggests the additional presence of two low mounds to the west of Site P henge. While tentative, these may be the remains of previously unknown ploughed-out barrows.

Iron Age

Following the Early Bronze Age, activity at Brú na Bóinne becomes less detectable in the archaeological record. Evidence of Iron Age activity in the region is particularly sparse; Knowth passage tomb was fortified with the excavation of ditches which enclosed the site (Stout 2002, 70). A large number of extended burials of Iron Age

date (190 BC–AD 250) were uncovered at Knowth (Raftery 1994; Stout 2002). A ring-barrow (SMR-ME019-058002, the dominant barrow-type of the Iron Age (Raftery 1981; 1994), lies 30m north-west of the Site B mound-barrow at Newgrange.

Early Medieval

The lower Boyne Valley formed part of the kingdom of Brega during the early medieval (Stout 2002, 76). From AD 688, the capital and royal residence of northern Brega was the reused passage tomb at Knowth (Cnogba) (Eogan 1991; Stout 2002). Knowth's transformation into a settlement site involved its surface and internal passages being adapted to create houses and souterrains. A souterrain was added to one of the passages of the Dowth tomb during this period. Contemporaneous ringforts are few at Brú na Bóinne itself, although a number are discernible in the fields north and south of the Boyne (Stout 2002, 78). The main mound at Knowth was also reused temporarily during the high medieval period, at which time it was converted into a motte (Graham 1974, 44; Stout 2002, 68).

Interestingly, Stout has noted early medieval references to 'boat-shaped' burial mounds at Brú na Bóinne, features which have not being identified to date in today's landscape (Stout 2002, 67). The possible sites may also be much later in date since the small mound-barrow at Rossnaree (ME019-059) 'Cormac's Grave', revealed inhumations and grave goods of the sixth century which do not conform to Christian ritual and thus may be of Viking origin (Stout 2002, 70)

3. The M3 and M4: Boyne River Landscape 'Transects'

(after Mulrooney & van Breda 2008d)

Introduction

The M3 and M4 National Roads Authority (NRA) Motorway Schemes have been built in the catchment area of the Boyne in recent years, both of which transect the Boyne (Fig. I.vix). The monuments excavated along these routes are shedding new light on the understanding of the archaeological landscape as whole, though particularly on the Bronze Age and early medieval periods (Carlin 2008).

Taking a 10km section of both route-ways with their respective fording of the River Boyne as centre points, a proxy-transect of the distribution of monuments and their placement in the landscape, focusing on their relationship to the Boyne, its tributaries and water courses, have been analysed using the GIS database record of soil types, elevations, monument distributions and chronological periods.

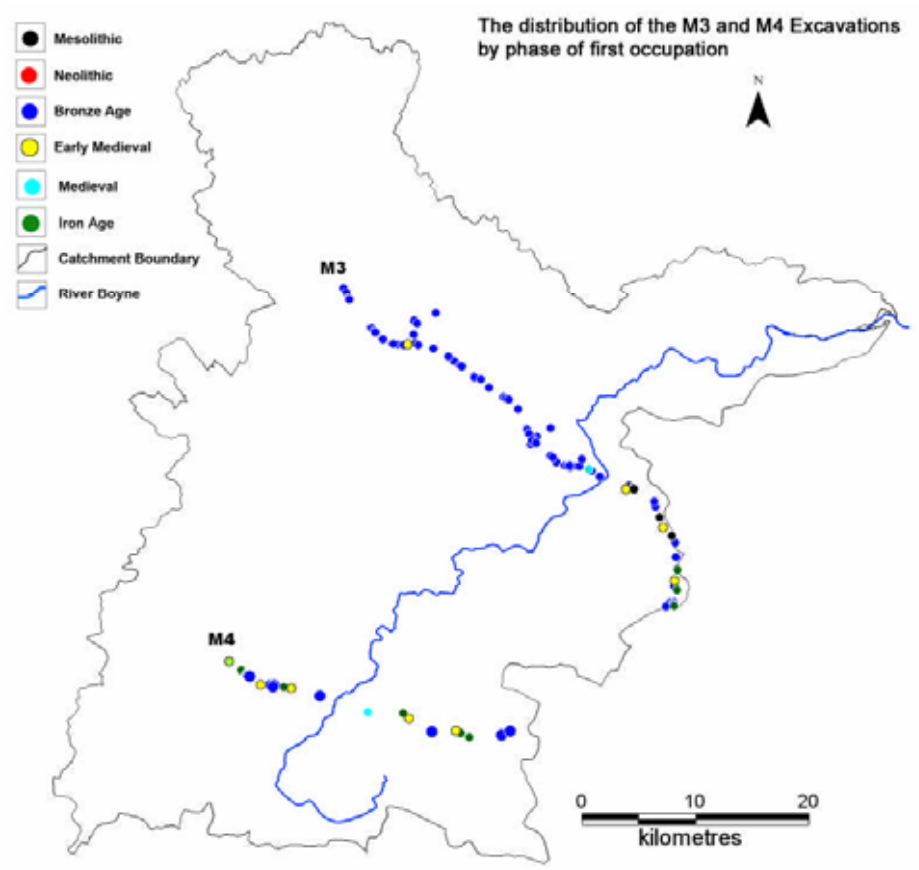


Figure I.vix Sites along the M3 and M4 motorway routes in the Boyne catchment

The M4 Motorway Monuments

The route of the M4 Kinnegad-Enfield-Kilcock Motorway Scheme stretches for almost 35km from the west of Kinnegad, Co. Westmeath on through Co. Meath, terminating at Kilcock, Co. Kildare.

Six sites were excavated along the 10km M4 transect which traverses the Boyne. The three western sites (Hardwood 2, Ardnamullan 1 and Towlaght 1) lie in Co. Meath, the remainder lie in Co. Kildare (the Boyne acts as a natural boundary between the two counties) (Table I.iii) (Fig. I.x). Four of the sites are multi-period in nature, so the first phase of occupation recorded at each is used to categorise the chronological distribution of the sites. This methodology is also applied to the M3 10km 'Boyne transect' (below).

The earliest evidence of activity uncovered through the M4 excavations dates to the Early Bronze Age (Carlin 2008) – it seems that the lands were not heavily exploited at that period, the features uncovered largely consisting of burnt mounds, isolated pits and one Bronze Age inhumation burial (*ibid.*, 1).

The first phase of occupation for all six excavations is accounted for by five periods ranging from the Bronze Age to early modern, two being Iron Age (Hardwood 2 and Moyvalley 1). The features excavated across sites of all periods are quite limited, but the repeated pits, charcoal spreads, burnt mounds, hearths and ditches indicating the various sites functioned as industrial sites. This has been interpreted as peripheral activity occurring on the edges of more densely settled areas (Carlin 2008, 1).

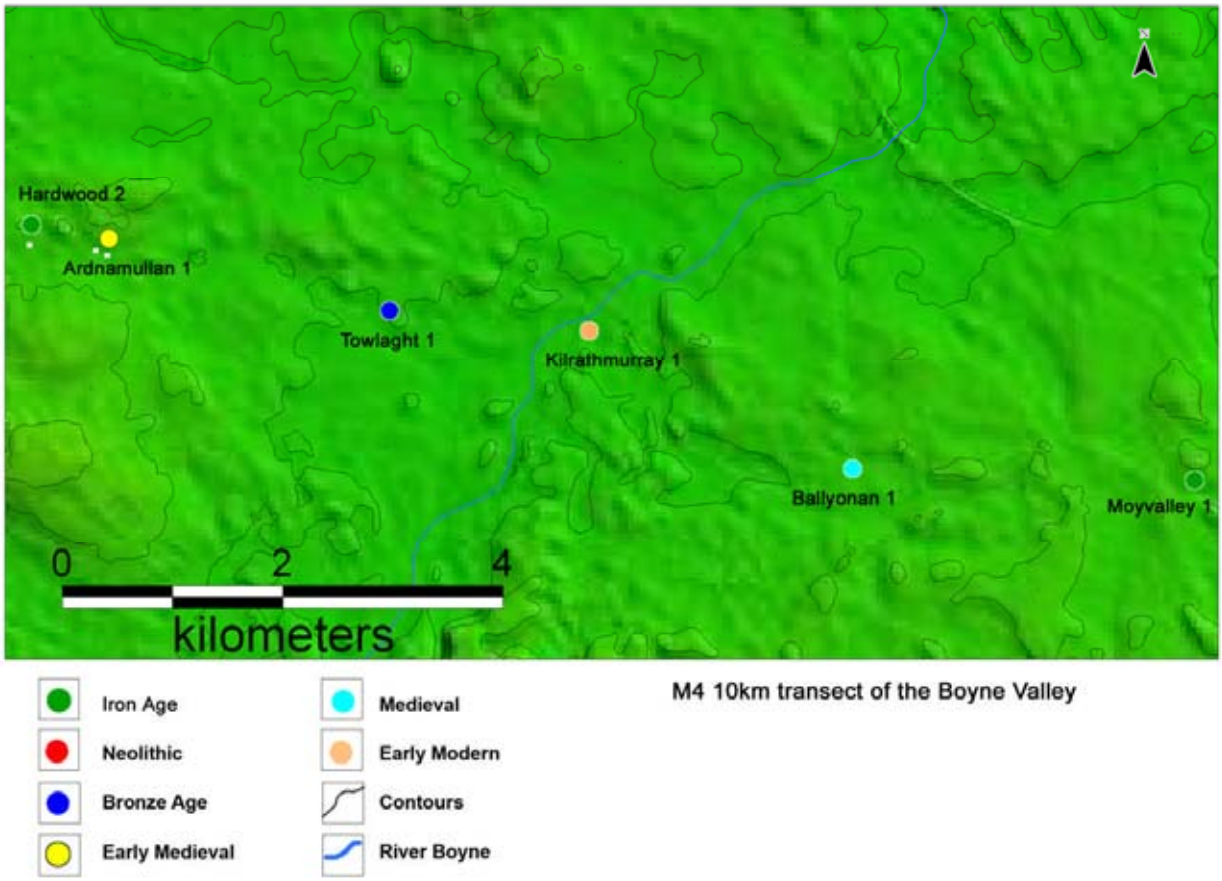


Figure I.x Sites discussed on the route of the M4 motorway

Regarding site distribution, a regular pattern emerges favouring the placement of sites of all ages on Carboniferous limestone till soils (soil type TLs), and at elevations between 70-80m OD (Table I.iii). The single exception is the early modern Kilrathmurray 1 (02E1085), the site of a nineteenth century cottage. The cottage is the lowest placed monument (60-70m OD), built, unlike the other sites, on Carboniferous limestone sands and gravels (soil type GLs). No sites were found upon intervening soil types lying between the excavated sites. It appears that areas of 'Cutover Peat', 'Alluvium' and 'Carboniferous limestone sands and gravels' were not utilised until the 19th century. However, survey and excavation methodologies used as standard by the NRA would not necessary uncover all site types – artefact scatters in the topsoil would not be necessarily be found, for example, since field practice frequently saw topsoil stripping without assessment.

All six sites are in relatively close proximity to tributaries of the Boyne, the three Meath sites each lying within 50-110m of a stream or river.

Table I.iii The six excavated M4 sites along the 10km transect traversing the River Boyne. The 'Period 1' column records the first phase of occupation of each site. TLs = Carboniferous limestone till; GLs = Carboniferous limestone sands and gravels

LICENCE NO.	SITE NAME	PERIOD 1	ELEVATION	SOIL TYPE	KM TO BOYNE
02E1140	Hardwood 2	Iron Age	70-80m OD	TLs	4.90km
02E1147	Ardnamullan 1	Early Medieval	70-80m OD	TLs	4.10km
02E1145	Towlaght 1	Bronze Age	70-80m OD	TLs	1.50km
02E1085	Kilrathmurray 1	Early Modern	60-70m OD	GLs	0.25km
02E1087	Ballyonan 1	High Medieval	70-80m OD	TLs	2.90km
02E1088	Moyvalley 1	Iron Age	70-80m OD	TLs	5.50km

The M3 Motorway Monuments

The route of the M3 Clonee-North of Kells Motorway Scheme within the boundaries of the Boyne catchment traverses a length of 40km. Of the 32 sites (Co. Meath) excavated along the 10km M3 transect which transverses the Boyne 26 were of archaeological significance (Kevin Martin unpublished). Thirteen of these sites lie west of the Boyne, 11 to the east (Table XX) (Fig. I.x). The first M3 excavation within the catchment is Johnstown 2, Co, Meath, an Iron Age excavation located one kilometre south-west of Dunshaughlin. Johnstown 2 is situated 12.70km south-west of Ardsallagh, Co. Meath the point at which the M3 straddles the River Boyne. Each of the 11 M3 sites east of the Boyne is situated within two to three kilometres of the Hill of Tara to the south (Fig. I.x).

The first phase of occupation for the 26 excavations are accounted for by six periods ranging from the Mesolithic to early modern, the first phase of activity of the majority (54%) belonging to the Bronze Age period. The earliest evidence of activity uncovered throughout the M4 excavations dates to the Mesolithic period e.g. the site of Blundelstown 1, Co. Meath where Mesolithic lithics were recovered (*ibid.*).

As with the M4 site distributions, soils of Carboniferous limestone till (soil type TLs) were favoured with thirteen of the 26 sites 'Boyne transect' (50%) excavated standing on this soil type. The excavated Bronze Age sites within five kilometres west of the Boyne are exclusively placed on these soils, at elevations between 40-50m OD. Sites situated on Carboniferous limestone sands and gravels are also strongly represented with 10 examples present (38.5%). Sites placed within zones of Carboniferous sands and gravels are exclusively located east of the Boyne and include the Ballinteer 1 (Neolithic) and Castletown Tara 3 (early medieval) sites (located 1km and 2.5km east of the Boyne respectively). None of the 26 M3 'Boyne transect' sites lies more than 0.90km from a tributary stream or river feeding into the Boyne, the majority placed within 100-400m of such a water course.

Table I.iv. The twenty six excavated M3 sites along the 10km transect traversing the River Boyne. The 'Period 1' column records the first phase of occupation of each site. TLs = Carboniferous limestone till; GLs = Carboniferous limestone sands and gravels; A = Alluvium; TNSSs = Namurian shales and sandstones till

SITE NAME	PERIOD 1	ELEVATION	SOIL TYPE	*S* to Boyne*
Gainstown 3	Bronze Age	70-80m OD	TLs/A	5.10km
Gainstown 1	Bronze Age	60-70m OD	TLs	4.90km
Gainstown 2	Bronze Age	60-70m OD	TLs	4.50km
Macetown 1	Bronze Age	60-70m OD	TLs	3.70km
Williamstown or Bawn 2	Bronze Age	50-60m OD	TLs	3.30km
Philpotstown 1	Neolithic	50-60m OD	TLs	3.30km
Williamstown or Bawn 1	Bronze Age	50-60m OD	TLs/A	2.60km
Kennastown 1	Bronze Age	50-60m OD	TLs	2.45km
Kennastown3	Bronze Age	40-50m OD	TLs	2.66km
Ardsallagh 3	Post-medieval	50-60m OD	TLs	1.60km
Ardsallagh 1	Bronze Age	50-60m OD	TLs	1.30km
Ardsallagh 4	Neolithic	50-60m OD	TLs	0.95km
Ardsallagh 2	Bronze Age	50-60m OD	TLs	0.50km
Ballinteer 2	Neolithic	40-50m OD	GLs	1.00km
Castletown Tara 3	Early Medieval	50-60m OD	GLs	2.00km
Philpotstown 4	Early Modern	50-60m OD	GLs	2.25km
Philpotstown 2	Bronze Age	50-60m OD	A	2.25km
Philpotstown 1	Early Modern	50-60m OD	A	2.30km
Castletown Tara 1 and 2	Neolithic	60-70m OD	GLs	2.15km
Blundelstown 2 and 3	Bronze Age	60-70m OD	GLs	2.60km
Blundelstown 1	Mesolithic	60-70m OD	GLs	2.75km
Lismullin 1	Neolithic	80-90m OD	GLs	4.00km
Skreen 3	Bronze Age	90-100m OD	GLs	4.75km
Skreen 2	Bronze Age	90-100m OD	TNSSs	5.10km
**** Distance to River Boyne along transect***				

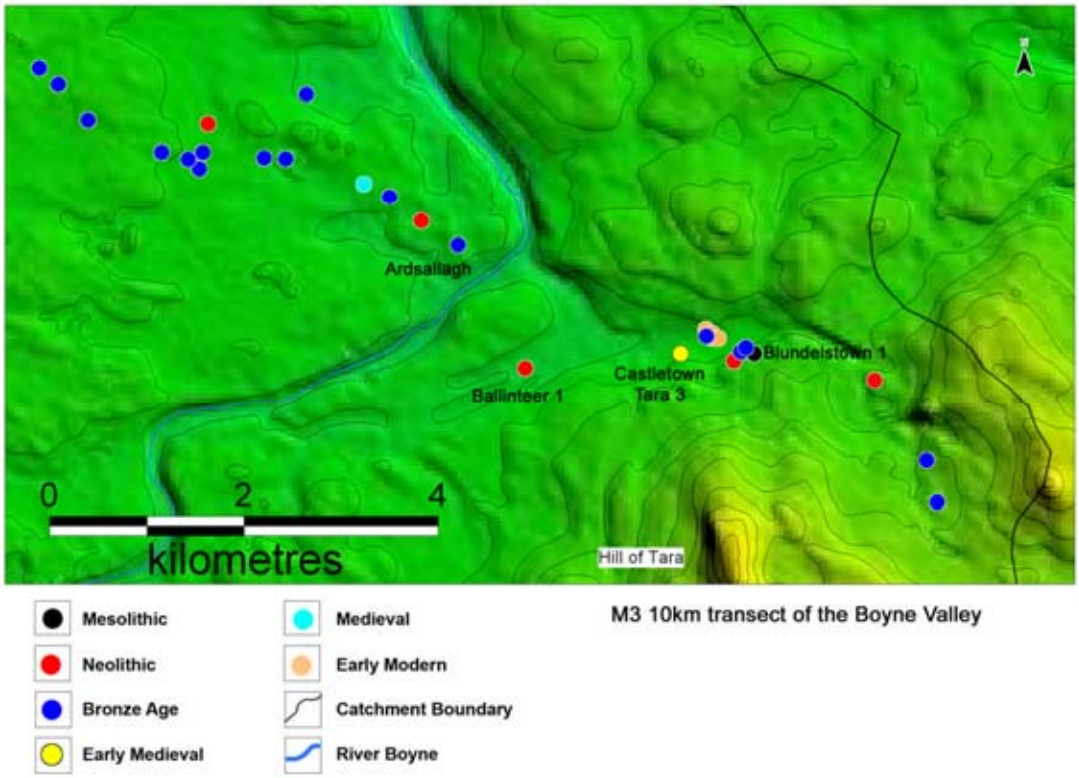


Figure I.xi Sites discussed on the route of the M3 motorway

APPENDIX II: AUGER PROFILES

Brú na Bóinne transect A-A[1]

Drill No.	Coord.	Layer No.	Colour	Soil Description	Depth (cm)	Anthropogenic features	Horizon	Remarks
1	300637/ 273164	1	Strong Brown	SILT, sandy, very fine. Slightly clayey. Reasonably humus-rich.	0-30		Ah	Start of transect in middle of pasture field (field 1). Flat area at base of E-W orientated 'valley' in a paleochaannel.
		2	Reddish Brown	Same layer 1 but with lower concentration of clasts, somewhat more clayey.	30-80		B	
		3	Reddish Brown	Same as layer 2, with higher concentration of clasts.	80-90		C	
2	300632/ 273115	1	Strong Brown	CLAY, silty	0-30		Ah	North of field (field 1) containing Drills 3-11. East of Newgrange Farm. Flat area (mini-terrace?) c. 35m north of field-fence. HL/GM.
		2	Reddish Brown	CLAY, silty, with frequent grey gravel, angular. Abandoned onto rock.	30-45		B	
3	300684/ 272383	1	Strong Brown	CLAY, silty, fluffy. Abandoned due to impenetrable gravels.	0-35		Ap	The first auger in northern end of field 2, just south of the east-west orientated field-fence. Field immediately north of field of henge/embanked enclosure (SMR ME026-006). HL/GM.
4	300678/ 272345	1	Strong Brown	SILT, very sandy. Reasonably humus-rich.	0-5		Ap1	Same field, 50m south of Drill No. 3. CG/WVB.
		2	Strong Brown	SILT, very sandy. A few clasts present.	5-30	Charcoal fleck at 25cm	Ap2	
		3	Reddish Brown	SILT, sandy, slightly clayey. More gritty and gravelly, all well rounded. Colour slightly lightens with depth.	30-50		B	
		4	Reddish Brown	SILT, very clayey. Very gritty. Many clasts. Weathered clasts, 1mm-10mm, angular and rounded.	50-80		C	
5	300683/ 272288	1	Strong Brown	CLAY, silty	0-30		Ap	50m south of Drill No. 4, same field. Flat grass and clover. HL/GM.

		2	Reddish Brown	CLAY, silty with rounded gravels >1cm. Becomes more silty with depth.	30-45		B	
		3	Reddish Brown	CLAY, silty as above, but frequent gravel of 1-3cm; sub-angular and subrounded.	45-70		B	
		4	Reddish Brown	GRAVEL in yellow clay (weathered?). As in Drill Nos 6 and 7 to the south.	70-80		C	
6	300677/ 272240	1	Strong Brown	CLAY LOAM, silty. Occasional gravel as in Ap Horizon of Drill No. 5.	0-45		Ap	In grass and clover field, north of the ploughed area of the field. Flat area between slope under Newgrange and slope to river terrace. HL/GM.
		2	Reddish Brown	SILT, clayey Occasional gravels.	45-65		Lower A/B	
		3	Greyish Brown	SILT, clayey Becomes more clayey with depth - incipient argillic (leaching clay).	65-80		C	
7	300671/ 272189	1	Strong Brown	SILT, clayey. Same as Ap Drill 9, Layer 1. Fluffy. Cobbles etc.	0-28		Ap	Ploughed field. HL/GM.
		2	Reddish Brown	SILT, clayey	28-38		B	
		3	Reddish Brown	SAND, loamy Very fine. Well sorted. Few inclusions. Slightly less Reddish brown than previous layer.	38-50		B	
		4	Reddish Brown	SAND, loamy Very fine. Well sorted. Few inclusions. Slightly less Reddish brown than previous layer.	50-75		C	
		5	Strong Brown	CLAY, gravelly silty Angular gravels 2-3cm.	75-95		C	
		6	Yellowish Red 5YR 4/6	Packed GRAVEL subrounded and subangular, 1-2cm. Yellow sand (weathered rock). Abandoned due to stoniness.	95-110		C	
8	300668/ 272153	1	Strong Brown	SILT, very clayey. Not compact, humus-rich. Strong Brown.	0-30		Ap	CG/WVB
		2	Strong Brown	SILT, sandy. Very fine. Reasonably humus-rich. Fe formation.	30-40		B	
		3	Reddish Brown	SILT, clayey, with coarse sands to fine gravels. Fe formation. Reasonably humus-rich.	40-50		B	
		4	Reddish Brown	SILT, very clayey. Non-compact, grey organic blobs. Coarse gravel at bottom, rounded and subangular.	50-60		B	
		5	Reddish Brown	SILT, slightly clayey. Lots of coarse grit and gravel.	60-80		B	
		6	Reddish Brown	CLAY, silty. Very gritty. Coarse sands-fine gravels. Angular and well-rounded clasts present.	80-90		B	
		7	Reddish Brown	CLAY, very silty. Slightly fewer clasts, angular and subrounded.	90-130	Charcoal speck.	B	

9	300676/ 272105	1	Strong Brown	CLAY, silty. Occasional gravel, 1-3cm subangular.	0-35		Ap	Ploughed field. HL/GM.
		2	Strong Brown 7.5YR 5/6	CLAY, silty. Compact.	35-45		B	
		3	Reddish Brown	CLAY, silty. Frequent angular gravel, 0.5-1.5cm. Abandoned due to tightly-packed gravels.	45-60		C	
10	300674/ 272061	1	Strong Brown	As Ap horizon Drill 11 to the south (11/1), but less fine gravel.	0-30		Ap. Brown earth (Colluvial)	Base of slope. HL/GM.
		2	Yellowish Red 5YR 5/6	CLAY, silty, with fine gravels, 3-4cm. Slightly more compact. Becomes less clayey with depth; Fe mottles and very fine graves 2-3mm, angular. Soil becomes silt loam. Gravels more rounded with depth.	30-65		B (Fe translocation)	
		3	Reddish Brown 5YR 5/4	LOAM, silty clay Soil as 2-3, but frequent rounded and subrounded gravel, 3-4cm.	65-84		C	
		4	Yellowish red	SAND with organic inclusions (organic mud) - medium-coarse sand.	84-90		Gravels and sand mixed with soil. (Layers 5-7). C	
		5	Dark Reddish Brown 5YR 2.5/2	SAND, frequent gravels 1cm, subangular.	90-95			
		6	Yellowish Red 5YR 4/6	SAND (coarse).	95-100			
		7	Yellowish Red	SAND, same as layer 5 i.e. gravelly.	100-125		C	
		8	Yellowish Red	SAND lens as above (Layer 7). Rest of layer is loamy sand. Lots of gravel and grit. Humus-rich aggregates.	125-160		C	
		9	Yellowish Brown 5YR 4/6	SAND, silty. Gravels, <1cm, angular. Lots of grit. Quite sandy, organic. Becomes gritty with depth. Abandoned at 170cm due to gravel.	160-170		C	
11	300675/ 272026	1	Strong Brown 7.5YR 4/6	CLAY, silty Gravel frequent, subangular to angular, some rounded. More frequent small gravels and slightly more compact with depth.	0-25		Ap. Brown earth (colluvial)	Ploughed field on glacio fluvial.
		2	Reddish Brown 5YR 4/3	SILT, clayey Mixed Ap. Width is 1-2cm sized. Aggregates organic soil inclusions. The latter is more gritty than the Ap. Ap has 1mm sized mottles (Fe).	25-45		Mixed Ap	
		3	Reddish Brown 5YR 4/3	As layer 2 but frequent gravels, 3-4cm sized.	45-60		Gravel deposit (glacial). C	

23		1	Brownish Yellow 10YR 6/6	SILT, sandy, very fine sand. Clayey. Hit gravels at 30cm.	0-30		Ap	In NW corner of field (western-most field of J. McDonald) near N end of E-W orientated terrace, just above shoulder of steep break of slope. Flat land in reseeded field. Western field-fence 2m to the west. Recommencement of Central Transect (i).
24		1	Brownish Yellow 10YR 6/6	SILT, sandy, very fine sand. Very loose, non-cohesive and dry. Gravels of 3-5mm in size.	0-45		Ap	Flat reseeded field. 2m west of western field-fence/ditch. 60m S of Drill 23. Middle of E-W orientated terrace (summit).
		2	Brownish Yellow 10YR 6/6	As layer 1, but clayey. More cohesive and water retaining. Gravelly, subangular clasts 5-10mm in size. Fe mottles. Hit gravels at 70cm.	45-70		B / C	Soil seems turned to this depth (ploughing).
25		1	Yellowish Brown 10YR 5/4	SILT, sandy, very fine sands. Reasonably clayey.	0-20		Ap	In SW corner of reseeded field at southern shoulder of the E-W orientated terrace. 2m east of western field-fence-ditch.
		2	Yellowish Brown 10YR 5/4	As layer 1, but more clayey. Angular clasts from c. 60cm	20-70		B	
		3	Brownish Yellow 10YR 6/6	SILT, very clayey. Cohesive. Clasts at bottom, subangular. Visually appears more greyish.	70-75		C	

Brú na Bóinne transect B-B[1]

Drill No.	Coord.	Layer No.	Colour	Soil Description	Depth (cm)	Anthropogenic features	Horizon	Remarks
12	300814/ 272744	1	Strong Brown 7.5YR 4/6	SILT, slightly clayey. Reasonable humus-rich. Compact. Occasional clasts.	1-20		Ah	Start of new transect (Drills 12-16). New field, south of Field 1. Middle of slope. Grass. Transect runs north-south between henge (ME026-006) to west and two ponds to the east. Drill No. 12 is the top of the field at very edge of terrace next to 'floodplain'. CG/WVB.
		2	Reddish Brown 5YR 4/3	SILT, clayey. Reasonably humus-rich. Compact, gravelly,. clast size +/- 2cm.	20-60		B	
13	300844/ 272710	1	Strong Brown 7.5YR 4/6	CLAY, silty. Occasional very fine gravel, sub-rounded.	0-70		Ah	Under short grass, but appears to be a ploughed field. 50m intervals between auger sites. HL/GM.
		2	Reddish Brown 5YR 4/3	CLAY, silty, with frequent <1cm black gravels. Abandoned due to gravels.	70-85		A/C	
14	300862/ 272667	1	Strong Brown 7.5YR 4/6	CLAY, silty Infrequent gravels, <1cm.	0-40		Ah	N.B. An unrecorded linear (bank material) observed running E-W (an old field boundary?) just metres south of this site.
		2	Reddish Brown 5YR 4/3	CLAY, silty, with very frequent strongly weathered rock fragments.	40-55		B	
		3	Light brown	SAND - medium to coarse. Light brown, becoming white at base, in occasional 1cm rounded pebbles.	55-63		C	
		4	Brown	LOAM, sandy, with frequent pebbles, slightly organic.	63-70+		C	
15	300905/ 272579	1	Strong Brown 7.5YR 4/6	SILT, clayey, with subangular gravels up to 2cm. Becoming clayey with depth. Becomes silty CLAY around 60cm but no boundary noted.	0-80		Ah	At edge of terrace edge, edge of the floodplain with slump. HL/GM

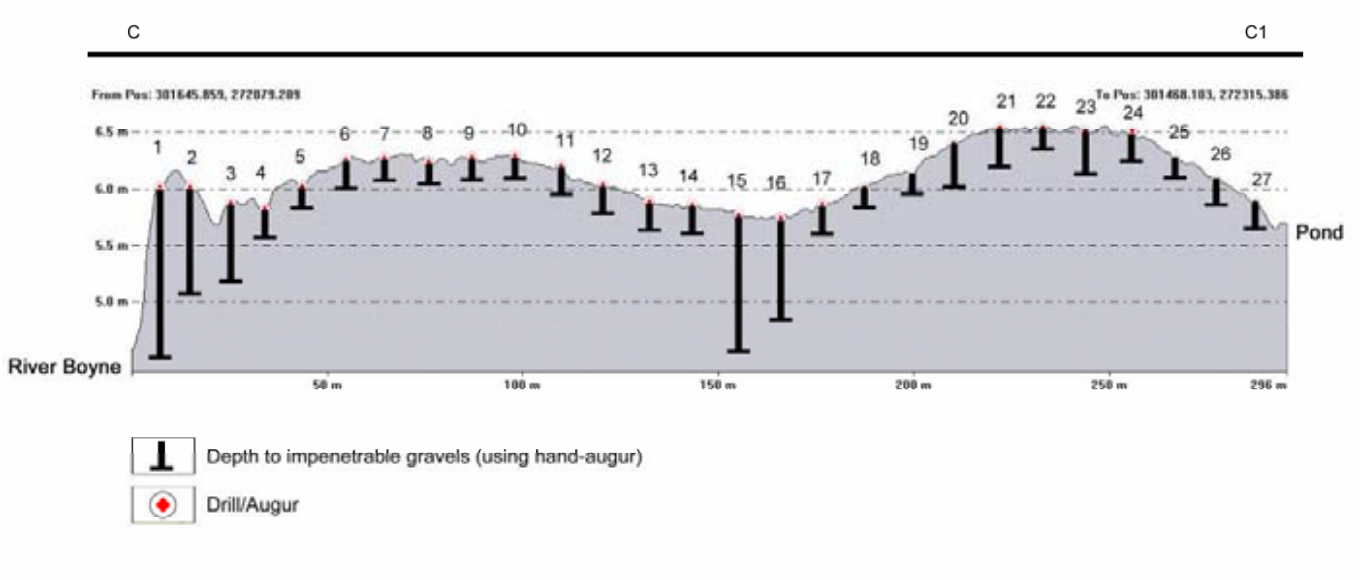
		2	Strong Brown 7.5YR 4/6	Same soil, but frequent gravels 1-2cm, sub-angular.	80-105		C	
		3	Reddish Brown	SAND, very fine, with grit.	105-125		C	
		3	Brown	CLAY, very sludgey (material lost; due to water table). Abandoned.	125-135		C	
16	300953/ 271873	1	Greyish Brown	CLAY, silty, very grey brown.	1-80		Alluvial A, 1-30 cm.	Floodplain, c. 5m north of river bank. Standing water, very wet. Oily, humic acid on surface. Reeds. HL/CG/WVB/GM.
		2	Brownish Grey	CLAY, slightly silty. Brown grey, reduced.	80-120		Alluvial	
		3	Brownish Grey	CLAY, slightly silty. Black organic blobs.	120-140		Alluvial	
		4	Greyish Brown	SAND, coarse. Full of shells. Grey brown.	140-150		Alluvial	SAMPLE
		5	Brownish Grey	CLAY, very non-compact. Organic threads.	150-180		Alluvial	
		6	Brown	PEAT, sandy. Organic matter, black.	180-210		Alluvial	SAMPLE
17		1	Brown 10YR 5/3	SILT, clayey; gritty.	0-40	Charcoal flecks	Alluvial A	7m south of south bank of river bank. Roughgrange townland. Flat area of pasture (poor quality). Pockets of nettles.
		2	Greyish Brown	SILT, slightly sandy. Very fine sand. Reduced. Tiny shell fragments. Iron oxide spots. Gradual boundary with layer 3.	40-100		Alluvial	
		3	Brownish Grey	SILT, slightly sandy. Very fine sand. Tiny shell fragments. Iron oxide spots. Slight organic accumulation at 120-125cm.	100-140		Alluvial	
		4	Blackish Grey	SILT, very clayey. Very organic (black).	141-147		Alluvial	SAMPLE of organic material.
		5	Greyish Brown	SILT, slightly sandy, with blackish organic concentrations. Lots of shell.	147-160		Alluvial	
		6	Greyish Brown	Silt, very clayey.	160-180		Alluvial	Two SAMPLES taken; from top and bottom of the layer. [Sample # 4 = NGD176180].
18		1	Dark Greyish Brown 10YR 4/2	SILT, clayey. Very non-compact.	0-40		Alluvial A	45m SSE of Drill 17. Slight breaks of slope visible between Drills 17 - 18.
		2	Olive Grey 5YR 4/2	SILT, very clayey, slightly sandy; very fine sand. Reduced. Fine shell fragments. Visually appears bluey grey.	40-95		Alluvial	
		3	Light Brown	SILT, clayey, slightly gritty. A few rounded pebbles. Concentration of iron mottles. Visually appears light brownish grey.	95-150		Alluvial	
		4	Brownish Grey	SILT, very clayey. No iron mottles. Abrupt boundary with layer 5. Visually appears blue grey.	150-175		Alluvial	

		5	Light Brown	SILT, very humus-rich, very peaty. Very crumbly. Sharp boundary with layer 6 beneath.	175-212		Alluvial	
		6	Greyish Brown	SILT, clayey. Visually appears grey.	212-220		Alluvial	
19		1	Dark Greyish Brown 10YR 4/2	SILT, clayey, slightly sandy. Very fine sand.	0-15		Alluvial A	25m south of Boyle Canal.
		2	Light Olive Brown 2.5Y 5/3	SILT, clayey, sandy. Medium fine sand. Grit. Fe mottles from c. 15-30cm. Gravelly towards bottom. Visually appears grey.	15-70		Alluvial	
		3	Light Olive Brown 2.5Y 5/3	GRAVEL, clayey. Rounded gravels, subrounded; Max size = 1.5cm	70-110		Riverbed deposits	
20		1	Light Yellowish Brown 10YR 6/4	SILT, slightly clayey. Containing subangular clasts from 30cm onwards; 1-2cm in size.	0-40		Ah	Just north of field-fence and road. 25m south of Drill 19. From this site looking eastward there is definitely an elevation noticeable, probably limit of Holocene channel.
21		1	Brownish Yellow 10YR 6/6	SILT, clayey, slightly sandy. Very fine sand.	0-10		Ah	On steep slope. Thick coverage of coniferous trees in plantation.
22		1	Brownish Yellow 10YR 6/6	SILT, clayey, slightly sandy. Very fine sand.	0-10		Ah	On steep slope. Thick coverage of coniferous trees in plantation.

Brú na Bóinne transect C-C¹

Drill No.	Layer No.	Soil Description	Depth (cm)	Anthropogenic features	Remarks
1	1	SILT, sandy. Medium coarse sand, slightly clayey. Contains shell fragments. Reasonably compact. Colour: 10YR 5/3 = Brown.	0-90	Charcoal at 80cm	Floodplain, flat pasture. SE of SMR ME0000000.Drill sited 2m north of the rivers northern bank. SAMPLE of charcoal.
	2	SILT, sandy. Medium coarse sand. Manganese mottles at bottom of core. Shell fragments. Hit gravels. Colour: 10YR 5/4 = yellowish brown.	90-150		
2	1	SILT, sandy Some shell fragments. Colour: 10YR 4/3 = brown.	0-95		10m NW of Drill 1.
3	1	SILT, sandy. Some shell fragments. Rounded gravels at base.	0-70		10m NW of Drill 2.
4	1	SILT, sandy. Few shell fragments. Hit gravels at 30cm, subrounded.	0-30		10m NW of Drill 3.
5	1	SILT, sandy. Hit gravels at 20cm, subrounded, 1-2cm size.	0-20		10m NW of Drill 4.
6	1	SILT, sandy. Almost no shells at this stage c. 52m north of riverbank.	0-30		10m NW of Drill 5.
7	1	SILT, sandy. No shell. Colour: 10YR 4/4 = dark yellowish brown.	0-20		10m N of Drill 6. Approx. 25m ESE of SMR ME00000.SAMPLE of slag.
8	1	SILT, Hit gravels at 20cm.	0-20		SAMPLE of gravels taken.
9	1	SILT, Hit gravels at 20cm.	0-20		10m NW of Drill 8.
10	1	SILT, Hit gravels at 20cm.	0-20		10m NW of Drill 9.
11	1	SILT, Hit gravels at 25cm.	0-25		10m NW of Drill 10.
12	1	SILT. Hit gravels at 25cm. 10YR 4/3 = brown.	0-25		10m NW of Drill 11.
13	1	SILT, Hit gravels at 25cm.	0-25		10m NW of Drill 12.
14	1	Hit gravels at 25cm.	0-25		10m NW of Drill 13.
15	1	SILT, clayey. Fe nodules. More compact with depth. Colour: 10YR 15/1 = yellowish brown.	0-70		At southern boundary of a visible swale orientated east-west parallel to the river course, c. 140m north of river bank. Swale appears as a 20m wide linear band of lighter green vegetation.
	2	SAND, clayey.	70-110		
	3	SAND, coarse. Shell fragments. Hit gravels at 120cm	110-120		

16	1	SILT, Hit gravels at 90cm	0-90		Middle of swale.
17	1	SILT, Hit gravels at 30cm	0-30		Northern boundary of swale.
18	1	SILT, Hit gravels at 20cm	0-20		10m NW of Drill 17.
19	1	SILT, Hit gravels at 20cm	0-20		10m NW of Drill 18.
20	1	SILT, Hit gravels at 40cm	0-40		10m NW of Drill 19.
21	1	SILT, Hit gravels at 35cm	0-35		10m NW of Drill 20.
22	1	SILT, Hit gravels at 20cm	0-20		10m NW of Drill 21.
23	1	SILT, Hit gravels at 40cm	0-40		10m NW of Drill 22.
24	1	SILT, Hit gravels at 25cm	0-25		10m NW of Drill 23.
25	1	SILT, Hit gravels at 20cm	0-20		10m NW of Drill 24.
26	1	SILT, Hit gravels at 25cm	0-25		10m NW of Drill 25.
27	1	SILT, Hit gravels at 25cm	0-25		10m NW of Drill 26.



Ardmulchan- Dunmoe transect D-D[1]

Drill No.	Coord.	Layer No.	Colour	Description	Depth (cm)	Anthropogenic features	Interpretation	Remarks
1	**290162/ 27021**	1	Brown 10YR 5/3	SILT, slightly clayey, slightly sandy. Fine sand. Fe mottles.	0-20		Ah	Top of terrace. Solid rock after 10cm. Pasture field. Flat land. NE of Dunmoe castle. Dunmoe townland. Very shallow soil - with rock outcrops occurring in the Dunmoe general area.
2	**290169/ 270234**	1	Brown 10YR 4/3	SILT, clayey, slightly sandy. Fine sand. Small speck of Fe mottles.	0-10		Ah	On crest of steep slope to the south. 1m N of an old field boundary (unrecorded on OS maps).
		2	Brown 10YR 4/3	As layer 1, with sharp class of angular shale, c. 10mm in size.	10-30		Ah	
3	**290170/ 270218**	1	Brown 10YR 4/3	As layer 1, Drill 2. Subangular clasts of 1-2cm size. Specks of Fe mottles.	0-20		Ah	Situated one third down from top of slope, steep angle. 25m east of Dunmoe castle.
4	**290173/ 270198**	1	Brown 10YR 4/3	As layer 1, Drill 3.	0-15	Possible speck of cement	Ah	Situated two thirds down from top of slope, steep angle.
5	**290177/ 270167**	1	Yellowish Brown 10YR 5/4	As above, but no clasts. Specks of Fe mottles. Lighter colour than in previous drills.	0-20		Ah	At base of slope, SE of Dunmoe castle. Area strewn with masonry fragments from castle ruin above.
6	**290181/ 270140**	1	Yellowish Brown 10YR 5/4	As layer 1, drill 5, a couple of rounded clasts.	0-25		Ah	In middle of a terrace, gently sloping. Pasture.

7	**290184/ 270117**	1	Brown 10YR 5/3	SILT, very clayey, no sand. Colour darker than previous drills, same as layer 1, Drill 1.	0-15		Ah	Southern edge of terrace.
		2	Brown 10YR 5/3	SILT, clayey, slightly sandy. Fine sand.	15-25		B	
8	**290188/ 270101**	1	Brown 10YR 4/3	SILT, clayey, slightly sandy. Very fine sand. Diffuse border with layer 2 below.	0-45		Alluvial A	On floodplain, 2m north of river bank. Flat pasture. Littered with detritus from latest flood. Situated 5m downstream of an old man-made channel possibly related to the old mill situated SW of Dunmoe castle.
		2	Brown 10YR 4/3	SILT, very clayey. Slightly sandy, very fine sand. Fe oxide mottles. Sharp border with layer 3 below.	45-90		Alluvial	
		3	Very Dark Greyish Brown 10YR 3/2	SILT, slightly clayey, slightly sandy. Very fine sand from 110cm downwards. Shell fragments and shells. Black organic nodules present throughout. Organic fibres.	90-190		Alluvial	
		4	Greyish Brown 10YR 5/2	SILT, clayey, very sandy. Coarse sand. Lots of shell fragments.	190-210		Alluvial	
		5	Greyish Brown 10YR 5/2	SAND, silty. Coarse sand, with lots of coarse shell fragments.	210-220		Alluvial	
9	**290155/ 270072**	1	Brown 10YR 4/3	SILT, clayey. Small shell fragments.	0-20		Alluvial	On floodplain, 2m south of river bank. South bank of river, Ardmulchan townland, south of Dunmoe castle. Just north of the canal. Set 0.5m N of a walking path parallel to the canal.
		2	Dark Greyish Brown 10YR 4/2	CLAY, slightly silty. Visually appears light grey colour.	20-30		Alluvial	
		3	Dark Brown 10YR 3/3	SILT, clayey.	30-40	Charcoal fragments	Alluvial	
		4	Dark Yellowish Brown 10YR 4/4	SILT, very sandy. Medium fine sand.	40-90		Alluvial	
10	**290155/ 270045**	1	Brown 10YR 5/3	SILT, clayey, slightly sandy. Reasonably fine sand. Not compact.	0-10		Alluvial A	15m. On the northern edge of the lawns of Ardmulchan House, due S of the stairs.
		2	Brown 10YR 5/3	As above, with subangular gravels 1-1.5cm size.	10-30	Fragments of fired brick	B / C	N.B. Ardmulchan House is built of red brick.

11	**290162/ 269996**	1	Brown 10YR 5/3	SILT, very clayey. Non compact.	0-15		Ah	Base of slope. On southern edge of steps of Ardmulchan House.
		2	Brownish Yellow 10YR 6/6	As layer 1, but more compact. Subangular clasts of 1-1.5cm size. Colour slightly more orange.	15-90	Specks of fired red brick	B / C	
12	**290166/ 269972**	1	Dark Yellowish Brown 10YR 4/4	SILT, very clayey, with grit. Non compact.	0-10		Ah	25m south of Drill 11, halfway up steep slope. Lawns of Ardmulchan House, overgrown portion.
		2	Yellowish Brown 10YR 5/6	SILT, slightly clayey, slightly sandy. Very fine sand. Subangular gravels of 1-5mm size.	10-75	Large specks of red fired brick and lime	B	Soil has been turned to depth of 75cm.
13	**290173/ 269937**	1	Brown 10YR 4/3	Same as Drill 10, layer 1 i.e. SILT, clayey, slightly sandy.	0-10		Ah	Terrace, at top of stairs, flat grass, mowed. *c*. 40m north of Ardmulchan House, 4m S of break of slope.
		2	Yellowish Brown 10YR 5/4	SILT, clayey. Gritty. More compact.	10-30		B	Southern terminal of western transect at Dunmoe/Ardmulchan.

Ardmulchan- Dunmoe transect E-E[1]

Drill No.	Coord.	Layer No.	Colour	Description	Depth (cm)	Anthropogenic features	Interpretation	Remarks
14	290369/ 270312	1	Brown 10YR 4/3	SILT, slightly clayey, slightly sandy. Fine sand. Hit bedrock at 15cm.	0-15		Ah	North bank of river, Dunmoe townland. Highest point of an E-W orientated terrace. Flat area of pasture field, west of field fence. Start of middle transect, Dunmoe.
15	290406/ 270264	1	Dark Yellowish Brown 10YR 4/4	SILT, clayey, slightly sandy.	0-10		Ah	In middle of a terrace.
		2	Light Yellowish Brown 10YR 6/4	SILT, slightly clayey, slightly sandy. Subrounded clasts of 2-3cm size. Few black organic nodules. Fe mottles.	10-60		B / C	
16	290436/ 270223	1	Brown 10YR 4/3	SILT, slightly clayey, slightly sandy. Very fine sand. Few subangular clasts 1-1.5cm. Fe mottles. Visually same colour as above.	0-40		Ah	At southern edge of terrace.
17	290470/ 270176	1	Brown 10YR 4/3	As drill 16, layer 1. Subrounded clasts.	0-30		Ah	On slope of terrace. 10m N of E-W orientated field fence.
18	290478/ 270148	1	Brown 10YR 4/3	SILT, slightly sandy; medium-coarse sand. Diffuse boundary.	0-10		Ah	71m north of riverbank. Top (northern end) of the field, c. 5m south of field fence.
		2	Light Yellowish Brown 10YR 6/4	SILT, clayey. Slightly sandy with coarse sand grains. Very fine sand. Hit stone at 55cm thus abandoned.	10-55		B	

19	290480/ 170137	1	Brown 10YR 4/3	SILT, slightly sandy; medium-coarse sand.	0-20		Ah	61m north of riverbank. Drills more clay-rich further up from the river.
		2	Pink 7.5YR 7/3	CLAY, very silty. Very compact. Clay-rich layer. Hit gravels/stone at 70cm (base) and abandoned.	20-70		B	
20	290483/ 270126	1	Brown 10YR 4/3	SILT, slightly sandy; medium-coarse sand.	0-40		A	Moved 10m north from No. 21 (51m from riverbank). Standing surface water. N.B. Iris ('yellow flag') noted growing in the area, a plant which needs a constant water presence - present from 40m beyond riverbank - perhaps being fed by springs.
		2	Pink 7.5YR 7/3	SILT, clayey. Slightly sandy with coarse sand grains. Manganese starting at 90cm. Fe mottles. Very compact. Hit a solid stone at base (100cm).	40-100		B / C	
21	290486/ 270114	1	Brown 10YR 4/3	SILT, slightly sandy; medium-coarse sand. Diffuse boundary.	0-20		A	Moved 10m north from No. 22 (41m from riverbank). Standing surface water. The floodplain does not seem to extend much further than c. 30m beyond the riverbank.
		2	Pink 7.5YR 7/3	SILT, slightly sand; very fine sand. Slightly clayey. From 100cm downwards manganese nodules are present which get bigger with depth. Fe mottles. Hit gravels and abandoned.	40-110		B / C	Water also present from springs to the north of Drill No. 5 are not due to flood waters but due to 'trapping' of water in colluvium material at base of slope i.e. Upper slope (>40m back from river) are damp even without floods.
22	290489/ 270104	1	Brown 10YR 4/3	SILT, slightly sandy; fine sand. Some shell fragments. Recent organic material. Gradual boundary.	0-40		Ah	Moved 10m north from No. 24 (31m from riverbank). Surface waterlogged. Flat.
		2	Brown 7.5YR 4/2	SILT, same as Layer 1 (archetypical overbank materials). Slight clay content (c. 10%). Contains organic materials. Non-compact. Diffuse boundary.	40-100		Bh	
		3	Yellowish Brown 10YR 5/6	SILT, slightly sandy; medium-fine sand, medium clayey. Manganese nodules. No organic materials, no shells. Compact.	110-155		B / C	
23	290491/ 270098	1	Brown 7.5YR 4/3	SILT, sandy; very fine sand, slightly clayey. Contains very small shell fragments. Gradual boundary.	0-50		Alluvial A	*A TEST/Confirmation drill, set midway between previous Drills nos 24 and 22, c. 45m south of Drill No. 18 (c. 26m north of riverbank).
		2	Brown 7.5YR 4/3	SILT, sandy; fine sand, slightly clayey. Reasonably compact. Sand laminations at bottom core; coarse sand in these laminations. More clayey towards base. Manganese mottles. Hit rock at 170cm.	50-170		Alluvial	No palaeo-channel present.

24	290494/ 270095	1	Brown 7.5YR 4/3	SILT, reasonably sandy. Reasonably fine sand. Small shell fragments. Recent organic matter (i.e. Non-black, roots). Fe mottles. Very gradual boundary.	0-55		Alluviual A	Moved 10m north from No. 25 (21m from riverbank). Surface waterlogged. Flat. Oily, humic acids present similar to Newgrange riverbank.
		2	Light Brown 7.5YR 6/4	SILT, reasonably sandy; medium-fine sand. Slightly clayey. Shell fragments. Fe mottles. Organic material. Very poorly sorted, and mixed.	55-130		Alluviual	
		3	Dark Greyish Brown 10YR 4/2	SAND, coarse, silty, slightly loam. Reduced. Shell fragments. Diffuse boundary.	130-135		Alluviual	
		4	Dark Brown 7.5YR 3/2	SILT, slightly sandy; medium-coarse sand. Non-compact. Hit gravels and abandoned.	135-170	Small flecks of charcoal	Alluviual	
25	290504/ 270083	1	Light brown 7.5YR 6/3	SILT, very sandy (sandy SILT). Very few shell fragments. Recent organic materials. Non-compact. Gradual boundary with layer 2.	0-40		Alluviual A	Moved 10m north from Drill No. 26 to No. 25. Situated 11m from bank of river. Slight break of slope at 10m, an old channel ledge (i.e. 1m south of auger). Ground gently rising along length S-N of transect.
		2	Light brown 7.5YR 6/3	SILT, very sandy. Sand laminations of coarse sand. Shell fragments. Recent organic fibres present. Reasonably compact.	40-95		Alluviual	
		3	Light Grey	SAND, very coarse. Lots of shell fragments. Sand is quite angular. Light grey. Abrupt end.	95-145		Alluviual	
		4	Greyish Brown 10YR 5/2	SILT, sandy. Medium coarse sand. Shell fragments, but less than in previous layer. Reduced. Diffuse boundary.	145-155		Alluviual	
		5	Greyish Brown 10YR 5/2	SAND, coarse. Silt laminations. Shell fragments. Reasonably compact at top of layer. Few organic remains. Auger hit gravels; abandoned.	155-180		Alluviual	
26	290497/ 270073	1	Brown 7.5YR 5/3	SILT, slightly clayey, with medium-coarse sand. Small shell fragments. Diffuse boundary with layer 2.	0-45		Alluviual	Situated on a levee, 1m north from riverbank edge. On floodplain. Generally swampy area surrounding, but Drill No. 26 stands on a dryer, slightly more elevated area as it stands on levee material..Southern terminal of middle transect.

		2	Greyish Brown 10YR 5/2	SAND, silty. Medium-coarse sand. Shell fragments. Some silt lens. Mottling (bars). Laminated sand and silt. Major coarse sand at 70cm, a lens of sand and shells. Diffuse boundary with layer 3.	45-70		Alluviual	
		3	Dark Grey 7.5YR 4/1	SILT, reasonably sandy. Fine sand. Reduced. Sand laminations whose sand is reasonably coarse. Organic materials, organic traces.	70-135		Alluviual	
		4	Dark Reddish Brown 7.5YR 3/2	SAND, coarse silty. Lots of shell fragments. Very organic. Non-compact layer. Colour = brownish black. Auger hit gravels at base (175cm).	135-175		Alluviual	

Ardmulchan- Dunmoe transect F-F[1]

Drill No.	Coord.	Layer No.	Colour	Soil Description	Depth (cm)	Anthropogenic features	Interpretation	Remarks
27	290599/ 270270	1	Brown 7.5YR 5/3	SILT, slightly clayey, slightly sandy. Very fine sand. Rounded clasts of 1-2cm size.	0-30		Ah	Edge of terrace. Flatish pasture field. 20m N of field fence. Start of eastern transect Dunmoe/Ardmulchan.
28	290627/ 270239	1	Greyish Brown 10YR 5/2	SILT, very clayey, gritty. Not very comptact. Visually appears grey.	0-70		Alluvial A/B	Floodplain. 5m N of northern bank of river, opposite river weir. Standing water, damp-loving trees and shrubs. Some humic acid in water.
		2	Dark Greyish Brown 10YR 4/2	CLAY, very silty, gritty. Iron oxide mottles. Organic fibres present. Very compact.	70-140		Alluvial B/C	
		3	Dark Greyish Brown 10YR 4/2	CLAY, reasonably silty. Quite sticky. Reasonably compact. No sandy lenses or events in this core. Hit gravels at 160cm.	140-160			
29	290703/ 270158	1	Brown 10YR 5/3	SILT, clayey, Very humus-rich. Shell fragments.	0-20		Ah	Base of slope. South bank of river, Ardmulchan townland. South of canal. Flat area of standing water. Abundance of damp-loving trees and shrubs present.
		2	Pale Brown 10YR 6/3	SILT, very clayey. Shell fragments. Visually appears greyish.	20-50		B, possibly alluvial B	
		3	Yellow 10YR 7/6	CLAY, silty. Very compact. Sandy lenses at 90cm composed of medium fine sands. Siltier towards base. Gravels from 100cm downwards. Sandy at 120cm.	50-120		C	

30	290730/ 270145	1	Dark Yellowish Brown 10YR 4/4	SILT, clayey, slightly sandy. Subrounded clasts.	0-30		Ah	Middle of steep slope. West of Ardmulchan church ruins. Pasture.
31	290752/ 270130	1	Dark Yellowish Brown 10YR 4/4	SILT, clayey, slightly sandy. Subrounded clasts.	0-20		Ah	Near top of steep slope. Pasture. Southern terminal of eastern transect at Dunmoe/Ardmulchan.

APPENDIX III - ILLUSTRATING THE APPLICATION OF THE ITRAX XRF CORE SCANNER

Jonathan Turner

The Itrax XRF Core is a state-of-the-art facility housed in the School of Geography, Planning and Environmental Policy, UCD, which allows for high-resolution (100 micron), non-destructive optical and X-ray imaging and XRF element analysis of soil and sediment cores. The potential application of the Itrax facility is illustrated in this section through a brief appraisal of a 50cm section of the Thomastown Bog sediments, representing a depth of 200-250cm. Figure III.i shows the optical image and overlain x-radiographic image illustrating the laminated structure of these lake sediments, especially below 220cm.

The following selected profiles in Fig. III.i show smoothed profiles (dynamic averaging over 0.5mm) for selected variables to demonstrate the potential of this analytical approach. These data show ratios and peak area counts for individual elements, where units are not shown but all changes can be regarded as genuine (but see kps interpretation below). A preliminary explanation and interpretation of the profiles is given as follows:

- The kps (kilo count pers second) profile provides an indicator of data quality. Significant drops in the kps values (e.g. at *c*. 207cm, *c*. 212cm and *c*. 220cm) mark the location of major cracks in the sediment sample and therefore elemental profiles should be considered suspect at these points.

- The inc/coh (incoherent/incoherent scatter) ratio reflects, in part, the balance between light and heavy elements in the sample matrix. This ratio has therefore been employed as a proxy for relative organic matter (ratio will increase) to mineral (ration will fall) content (e.g. Guyard *et al.* 2007). In the sample of Thomastown Bog sediments reported this ratio shows only minor variability up the 50cm profile, rising more consistently above 214cm. Between *c*. 218cm and 248cm inc/coh ratio peaks generally correspond to elevated detrital clay/sediment indicators (Si, Ti and K) and inversely to the Ca/Fe ratio.

- The Ca/Fe ratio can be used to indicate the ratio biogenic carbonate:detrital clay content (Rothwell *et al*. 2006), and more generally changes in lithology. In the case of the Thomastown Bog sediments this ratio probably reflects changes in sediment supply and/or lake activity. The lower Ca/Fe ratio below 246cm and above 220cm corresponds directly to significant increases in a number of element profiles (Si, Ti and K) that are indicative of detrital inputs. Both Si and Ti have also been employed in lake studies as a proxy for catchment vegetation openness (e.g. reduction in woodland cover and/or increases in agriculture (Coombes *et al.* 2008). The fall at the base of the profile and subsequent step-up in Si, Ti and K counts at 220cm may therefore reflect anthropogenic disturbance and/or increasing climatic instability in the catchment. The elevated Ca counts in the remainder of the core suggests

contrasting conditions of relative quiescence in the lake system, when allochthonous inputs associated with surface wash processes declined and calcite-rich groundwater inputs predominated.

- The final two profiles for Cl and Pb have been included in Fig. III.i, because they appear to show the timing of specific discrete inputs into the Thomastown Bog lake system. Chlorine is generally quite mobile in soils and sediment, but highly insoluble in water if associated with lead as the mineral cotunnite ($PbCl_2$). Further mineralogical testing is needed to confirm this association, but if this is the case, this would provide evidence for apparently unusual mineralogical inputs into the Thomastown bog. Cotunnite is an alteration product of galena (PbS) and has been reported at a number of mine sites in the UK, the closest being the Penryhn Du Mine in Wales (Hubbard and Green, 2005), but not in Ireland. The mineral is also readily associated with volcanic rocks, although whether this would include tephric deposits needs to be confirmed. Although it is possible that the elevated Cl and Pb, peaking between ca. 226cm and 212cm is naturally occurring, a more probable explanation would be anthropogenic disturbance (possibly mining) in the catchment. These data may therefore provide an indicator for early industry in the catchment and important chemostratigraphic markers for the timing of this activity.

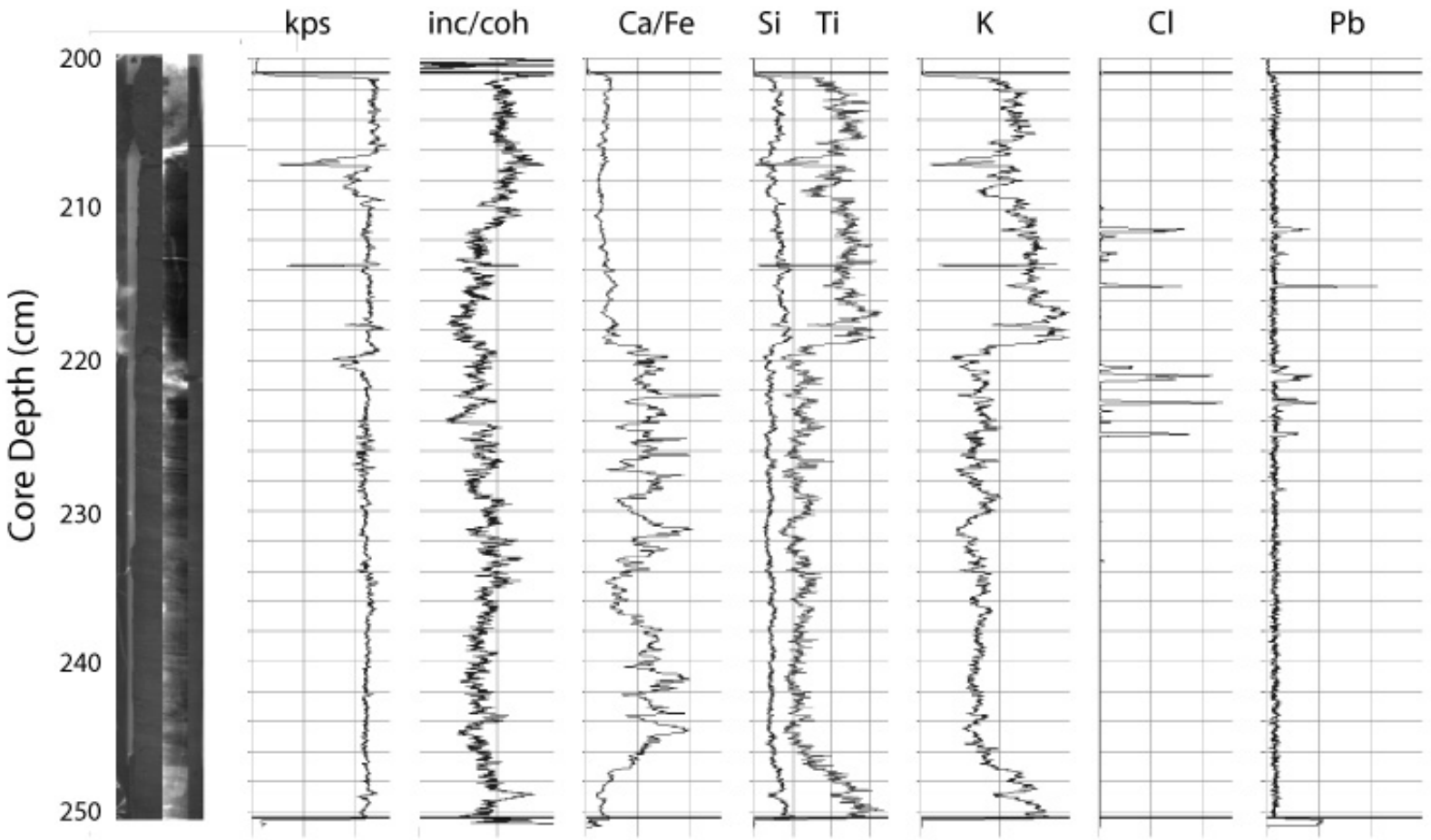


Fig. III.i Kps (kilo counts per second), Inc/coh (incoherent/coherent scattering),Ca/Fe ratios and Si, Ti, K, Cl and Pb peak area counts per second for cored 50cm section of Thomastown 'bog' sediments – depth 200–250cm. Explanation of the profiles is given in the text.

APPENDIX IV: RADIOCARBON DATING REPORT

(Beta Analytic Inc.)

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Helen Lewis — Report Date: 12/3/2008

University College Dublin — Material Received: 11/21/2008

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 252191	104.1 +/- 0.4 pMC	-25.5 o/oo	104.2 +/- 0.4 pMC
SAMPLE : CRBN80			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid			
COMMENT: reported result indicates an age of post 0 BP and has been reported as a % of the modern reference standard, indicating the material was living within the last 50 years.			
Beta - 252193	110 +/- 40 BP	-26.2 o/oo	90 +/- 40 BP
SAMPLE : DUNMOE2160D8			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 1680 to 1770 (Cal BP 270 to 180) AND Cal AD 1800 to 1940 (Cal BP 150 to 10) Cal AD 1950 to 1960 (Cal BP 0 to 0)			
Beta - 252194	1890 +/- 40 BP	-40.3 o/oo	1640 +/- 40 BP
SAMPLE : NGD165			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 330 to 540 (Cal BP 1620 to 1420)			
Beta - 252196	1360 +/- 40 BP	-41.5 o/oo	1090 +/- 40 BP
SAMPLE : NGD176180			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 880 to 1020 (Cal BP 1070 to 930)			
Beta - 252197	200 +/- 40 BP	-27.1 o/oo	170 +/- 40 BP
SAMPLE : NGD15130150			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 1650 to 1890 (Cal BP 300 to 60) AND Cal AD 1910 to 1950 (Cal BP 40 to 0)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Helen Lewis

Report Date: 12/3/2008

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 252198	136.4 +/- 0.5 pMC	-29.4 o/oo	137.6 +/- 0.5 pMC

SAMPLE : TMSTN615CM
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
COMMENT: reported result indicates an age of post 0 BP and has been reported as a % of the modern reference standard, indicating the material was living within the last 50 years.

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

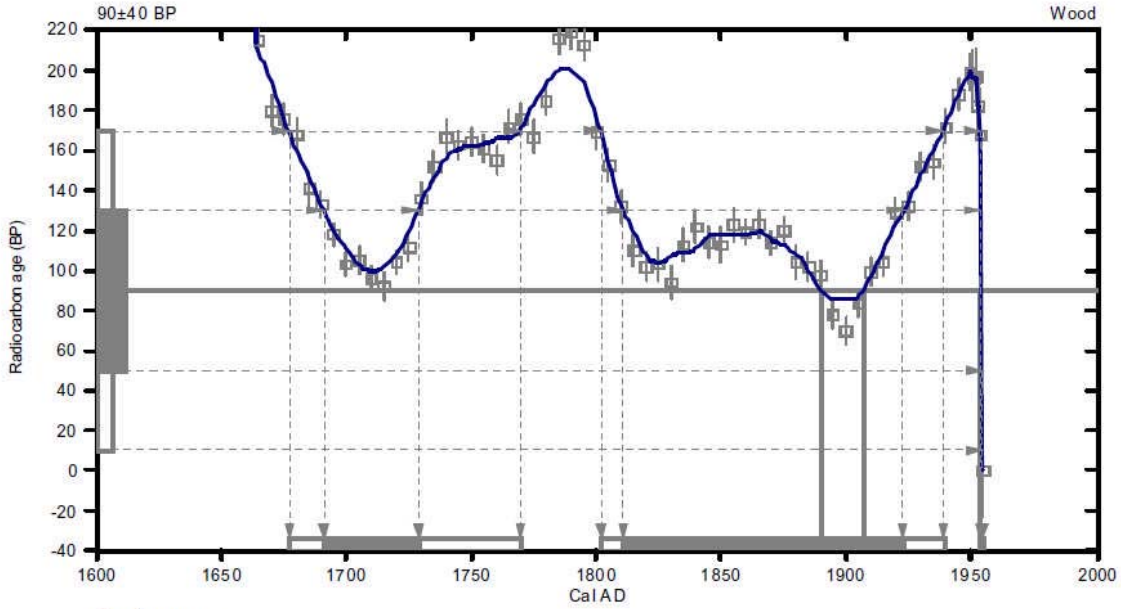
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.2:lab. mult=1)

Laboratory number:	**Beta-252193**
Conventional radiocarbon age:	**90±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 1680 to 1770 (Cal BP 270 to 180) and Cal AD 1800 to 1940 (Cal BP 150 to 10) and Cal AD 1950 to 1960 (Cal BP 0 to 0)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 1890 (Cal BP 60) and Cal AD 1910 (Cal BP 40) and Cal AD 1950 (Cal BP 0)
1 Sigma calibrated results: (68% probability)	Cal AD 1690 to 1730 (Cal BP 260 to 220) and Cal AD 1810 to 1920 (Cal BP 140 to 30) and Cal AD 1950 to 1960 (Cal BP 0 to 0)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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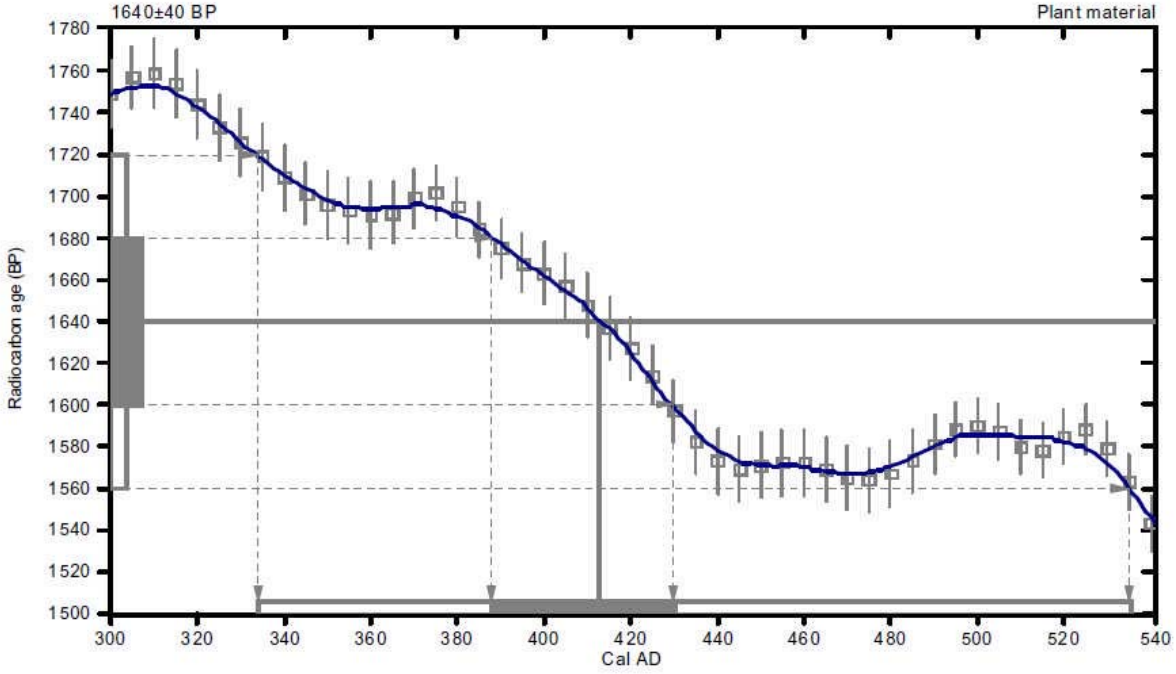
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-40.3:lab. mult=1)

Laboratory number:	**Beta-252194**
Conventional radiocarbon age:	**1640±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 330 to 540 (Cal BP 1620 to 1420)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 410 (Cal BP 1540)
1 Sigma calibrated result: (68% probability)	Cal AD 390 to 430 (Cal BP 1560 to 1520)



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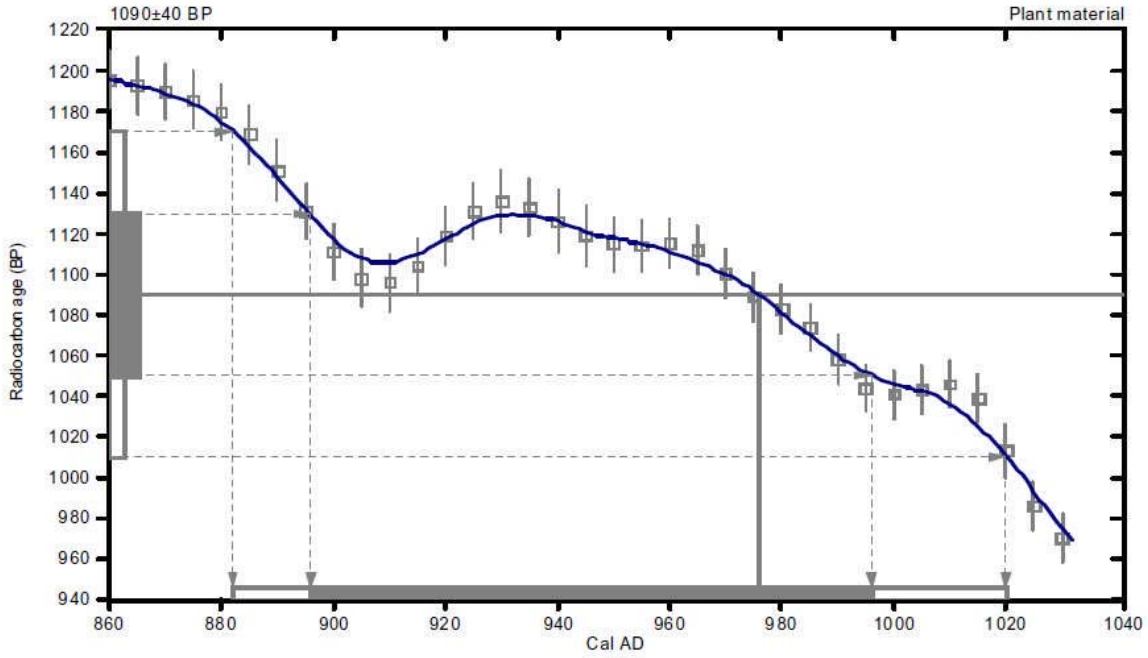
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-41.5:lab. mult=1)

Laboratory number:	**Beta-252196**
Conventional radiocarbon age:	**1090±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 880 to 1020 (Cal BP 1070 to 930)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 980 (Cal BP 970)
1 Sigma calibrated result: (68% probability)	Cal AD 900 to 1000 (Cal BP 1050 to 950)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.1:lab. mult=1)

Laboratory number: **Beta-252197**

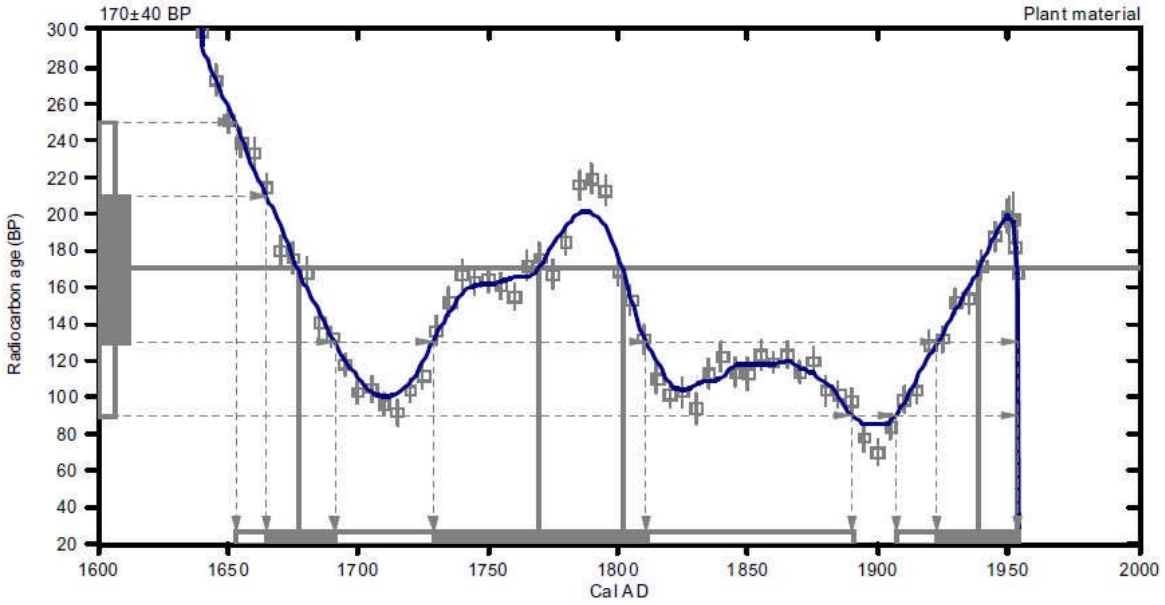
Conventional radiocarbon age: **170±40 BP**

2 Sigma calibrated results: **Cal AD 1650 to 1890 (Cal BP 300 to 60) and**
(95% probability) **Cal AD 1910 to 1950 (Cal BP 40 to 0)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1680 (Cal BP 270) and
Cal AD 1770 (Cal BP 180) and
Cal AD 1800 (Cal BP 150) and
Cal AD 1940 (Cal BP 10) and
Cal AD 1950 (Cal BP 0)

1 Sigma calibrated results: Cal AD 1660 to 1690 (Cal BP 280 to 260) and
(68% probability) Cal AD 1730 to 1810 (Cal BP 220 to 140) and
Cal AD 1920 to 1950 (Cal BP 30 to 0)



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