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# Textile from the Crannog: analyses and weave experiment of a 2/1 twill weave from Oakbank, Scotland, 400 BCE

## Abstract

Oakbank Crannog on Loch Tay, Scotland, was built and occupied in the later centuries of the first millennium BCE. Starting in the 1980s and lasting several decades, underwater excavations revealed a variety of organic finds, including a piece of 2/1 twill weave textile preserved in its organic state. The textile appears to be the earliest preserved twill weave textile in Scotland, dating to 400 BCE. It was first studied in the 1990s, and recently as part of a project by the Scottish Crannog Centre (United Kingdom). In the current study, it was analysed to gain new results including a radiocarbon date from the textile, measurements for the characterisation of early fleece through wool quality analysis and updated contextual research. A reconstruction of the textile at the Scottish Crannog Centre found that the 2/1 twill weave was most readily woven on a two-beam vertical loom, and concluded that it was unlikely to have been woven on a warp-weighted loom. No additional conservation treatment or dye analysis was performed. The Scottish Crannog Centre mission is to care for and make accessible the finds of the Crannog dwellers for the benefit and education of all. The textile project involves academics, museum personnel, weavers, crafters and woodworkers, and will be a catalyst for learning and experimentation.

**Keywords:** Twill weave, two-beam loom, wool quality, Iron Age, crannog

## Oakbank; an Iron Age Crannog

Crannogs are islands, also known as lake dwellings or pile dwellings, built predominantly of wood or stone at the edges of lochs in Scotland and Ireland although naturally occurring islands can also be classified as crannogs (Dixon 2004a). They were used for many purposes including dwellings, livestock stockades, kennels, food processing, and so on. The earliest Scottish crannogs are Neolithic and have been dated to c. 5,000 years ago and the most recent ones are Victorian. In the Iron Age, many Scottish crannogs served as high-status farmhouses, including Oakbank Crannog on Loch Tay, from which the Oakbank textile fragment was excavated (Dixon 1984; 2004b; Brown et al. 2022). The Iron Age in Britain marks a time of great change. Society became more hierarchical, contact with the European continent increased, the population grew, and iron technology marked a significant development (Cunliffe 2005; Pryor 2004). In 1979, the Scottish Trust for Underwater Archaeology,

based at the University of Edinburgh, undertook an underwater survey of Loch Tay in Perthshire. The aim of the survey was to locate the crannogs in the loch and to examine them for structural and dating evidence. On the basis of this work, one crannog – Oakbank Crannog – was chosen for further investigation.

Oakbank Crannog had originally consisted of a thatched roundhouse on a timber platform supported by timber foundation piles driven into the soft shallow bed of the loch. The extended family group of crannog dwellers were largely self-sufficient farmers, growing crops and tending livestock (Dixon 2004a). They utilised the networks of Scottish waterways to trade and communicate further afield via dugout boats. It was during excavations of the remains of Oakbank Crannog that the textile fragment was discovered.

Excavations were carried out throughout the 1980s and early 1990s, followed by further work in 2002, 2003 and 2005 (Dixon 1982; 2004a). Organic material was found to have survived extremely well and a



range of significant artefacts was discovered due to the anaerobic conditions of the compacted, collapsed crannog mound. This included a butter dish with remains of a dairy product adhering to the inside, a small iron dagger, one of Scotland's finest examples of a swan neck pin, a putative bridge from a seven-stringed lyre, and a piece of woven wool textile which was recovered in 1986. In 2019, the director and the curator of the Scottish Crannog Centre mooted the idea of delivering a project which would focus on the Oakbank textile. The project aims were to carry out further tests and examination of the piece, create a new museum display, and undertake experimental archaeology with community involvement.

The Oakbank textile (OB86.350) was first studied by Elizabeth Wincott Heckett whose unpublished report identified it as a wool textile in 2/1 (or 1/2) twill weave with a hem, woven with z/s single yarn (Wincott Heckett 1990). Never published in full, the results are summarised in a compendium of Scottish and Irish Bronze and Iron Age textiles (Wincott Heckett 2012). At the time, the textile was cleaned and freeze-dried providing stability and resulting in a small size increase from 60 x 70 mm to 63 x 77 mm, and a lightening of the overall colour (Wincott Heckett 1990, 1–2). Dye analysis did not reveal any dyestuff (Wincott Heckett 1990, 3) and may have been negative

due to the loss of dyestuff during centuries buried in the loch. The Oakbank textile is important due to its secure excavation context. Wincott Heckett noted the significance of 2/1 twill weave, because this is an unusual weave for the Early Iron Age in northern Europe. Nick Dixon published a summary of Wincott Heckett's results (Dixon 2004a, 155, fig. 61). In 2021, the Oakbank textile was re-examined at the University of Glasgow, where fibre identification, wool quality analysis, and contextual research were carried out. A sample of the textile was taken and sent to the Scottish Universities Environmental Research Centre (SUERC) for radiocarbon dating.

### Method

The textile was delivered to Glasgow by the curator of the Scottish Crannog Centre and examined in March 2021 using the Leica M80 and portable Dino-lite at magnifications from x7.5 to x60. The textile was photographed front and back by Aristotelis Palyvos using a Nikon digital SLR and light stand. The textile was analysed following standard procedures including the identification of textile structure, thread twist, diameter, angle, thread count per cm of weaving – an indicator of quality – and observation of thread features, preserved colour and finish. Classification of thread and weave structures follow Emery's



Fig. 1: Oakbank textile fragments, 2/1 twill weave, largest showing the front (obverse), fragment with possible hem on the left; scale 10 cm (Image: Aristotelis Palyvos)

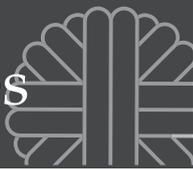


Fig. 2: Oakbank textile fragments, 2/1 twill weave, largest showing the back (reverse), fragment with possible hem on the right, scale 10 cm (Image: Aristotelis Palyvos)

terminology (Emery 1994). Two samples were taken for scientific analysis from loose material in the storage box. Sample 1 for dating: 0.01 g of textile weighed using a precision balance, packed in aluminium foil, sealed in a plastic bag and sent to Scottish Universities Environmental Research Centre (SUERC) Radiocarbon Laboratory. Sample 2 for fibre analysis: two fragments of textile less than 5 mm sq and a length of yarn about 5 mm were removed and adhered to aluminium stubs using adhesive carbon tabs. Sample 2 is currently stored on the aluminium stubs at the University of Glasgow and can be returned to the Scottish Crannog Centre or used for future analysis.

The Oakbank textile fibres may have shrunk or expanded marginally during their time in the waterlogged deposits minimally affecting individual fibre measurements.

Fibre analysis was carried out using the Quanta 200F scanning electron microscope (SEM) at the Imaging Spectroscopy and Analysis Centre (ISAAC), University of Glasgow in August 2021. Samples were placed in the SEM chamber, examined in backscatter mode under 15KV accelerating voltage at about 10 mm working distance using magnifications of x50 to x2500. For species identification, the morphological features

of the fibres were described and identified following the terminology in two fibre atlases (Appleyard 1978, vii-viii; Teerink 1991). Wool quality analysis follows a method for SEM of archaeological textiles (Gleba 2012, 3646). Micrographs for wool quality analysis were taken at x500 magnification. Diameters of longitudinal, whole mount fibres were measured using ImageJ software. Wool diameter distributions are presented as histograms at intervals of 2 µm. Fibres from Sample 2 were mounted longitudinally on a glass slide and examined for colour coating or pigmentation with transmitted light using the Leica DM2000.

### Results

The Oakbank textile OB86.350 is in two large pieces and several smaller ones (fig. 1–2). The largest piece measures 47 x 50 mm. The fragment with the folded edge, possibly a hem, measures 35 x 19 mm. Two detached fragments measure 11 x 10 mm and 13 x 15 mm. They are all part of the same textile.

### The textile

The Oakbank textile is woven in 2/1 twill weave. This notation indicates that the front of the textile is the side on which the weft threads pass over two warp

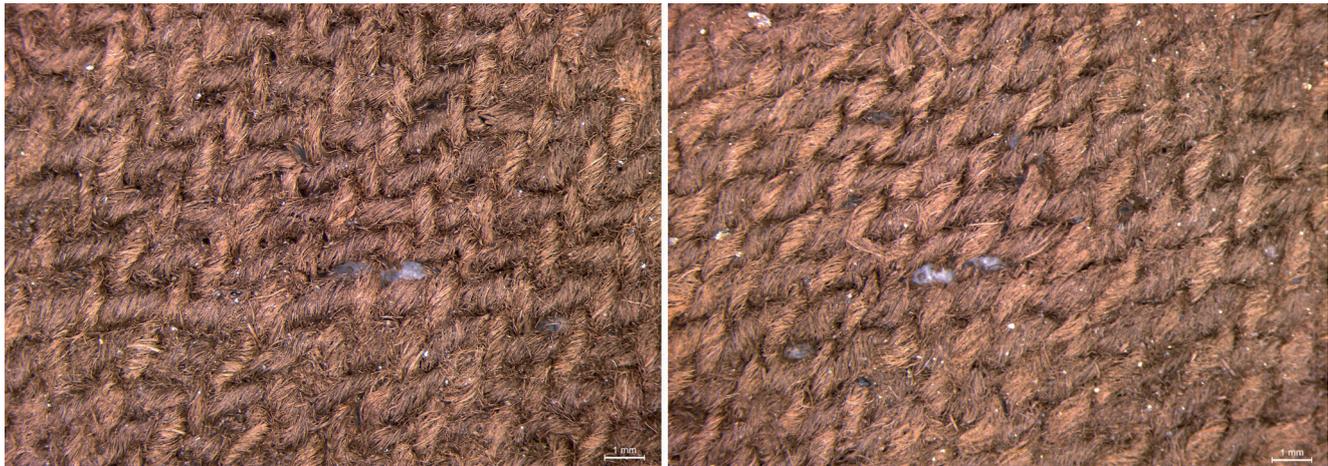


Fig. 3: Micrograph of the front (left) and reverse (right) of 2/1 twill weave structure; scale 1 mm, Leica M80 (Image: Susanna Harris)

threads. As is characteristic of this weave structure, the diagonal linear pattern of 2/1 twill weave is visible on the front where the weft threads float over two warp threads (fig. 3, left). The twill weave formation is less visible on the back, where the weft passes under only one warp (fig. 3, right). There is no selvedge or starting border. The textile is discoloured brown and covered with particles of soil due to being buried in the loch environment for many years. Despite this, the two yarn systems have distinct tones. The preserved warp threads are yellowish red (Munsell 5YR 4/6); the weft threads are reddish brown (Munsell 2.5YR 4/4). The colour difference could be either due to one or both yarns being dyed or pigmented. Observed with transmitted light, the fibres appear coated. However, whether this is due to contaminants from the waterlogged deposit or dye cannot be determined. The lighter, finer, more consistently spun yarn with a

higher thread count is likely to have been the warp (Wincott Heckett 2012, 437). The darker, thicker yarns with more variable thickness are likely the weft. There are 14 to 16 warp threads per cm. The weft threads are more consistent with 12 per cm. The Oakbank textile has a smooth finish with no evidence of fulling (processing after weaving). One edge is folded and appears to have indistinct and irregular stitches, which form a possible hem (fig. 1, fragment to the left). Compared to plain weave fabric structures, twill weave is inherently a more flexible weave. It may also be denser, because there are fewer intersections in the fabric, allowing the yarns to lie closer together.

#### *The threads*

The Oakbank warp threads are z-twisted, single yarn with a mean diameter of 0.52 mm (range 0.46 mm to 0.60 mm) and mean twist angle of 41° (range 23° to 51°) (table 1). The weft

Object	Weave structure	Twist direction	Thread diameter mean, mm	Thread diameter range, mm	Thread angle of twist, mean °	Thread angle of twist, range °	Thread count, mean	Thread count, range
OB86.350, warp	2/1	z	0.52	0.46 - 0.60	41	23 - 51	15	14 - 16
OB86.350, weft	2/1	s	0.67	0.42 to 0.91	43	30 - 57	12	9-11

Table 1: Analysis results for Oakbank textile OB86.350; thread measurement in mm, angle of twist in degrees, thread count over 1 cm

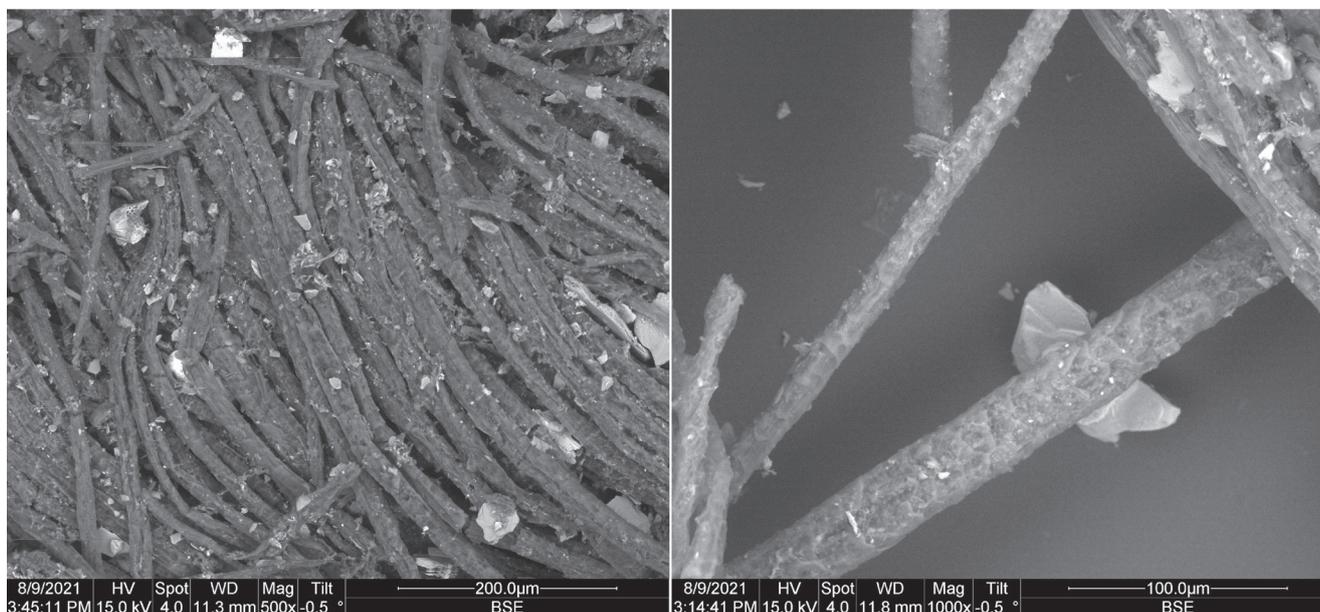


Fig. 4: Scanning electron micrograph of wool fibres – Sample 2 x500 (left) and x1000 (right) (Image: Susanna Harris, ISAAC Laboratory, University of Glasgow)

is made of s-twisted single yarn, with a mean diameter of 0.67 mm (range 0.42 to 0.91 mm), and mean twist angle of 43° (range 30° to 57°). Textiles with both z and s-twisted threads are denoted z/s. While according to the mean twist angle both appear tightly spun (Emery 1994, 12), visually, there are distinctions. The sharp profile and tight spin of the warp threads show the fibres were aligned in parallel before they were spun. This may be because the wool was combed straight prior to spinning. Such techniques create smooth, firm, relatively inelastic yarns, historically referred to as worsted-spun (Ross 1983, 18). The weft threads are looser in appearance, creating a bulkier, less regular yarn. It could be that the wool for the weft threads was prepared and spun using a different technique which left the wool fibres lying in multiple directions. Historically, this type of yarn was referred to as woollen-spun and while it was weaker than worsted, it had the benefit of providing more insulation (Ross 1983, 17).

#### **Fibre identification**

Fibres are the raw materials of textiles. The Oakbank fibres are degraded and have soil adhering. Examined longitudinally, the surface of the fibres (cuticle) has flat, overlapping scales characteristic of animal fibre. The scale pattern is an irregular mosaic; the scale margins are near with prominent, smooth margins; the diameter is irregular (fig. 4). Most of the transverse cross-sections are highly degraded. Where visible, transverse cross sections are circular to oval; some are

irregular, and a number are medullated. On the basis of these observations, the fibre is consistent with the features of sheep wool, genus *Ovis* (Appleyard 1978, 26–27).

#### **Wool quality analysis**

The range of fibre diameters and positive skewness of distribution in the warp threads, following Ryder's classification of sheep fleece, is consistent with a semi-fine or shortwool fleece type (Ryder 2000, 4). In the weft threads, the range of fibre diameters is consistent with fine wool. However, the positive skew of distribution and presence of medullated fibres means that this falls into the semi-fine or shortwool fleece type.

In Rast-Eicher's classification, there are 11 wool grades from grade F, the coarsest, to grade AAA, the finest (Rast-Eicher 2008, 155, table 89). Following this system, the Oakbank warp threads are closest to grade A fleece, with 94% of wool fibre diameters less than 30 µm, 6% greater than 30 µm and none greater than 40 µm. The Oakbank weft threads are closest to grade AA with 87% of fibres less than 25 µm, 8% greater than 25.1 µm and 1% greater than 30 µm.

Today's sheep fleece is the result of selective breeding since the Neolithic era. The domestication of sheep fleece was first studied by Michael Ryder. He adapted a method employed by the wool industry of the 1960s to understand fleece quality. This compared wool diameter distributions from a sample of at least 100 fibres from a fleece or textile (Ryder 1969, 517–520;

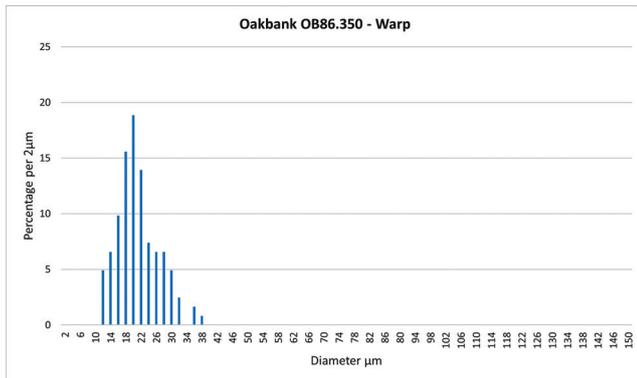


Fig. 5: Histogram of wool quality measurements of Oakbank textile OB86.350, warp (Chart: Susanna Harris)

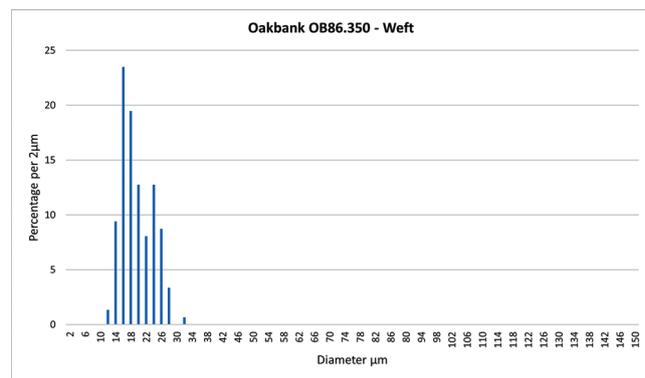


Fig. 6: Histogram of wool quality measurements of Oakbank textile OB86.350, weft (Chart: Susanna Harris)

Ryder 1983a; 1983b, 42–47). Several scholars have updated Ryder’s method by introducing new grading systems and placing greater emphasis on the impact of sorting and preparing fleece on the fibre diameter distributions (Christiansen 2004; Rast-Eicher 2008; Gleba 2012). The results of the wool quality analysis of OB86.350 are presented in table 2 and fig. 5 and fig. 6.

#### Dating

A single AMS radiocarbon date of Oakbank wool textile OB86.350 from SUERC provides a calibrated date of 480–390 calBCE (2360 ± 19 SUERC-99033 / GU57713; 480–390 calBCE at 95.4% probability). Dates of the large timbers used in the construction of Oakbank Crannog have been radiocarbon dated to 520–465 calBCE (Cook et al. 2010, 346). The chronology of crannogs is complex, and many remained in use for decades (Stratigos and Nobel 2018, 152–154). This places the textile in the Early Iron Age, 700–100 BCE within the full span of the Scottish Long Iron Age, 700 BCE–900 CE (ScARF Hunter and Carruthers 2012, iii, table 1, 8–10). There are three chronological divisions

of the Scottish Long Iron Age: Early Iron Age 700–100 BCE; Middle Iron Age 200 BCE–400 CE; and Late Iron Age 300–900 CE (Parker Pearson and Sharples 1997, 359). Across much of Europe, the centuries 700–100 BCE are referred to as La Tène period. Dates of comparative finds are quoted as calendar years, where possible.

#### Weaving 2/1 twill at the Scottish Crannog Centre

The Scottish Crannog centre set up an experiment to weave a 2/1 twill with the aim of understanding the possible loom types used to weave it. Three heddles are required to achieve this twill. To use a warp-weighted loom necessitates creating a starting border holding the warp; in this case a tablet-woven band. This process involves stretching a length of yarn (the initial weft thread) between two anchors. The weft thread is doubled over, passes through the band warp threads, and is attached to a further anchor point some distance away. This will determine the length of the warp in the ground weave. The procedure creates a thin (tablet-woven) band, with long warp threads hanging down from one side (see observations by

Object	Number of Fibres	Median	Mode	Mean	St. Deviation	Diameter range	Skewness of distribution	Ryder Fleece type	Rast-Eicher Grade
OB86.350, warp	122	19.6	19	20.6	5.47	11-38	+0.57	Fine/semi-fine	A
OB86.350, weft	149	18.2	16	19.0	4.11	11-31	+0.61	Fine/semi-fine	AA

Table 2: Wool fibre measurements for Oakbank textile OB86.350 in micrometers (µm)



Hoffmann 1964). The band is attached to the top of the loom and the long warp threads are attached to the loom weights. However, the warps threads, having been doubled over, hang down in pairs. Groups of three threads are required for a 2/1 twill weave so, in the Crannog Centre's experiments, when the doubled threads were passed through, the second doubled thread had to be snapped and pulled back through the tablets. This proved to be an incredibly complex task and seemed counter-intuitive and impractical.

Early experimentation at the Scottish Crannog Centre with a two-beam loom to weave a 2/1 twill weave were successful, but not without problems. The two-beam loom, in contrast to the warp-weighted loom, was very easy to set up and used a single, long piece of yarn wrapped over the top beam and then passed under the bottom beam (fig. 7 and fig. 8). The beam at the top could be moved to accommodate for a change in tension as the weaving progressed. The warp threads were easily separated into groups of three, and the whole process took a little under four days; a marked contrast to the three weeks taken to set up the warp-weighted loom. Because the 2/1 twill weave required

the weft yarn to pass over two warp threads and under one warp thread, initially the experimenters were pulling out two heddles at a time, creating a 'heavy lift'. This caused the warp threads attached to the third heddle to loosen and the twill appeared on the front of the weave. With effort, the experimenters were able to separate out the third heddled yarn at the back of the weave. They are now reversing this process so that only one heddle is pulled out. This 'light lift' means the weave appears on the reverse of the woven cloth. This sped up the process significantly and made the weaving much easier.

Up to the time of publication, the experimenters have been using a medium weight, modern weaving yarn, in order to establish a weaving technique. In future, they will spin single yarn, which will then be stretched over the loom. They predict problems will arise, such as threads breaking whilst under tension, and environmental factors such as humidity affecting the tension of the yarn over time. It is possible that a form of starch or boiled cow hooves may be needed to act as a stiffener on the yarn to stop it from snapping. Further tests, including chromatography and strontium



Fig. 7. Left – From left to right, these are master weaver Ashleigh Slater, craftsperson Lorraine Welsh and experimental archaeologist Jason Oliver. Lorraine is tensioning the loom ready for weaving. Right – The finished two beam loom (Image: © Scottish Crannog Centre Trust)

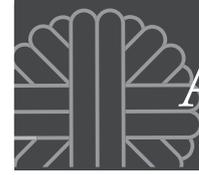


Fig. 8. Left – John Strachan, University of Edinburgh archaeology student, attaching the heddles to the warp threads. Right – Graham Liney, Crannog Centre staff, beating the weft with a weaving sword (Image: © Scottish Crannog Centre Trust)

isotope analysis will inform the experimental process and bring the Crannog Centre team closer to how the people of the past constructed the original textile. Following the practice of experimental archaeology, repetition of the experiment will be important to avoid an isolated and therefore inconclusive result (Coles 1979, 46–47). Furthermore, the results of the experiment using a two-beam loom to create a 2/1 twill will not be taken as absolute proof of the method of manufacture. However, the 2/1 twill weave does fit better on such a loom. To date, approximately 80 people have been involved in the entire process, including a master weaver, woodworkers, craftspeople, volunteers and members of the public, without whose help this project would not have evolved in such a manner.

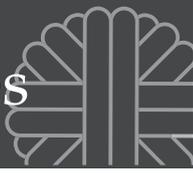
### Discussion

There is only a handful of published textiles of Early Iron Age date in Scotland. For this reason, the scope of comparative material extends beyond it both geographically and chronologically. The discussion focuses on twill weave textiles in wool.

### *Twill weave*

The earliest twill weave fabric structure in the British Isles is a tasselled herringbone twill weave horsehair band used to wrap a metal hoard from Cromaghs, County Antrim (dated 900–700 BCE) (Wincott Heckett 1998). However, the Cromaghs band is an unusual object, of narrow width and made from single horse hairs that could have been woven using non-heddle techniques. Therefore, it is technically and materially distinct from the Oakbank textile.

The most significant group of textiles dating to the Early/Middle Iron Age in Great Britain are from sites in East Yorkshire. At Rudston and Burton Fleming, cemeteries of the Arras Culture (400–200 BCE), preserved textiles were recorded on 57 metal objects, mostly brooches or pins (Crowfoot 1991, 124–125; Crowfoot 1989, 1). The majority are 2/2 twill weaves or its chevron and broken diamond variations, woven with 5 to 11 threads per cm using z or s-twisted singles yarn from 1 to 1.5 mm in diameter. There are no recognised 2/1 twill weaves. The mineralised



textiles of Wetwang Slack follow the same general pattern (Crowfoot 1991, 120, 122). Two twill weave textiles worn beneath a chain mail coat in Burial K5, Kirkburn were woven in 2/2 twill weaves, with single yarn (z/s, 13/10 threads per cm; z/z, 10/8 threads per cm) (Crowfoot 1991, 123). From West Yorkshire, a preserved organic broken diamond twill weave textile (z/z, 5/6 threads per cm) is documented from Skipworth Common (500–100 BCE) (DeRoche 2012, 446). The Skipworth textile is matted, which possibly indicates fulling (Wild 2012, 446). Scattered Early/Middle Iron Age twill weave textiles from across Great Britain follow a similar pattern (DeRoche 2012, 446). In comparison, the Oakbank textile stands out because it is a 2/1 twill weave and is relatively fine (15/12 threads per cm).

Twill weave remained the staple textile of Middle Iron Age Scotland and Romano Britain. A diamond twill weave textile (s/z, 11–14/14–16 threads per cm) was found with a mirror and other metalwork from Balmaclellan, Dumfries and Galloway, dated 1–200 CE (Crowfoot 1948, 15–225–7; Bender Jørgensen 1992, 198). Textile traces on an Iron Age/Early Roman annular brooch from Craigie, Dundee, Angus, are probably 2/2 twill weave (6/5 threads per cm) (Bender Jørgensen 1992, 198).

The closest parallel to the Oakbank twill weave given by Wincott Heckett was a textile from Island McHugh crannog site in County Tyrone, identified as a 2/1 twill weave (Wincott Heckett 1990, 5). However, the Island McHugh textile is not securely dated. Reportedly of Late Bronze Age date, it could be as late as the 17th century CE, making it a poor comparison (Wincott Heckett 1990, 5).

By examining the earliest evidence for twill weave fabrics across Europe and into Turkey it has been concluded that the earliest twill weave textiles were a Bronze Age innovation, becoming the most dominant weave in the Hallstatt period in central Europe (Bender Jørgensen and Rast-Eicher 2016, 83; Grömer 2012). In the late first millennium BCE, the popularity of 2/2 twill weave is evident across much of north and central Europe: for example, textiles of the Pre-Roman Iron Age in Denmark and Sweden (500–1 BCE) are mostly wool textiles woven in 2/2 twill weave or tabbies, with 5 to 10 threads per cm, in wool single yarn with minimal surface treatment (Mannering et al. 2012, 103; Franzén et al. 2012). In Germany, La Tène textiles are typically 2/2 twill weaves, woven with single yarn or a combination of singles and S2z-ply yarn (Möller-Wiering 2012, 131). In central Europe, the Early Iron Age twill weave textiles from the Hallstatt salt mines (800 BCE to 400 BCE) were mostly wool textiles woven

using single yarn in 2/2 twill weave (5 to 15 threads per cm) and its many chevron or herringbone variations (Grömer 2005, 17; 2012, 43).

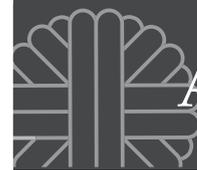
### **Wool**

The Oakbank textile is typical of the Iron Age, as the predominant textile fibre was wool (DeRoche 2012, 445; Wincott Heckett, 2012, 431). It is a very useful textile fibre being warm to the touch, a good heat insulator due to its low heat conductivity and bulkiness, and its ability to hold 40% of its weight in water yet still feel warm and dry (Harris 2010, table 18.3).

Wool is known in Scotland from the Early Bronze Age as preserved fibres possibly from a sheepskin in a cist burial in Spinningdale, Sutherland (2051–1911 calBCE) (Arabaolaza et al. 2013, 15). By the Late Bronze Age, there are preserved wool textiles in tabby, including the shroud from an oak coffin burial in Rylstone, North Yorkshire (840–590 calBCE), and preserved on a metal hoard from St Andrew's, Fife (1000–800 BCE) (Gabra-Sanders 1994, 36; Wincott Heckett 1998, 29–30; Melton et al. 2016). Iron Age textiles from the Arras Culture burial sites of East Yorkshire (400–200 BCE) also appear to be made of wool (Crowfoot 1991, 119, 122). During the Middle Iron Age in Scotland, wool continues to be the most significant textile fibre, used for the Balmaclellan diamond twill weave (1–200 CE) and the Falkirk 'tartan' (about 250 CE) (Crowfoot 1948). To the south, wool was the main textile fibre at Roman forts such as Vindolanda (about 100 CE) (Wild 2012, 452). The Oakbank textile fits this pattern.

### **Wool quality**

By the Iron Age, sheep fleece was less pigmented, consisting of fibres of fine to medium diameter and contained few to no hairy kemp (Bender Jørgensen and Rast-Eicher 2016, 71; Ryder 1969, 497, fig. 2; Walton 1988, 146). A diverse array of sheep fleece qualities existed, and processing fleece was more sophisticated than during earlier periods (Rast-Eicher and Bender Jørgensen 2013, 1240). At the Hallstatt salt mines, Austria, for example, Bronze Age fleece types persisted alongside sheep with mixed fibres, and a third type of fine, white wool was used for fine yarns, about 0.3 mm in diameter (Rast-Eicher and Bender Jørgensen 2013, 1231–1232). The Oakbank textile, with its semi-fine wool, following Ryder's classification, or grade A and AA wool quality following Rast-Eicher's system, is consistent with what might be expected of a finer Iron Age fleece. As preserved, the fibre diameters (majority below 30 µm) and distribution of fibres remain indicative of a semi-fine or fine quality wool. To give a sense of the haptic qualities of this textile, in the modern wool industry, fibres between 17 µm to 30



$\mu\text{m}$  are considered fine enough to be used for clothing textiles; those with fibres over 32  $\mu\text{m}$  in diameter are deemed coarse and used for carpets (Tridico 2009, 37, fig. 3.7).

#### **Yarn**

Throughout the first millennium BCE across England and Scotland, wool was spun into single yarn with either a z or s-twist and woven in various combinations (DeRoche 2012, 446; Bender Jørgensen 1992, 20). For example, the textiles of the Arras Culture cemeteries from East Yorkshire (400–200 BCE) were spun using predominantly z-spun yarns in warp and weft (z/z), and approximately one third woven with mixed yarns (z/s or s/z) (Crowfoot 1989, 119). In textiles woven with mixed yarns, the fibres lie in the same direction creating fabrics that were “said to be thorn-proof and rain repellent” (Crowfoot 1991, 119). In one example at Burton Flemming, East Yorkshire, a textile was woven using alternating groups of z and s-twisted yarns, creating a spin pattern, possibly originally coloured, within a broken diamond twill weave textile preserved in the corrosion products of a brooch (BF20) (Crowfoot 1989, 119–121, fig. 79a–c and fig. 80). Although not as elaborate as this, the Oakbank textile with its mixed z and s-twist yarns with light and dark hues fits the broad pattern of Early Iron Age textiles. It adds to the evidence that mixed spin directions were present in textiles in Great Britain before the Roman period (DeRoche 2012, 446).

#### **Loom**

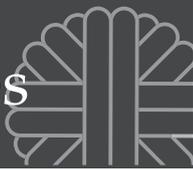
Twill weave is woven using a loom with three or more sheds created by shafts and heddles. As noted above, 2/1 twill weave is woven using three sheds. In the case of the warp-weighted loom, one shed is formed by the natural fall of the weights. Wincott Hekett proposed that the Oakbank 2/1 twill weave was woven on either a warp-weighted or two-beam vertical loom (Wincott Hekett 1990, 3–4). The characteristic features produced by different looms are apparent in the textile selvages, the starting and finishing borders. These are absent in the Oakbank textile. While archaeological evidence of loom weights is indicative of the warp-weighted loom, it is worth considering that the contemporary checked textiles of Huldremose, Jutland, Denmark (350–41 calBCE) and Gerum, Västergötland, Sweden (360–100 calBCE) have technical features characteristic of weaving with a tubular warp on a two-beam vertical loom (Hald 1980, 167–185; Gleba and Mannering 2010, 32; Frei et al. 2009, 33; Franzén et al. 2012, 361). The use of a two-beam loom to weave a tubular warp textile was

first proposed by Danish textile specialist, Margarethe Hald (Hald 1980, 167). Hald’s identification was based on the thread lock used to keep the ends of the warp together in tubular warp textiles, as seen on the Huldremose textiles. This indicates that some Early Iron Age twills in northern Europe were woven on a two-beam vertical loom with a tubular warp; a technology that was used alongside the warp-weighted loom, as evidenced by loom weights (DeRoche 2012, 449; Wild 2012, 453; Wild 2002, 10–11).

#### **Conclusion**

In summary, textile OB86.350 from Oakbank Crannog is a rare example of a preserved organic textile from Iron Age Scotland. Securely dated to 480–390 calBCE through the archaeological context and radiocarbon dating analysis, it appears to be the earliest wool twill weave in Scotland. The Oakbank textile is characteristic of earlier Iron Age textiles in Britain, and in northern and central Europe because it is a twill weave, woven with single yarn with both z and s twists. The wool used for warp and weft is notably fine, and fits with the wider European pattern of fine, well-sorted Iron Age fleeces. However, the 2/1 twill weave structure is atypical among preserved textiles and appears to be the earliest example of this type of weave in Britain. Most twill weaves of the later first millennium BCE are 2/2 twills. The thread count (15/12 threads per cm) is comparatively fine, although not exceptionally so. The two-tone warp and weft link it to a wider concern for colour in wool textiles of this period in north and central Europe. It would be worth carrying out new dye analyses using current techniques. Given the scarcity of Early Iron Age textiles in Scotland and across the British Isles, it is difficult to judge the chronological and geographical significance of this early 2/1 twill weave. Whether it was a unique example or part of a regional tradition is a matter of speculation.

The experiments with warp-weighted and two-beam vertical looms to weave 2/1 twill found the three shed twill weave was more readily woven on the two-beam vertical loom. This raises important questions about the types of loom used in Iron Age Scotland, while acknowledging that experiments can only raise possibilities of techniques, rather than prove them. In the future, the Scottish Crannog Centre aims to source fleece, spin the wool, and replicate the Oakbank weave. To date, the Scottish Crannog Centre has brought together academics, museums, weavers, crafters, and woodworkers in a creative springboard of learning and experimentation. The textile project will continue to be delivered at the new



Scottish Crannog Centre, where it, and prehistoric textile interpretation, will play a key role in the organisation's development plans as it relocates to new premises on Loch Tay, close to the original Early Iron Age Oakbank Crannog site.

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