Research Department Report Series 33/2006

Yarnton, Oxfordshire
Conservation of a Bronze Age Wooden Log Ladder from

Vanessa Fell

Summary

Part of a Bronze Age wooden log ladder was recovered during excavations at Yarnton, Oxfordshire in 1998 (YFPB98). This report describes the stabilisation of the ladder by freeze-drying.

Keywords

Conservation
Bronze Age
Wood, Worked

Author's Address
Vanessa Fell: Centre for Archaeology, Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth, PO4 9LD. Telephone: 02392 856787. Email:vanessa.fell@english-heritage.org.uk

Research Department Report Series 33/2006

Yarnton, Oxfordshire.
Conservation of a Bronze Age Wooden Log Ladder

Vanessa Fell

ISBN 1749-8775

Research Department Report Series 33/2006

Yarnton, Oxfordshire. Conservation of a Bronze Age Wooden Log Ladder from

Vanessa Fell

Summary

Part of a Bronze Age wooden log ladder was recovered during excavations at Yarnton, Oxfordshire in 1998 (YFPB98). This report describes the stabilisation of the ladder by freeze-drying.

Keywords

Conservation
Bronze Age
Wood, Worked

Author's Address
Vanessa Fell: Centre for Archaeology, Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth, PO4 9LD. Telephone: 02392 856787. Email:vanessa.fell@english-heritage.org.uk

Introduction

Part of a wooden log ladder was recovered during excavations at Yarnton, Oxfordshire, in 1998. The ladder (YFPB98 15039 W74) is from a waterhole (15014) dug into the base of a shallow palaeochannel. Radiocarbon dating (OxA-8673) of a sample of wood from the ladder ($\delta^{13}C = -26.5‰$) has provided a date of 3365 ± 40BP (95% confidence) equivalent to 1750 – 1520 cal BC (Bayliss and Hey, in prep).

There are three main fragments of the ladder. One end is eroded or worn away to a smoothed blunt point, and this end may be complete in length (left in Figs 1 and 2). Together, the three fragments measure 1.37m in length and the maximum diameter is 0.18m. Parts of five notches survive; these form the footholds or 'steps' of the ladder. Three of these are fractured across at the narrowest and weakest areas, including a partial step at the incomplete end (right in Figs 1 and 2). The notches are cut at c. 90 degrees to the length of the timber, to depths between 60 and 70mm. The distances between the notches are 250mm, 260mm, 210, and 400mm (left to right in Figs 1 and 2). The ladder is slightly curved inwards, towards the notches. Tool marks resembling axe cuts are clearly visible within the notches at the angles of the bases of the 'steps'.

The wood species was identified by Maisie Taylor as *Alnus/Corylus* sp. (alder /hazel) and a full description of the ladder will be available elsewhere (Taylor forthcoming).

Prehistoric log ladders are not common. A complete one with four notches, dated to the early Iron Age, was found at Sutton Common, South Yorkshire (Parker-Pearson and Sydes 1997, 233–4, fig 14). Fragments of two or more ladders come from a Late Bronze Age well at Lofts Farm, Essex (Brown 1988, 293, figs 26–27).

Figure 1. The ladder after freeze-drying. Because it is slightly curved in towards the notches, the fragments do not fully align in this photograph.

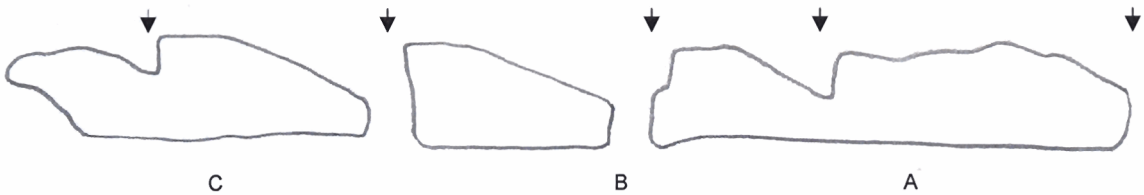

Figure 2. Sketch showing the relationships of the main fragments of the ladder, referred to as Fragments A, B and C (arrows indicate positions of the 'steps').

Other Late Bronze Age examples come from Goose Acre Farm, Radley, Oxfordshire and Stanwell, Heathrow Airport, and another ladder fragment was found at Kemerton, Worcestershire (Brown 1988, 233).

The primary aim of the conservation process was the stabilisation of this waterlogged organic artefact as well as to assist interpretation and enhance its long-term stability. Vacuum freeze-drying was chosen, a process by which frozen water is removed by sublimation thus preventing physical damage to the cellular structure of the wood. This method has the advantage of lightening the colour of wood, which produces a pleasant surface for display purposes.

Condition

The ladder was recovered from a waterlogged context in 1998 and for seven years it was stored wrapped in dark polythene so that it would remain damp, and to exclude daylight. When possible it was kept at reduced temperatures, in particular during the latter four years when it was stored at 4°C in a coldroom.

The wood itself was in reasonable condition given the long storage time, although the surfaces were soft and spongy with some white staining from fungal attack (Fig 3) and soft white deposits or concretions in places (Fig 4).

On Fragment A there is evidence of insect damage, visible as short narrow channels up to 15mm long and 1mm wide and deep, which appear to be restricted to the surface. These had probably occurred pre-burial, although were not visible until the surface of the wood had started to dry out slightly (J Watson pers comm).

Figure 3. Fragment A before treatment. White fungal deposits are visible on the surface as well as narrow short channels due to insect damage (arrowed).

Figure 4. Fragment B before treatment. The orientation is the same as in Fig 1, with a flat 'step' to the left and the riser to another 'step' to the right. White deposits or concretions are visible intermittently on some surfaces.

Figure 5. Fragment B, fractured across the 'step' that adjoins to Fragment C (shown to the left in Fig 4 above). The flat part of the 'step' is at the upper left side of the cross-section shown, with white concretions on the surface. The other part of the section shows a modern fracture (lower right of section and picture).

Fragment C appears to be the most decayed piece of the ladder. There are a number of fissures running longitudinally from the end that is probably complete, and these appear to be damage through drying and shrinkage of the wood. During freeze-drying, two small fragments of wood became detached from this area, the larger of which comes from near to the 'step' (c. 200mm from the ladder end).

The ladder retains tool marks from its manufacture, in particular within the notches. However, there are no clear tool marks on the 'steps' themselves, presumably due to wear. On the risers to the 'steps' there are a few facets from tool marks that survive, although these are not sharp and clear, possibly due to the relatively weak and spongy condition of the wood.

Methods

The ladder had been cleaned previously elsewhere to remove soil deposits prior to recording. Before treatment, it was cleaned with water and a soft brush to remove fungal deposits and other accretions, measured and weighed (Table 1).

Table 1. Dimensions and weights of the ladder fragments before treatment

	A	B	C
Length	670mm	260mm	450mm
Diameter	Incomplete end: 140mm	A/B junction: 130mm	B/C junction: 130mm
Diameter	A/B junction: 135mm	-	-
Weight	10,560g	3,148g	3,676g

Before freeze-drying, the ladder was pretreated in aqueous solutions of polyethylene glycol (PEG) of two different molecular weight grades, PEG 400 and PEG 4,000. The role of the lower molecular weight wax, PEG 400, is threefold: to compensate for the expansion in volume when the wood is frozen, to sequester minerals in solution, and to provide buffering action in differing humidities for the dried wood after treatment (Watson 1987). The PEG 4,000 is a solid wax at ambient temperatures, and after freeze-drying this serves as a bulking agent to provide support for the outer few millimetres of the cellular structure of the degraded wood. The concentrations of the PEG solutions and durations of immersion were selected according to wood density and deterioration (Watson 1982; 1987). Although detailed analyses of cellulose or water content were not made, visual examination suggested that the wood was of medium density and level of deterioration (J Watson pers comm).

The pretreatment procedure was as follows. The wood was maintained in aqueous solutions held in dark conditions at 4°C in a coldroom at the laboratories of English Heritage, Fort Cumberland, Portsmouth. The wood was submerged in a 30 litre tank of 10% vol/vol PEG 400 for 9 weeks in total, with the solution being changed every 3 weeks to combat bacterial slimes. Solid PEG 4,000 was then added to the PEG 400 solution, with an increase in the concentration of the PEG 4,000 of 5% wt/vol over 2 week intervals until the final concentration was 15%. The ladder was left in this final solution for a further 21 weeks. These concentrations are summarised in Table 2.

Table 2. Concentrations of pretreatment tank solutions

Date	Duration (weeks)	Added wax	Final composition	Temp	Amount added
20.6.05	3	10% PEG 400	10% PEG 400	4°C	30 litres
11.7.05	3	10% PEG 400	10% PEG 400	4°C	30 litres
01.8.05	3	10% PEG 400	10% PEG 400	4°C	30 litres
22.8.05	2	5% PEG 4000	10% PEG 400 +5% PEG 4000	4°C	1,500g
05.9.05	2	5% PEG 4000	10% PEG 400 +10% PEG 4000	4°C	1,500g
19.9.05	21	5% PEG 4000	10% PEG 400 +15% PEG 4000	4°C	1,500g
13.2.06	Wood was removed for freeze-drying				

The wood was then removed from the solution, patted dry, weighed, wrapped in cling-film to reduce evaporation of water within the wood, and frozen at c. –22 °C over several days. It was vacuum freeze-dried at a chamber temperature of around –20°C and with a condenser vacuum of 50–75 mTorr at around –50 °C. Progress was regularly monitored by weighing weekly until the wood was found to be dry on the basis of no further weight loss (Appendix 1 and Fig 6). For these weighings, it was necessary to remove the pieces from the freeze-dryer and this was accomplished as rapidly as possible so that the frozen solutions in the wood did not melt. When drying was complete, the pieces were removed from the freeze-dryer and brought to ambient humidity and temperature. Traces of white crystals of PEG 4,000 (which are commonly found on freshly freeze-dried wood), were brushed off the surfaces with a soft paint brush.

The final drying process was thus about 6 weeks for the largest fragment (A), which had the smallest surface area ratio to weight. The other two fragments (B and C) required about 4 to 5 weeks to dry. All fragments lost between 74% and 79% of the original waterlogged weights (Appendix 1 and Fig 6). The total treatment time, between 20 June 2005 and 13 February 2006, was 34 weeks (8 months).

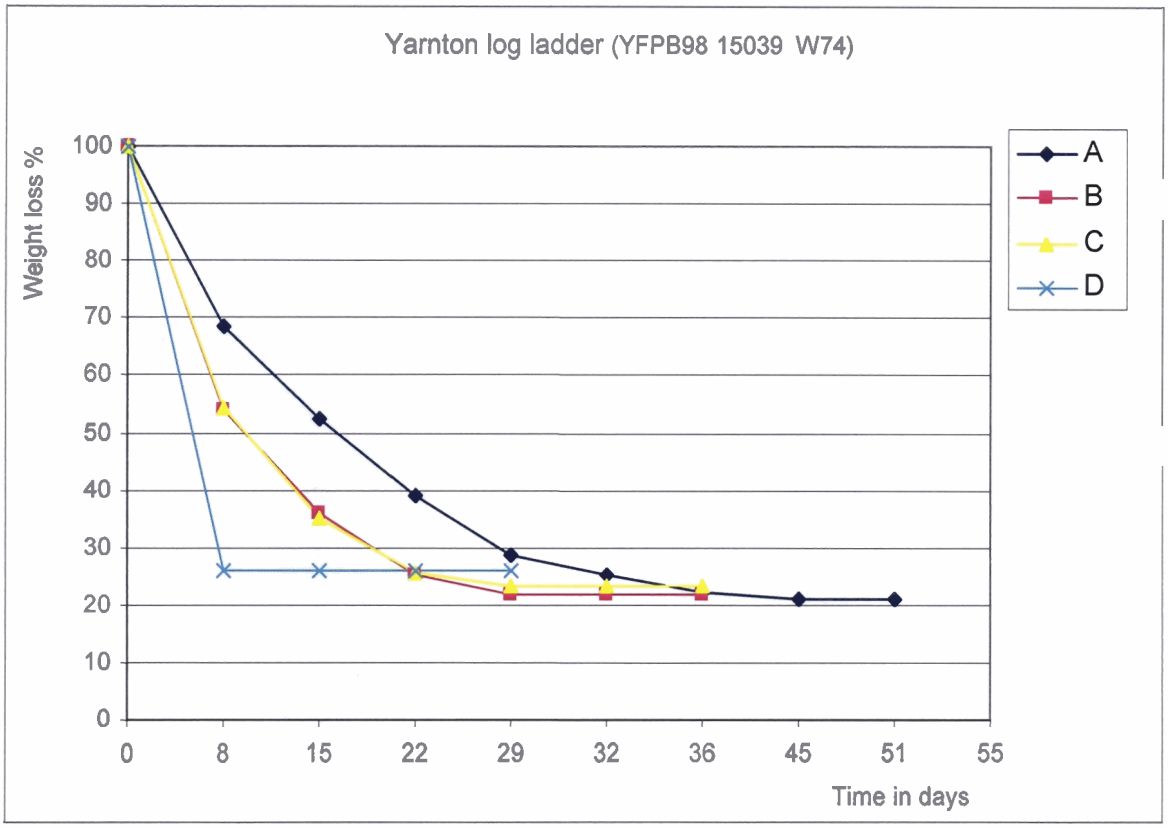

Figure 6. Weight loss of the ladder fragments during freeze-drying

The colour of the freeze-dried wood is light brown and matt. Two small areas of bark survive on opposing sides of Fragment C (Fig 7). There is slight evidence of iron staining, resulting from bacterial activity within the wood structure during burial (J Watson, pers comm). Tool marks are clearly visible within the 'steps' and the insect damage is still apparent. The freeze-drying treatment has not enhanced the visibility of these surface features, which were more clearly visible in the wet state. The surfaces are still fragile and will not withstand too much handling. Nevertheless, it was decided not to consolidate the surface of the ladder at this stage, although it may be beneficial in the future depending on environmental conditions if the ladder is displayed.

Recommended storage conditions

Recommended conditions for storage within buffered acid-free packaging are 45–65% relative humidity (RH) and a temperature of 20°C or less. The conditions are more critical if the wood is on display, without any buffering action of packaging materials, when the narrower limits of 55 ± 5% RH and 18 ± 2 °C are recommended (Watson 1997; 2004). Exposure to dust and direct light should be kept to a minimum.

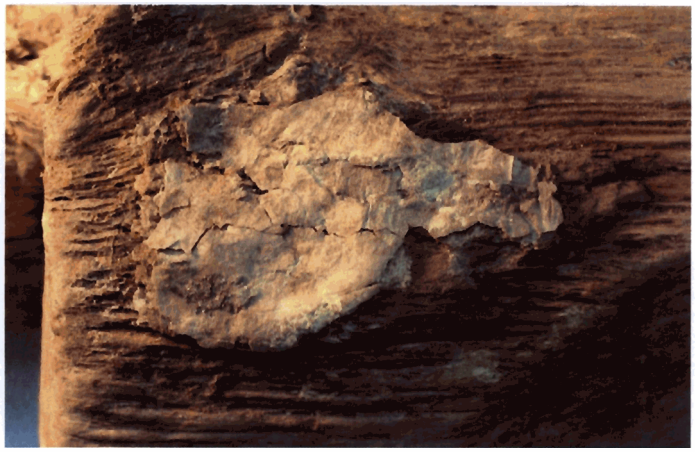

Figure 7. Bark surviving on Fragment C

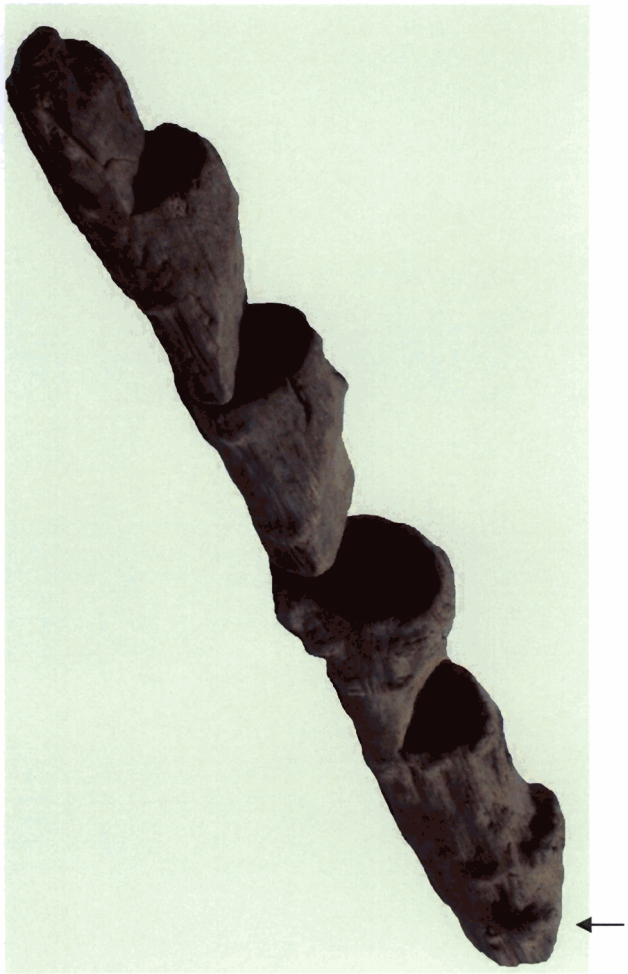

Figure 8. The ladder after freeze-drying. Four 'steps' are clearly visible; the slope or riser of the fifth partial step is visible at the lower end arrowed). Photo: Karla Graham.

Conclusions

The log ladder was successfully stabilised by freeze-drying and the appearance of each of the three main components is a light-brown natural colour, revealing tool marks as well as insect damage. The total treatment time was 8 months.

Acknowledgements

I thank Jacqui Watson for advice on the treatment of waterlogged wood and assistance throughout this project.

References

Bayliss, A, and Hey, G, in prep. 'Scientific dating' in Hey, G (ed) *Yarnton Neolithic and Bronze Age settlement and landscape*. Oxford: Thames Valley Landscapes Monograph

Brown, N 1988 'A Late Bronze Age Enclosure at Lofts Farm, Essex', *Proceedings Prehistoric Society* **54**, 249–302

Parker-Pearson, M and Sydes, R E 1997 'The Iron Age Enclosures and Prehistoric Landscape of Sutton Common, South Yorkshire', *Proceedings Prehistoric Society* **63**, 221–259

Taylor, M, forthcoming, in Hey, G (ed) *Yarnton Neolithic and Bronze Age settlement and landscape*. Oxford: Thames Valley Landscapes Monograph

Watson, J 1982 'The application of freeze-drying on British hardwoods from archaeological excavations', in Grattan, D W (ed) *Proceedings of the ICOM Waterlogged Wood Working Group Conference, Ottowa 1981.* Ottowa: ICOM-CC Waterlogged Wood Working Group, 237–242

Watson, J 1987 'Suitability of waterlogged wood from British excavations for conservation by freeze-drying', in Black, J (ed) *Recent Advances in the Conservation and Analysis of Artifacts,* 273–276. London: Summer Schools Press

Watson, J 1997 'Freeze-drying highly degraded waterlogged wood', in Hoffman, P, Grant, T, Spriggs, J A, and Daley, T (eds) *Proceedings of the 6th ICOM Group on Waterlogged Organic Archaeological Materials Conference, York 1996.* Bremerhaven: ICOM-CC Working Group on Wet Organic Archaeological Materials, 9–23

Watson, J 2004 'Conservation', in Clark, P (ed) *The Dover Bronze Age Boat.* London: English Heritage, 282–289.

Appendix 1. Weights before and during freeze-drying

	Fragment A (g)	% original weight A	Fragment B (g)	% original weight B	Fragment C (g)	% original weight C	Fragments D + E (g)	% original weight D + E
Before treatment (rinsed clean)	10,560		3,148		3,676		-	
After PEG, before freezing	10,707		3,206		3,709		25.5 + 1.4	
Increase in weight after PEG	147	1.39	59	1.86	33	1.62*	-	
Weight after freezing	10,727	100	3,209	100	3,714	100	26.9	100
After 8 days freeze-drying	7,368	68.68	1732.6	53.99	2,014	54.22	7.0	26.02
After 15 days freeze-drying	5,616	52.36	1,155	36.00	1,304	35.11	7.0	26.02
After 22 days freeze-drying	4,178	38.95	814	25.36	951	25.60	7.0	26.02
After 29 days freeze-drying	3,094	28.85	700	21.82	869	23.40	7.0	26.02
After 32 days freeze-drying	2,727	25.42	701	21.83	870	23.42	-	-
After 36 days freeze-drying	2,398	22.35	700	21.82	870	23.41	-	-
After 45 days freeze-drying	2,244	20.91	-	-	-	-	-	-
After 51 days freeze-drying	2,244	20.89	-	-	-	-	-	

Weight losses shown as percentage of original weights, after freezing
* Including Fragments D and E