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Volume III
The Early Wooden Forts

Preliminary reports on the:
Leather, Textiles, Environmental Evidence and Dendrochronology

by
Carol Van Driel-Murray, John Peter Wild, Mark Seaward and Jennifer Hillam,
with an Introduction by Robin Birley

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The milestone at the side of the Stanegate road opposite the entrance to Codley Gate farm and below the north-eastern corner of Vindolanda's stone fort. Sketched by Collingwood Bruce’s artist, H. Burdon Richardson circa 1850, it shows smoke rising from the chimney of a croft, just beyond the NE corner of the fort, known as Little Chesters of Chesters Wall. The croft was then inhabited by coal and ironstone miners. By 1861 it was deserted and by 1900 all surface traces of the building had disappeared.
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The Dating of the Periods of Occupation

The dating of the occupation periods at Vindolanda is discussed in detail in Volume I of this series, but as an aid to those who read this volume on its own, the approximate dates and sizes of the forts, and the composition of the garrisons are shown below.

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Introduction

by Robin Birley

In the course of the excavation programme of 1973-76 and 1985-89, a very large quantity of leather, textiles, wood and environmental material was recovered, much of it preserved in exceptionally good condition. The renewed excavations, which started in 1991, have produced a further substantial quantity. Detailed research is being conducted by the scholars who have submitted preliminary comments to this series of reports. Much of this work has been undertaken in spare time, with little or no financial support from any organisation, and the Vindolanda Trust is deeply grateful for such onerous and voluntary contributions.

Volume I in this series includes the main archaeological report, and reference to that volume is essential for an understanding of the complicated sequence of occupation at Vindolanda in the Roman period. In some parts of the site there is up to 6m of occupation debris, with the remains of six successive timber structures, and three stone buildings above them. Hanson 1978 has argued that the maximum life of a timber structure, in the north of Britain, built with softwoods, was unlikely to be more than ten years, since the untreated timbers would soon fall prey to a variety of diseases and the elements. On that proposition alone, an occupation lasting from AD 85 to the early Hadrianic period would require at least three reconstructions, but it is clear from the evidence that Vindolanda also experiences a number of changes in the composition of the garrison in this period, and that could lead to the demolition of unsuitable buildings and their replacement with something different.

It was the very thoroughness of the processes of demolition and reconstruction which created at Vindolanda anaerobic conditions over much of the deepest layers of the site. Demolition usually involved the removal of all still sound timbers, or the recovery of those parts of them which could be salvaged without time-consuming digging down into the foundations. Litter and abandoned utensils or goods were ignored, since the entire site was always covered with a layer of turf or clay, to provide a clean area for the new structure. The multiple layers of turf and clay created the anaerobic conditions, in which all the material survived in virtually the same condition as it was when the turf or clay was laid down above it. Thus, if demolition and re-building followed abandonment in a short space of time, before any exposure to the elements and other rotting processes had occurred, even the most fragile of goods remained in a fair degree of preservation.

There was only one significant problem in the path of those who sought to recover these delicate materials. Vindolanda is and always has been a very wet site. The position chosen for the fort lies on a slightly sloping platform above the junctions of two streams and two
'sikes', which draw copious supplies from the natural springs on that plateau. When the property came into the hands of the antiquarian Anthony Hedley, in 1814, even his dedicated enthusiasm for all things Roman did not prevent him from setting men to work in an attempt to drain the fields and improve the grazing for his tenant. (It was to prove the death of him eventually, for in January 1835, when suffering from a severe cold, he received news that one of his drain-digging labourers had come across a fine Roman vessel, and requested assistance to remove it before further damage was done to it. Hedley spent several hours crouched down in the drain, in pouring rain, assisting with the excavation, and he died, probably of pneumonia, two weeks later). Many subsequent tenants and owners continued the struggle, inserting numerous pipe-drains, until the present author, determined to solve the problem once and for all, attempted to lay down a really efficient drain off the south-west corner of the stone fort. This required a depth of over 2.5m at the southern end, to ensure that the water flowed properly southwards, to join the Doe Sike. It was that drainage trench which penetrated, for the first time, the deep layer of clay below the foundations of the stone vicus structures, and encountered the extraordinary laminated layers of carpeting in what is now known as the periods III and IV timber forts.

That portion of Vindolanda's ample water supply that does not fall directly from the skies now makes its way upwards from various springs, to seep into the foundations of the stone buildings and to spill out amongst the topsoil and turf. It does not normally penetrate the layers of turf and clay laid down above the early timber structures, where the weight of debris above them had led to great compaction. Excavators are therefore faced with what is in effect a suspended water-table, reached within a metre of the surface almost everywhere, and continuing down to a depth of some 2.5m. Down beyond that, the ground is merely slightly damp. The problem, therefore, is to divert the inevitable water flow from the early occupation layers, and this can only be done with a series of sumps, constantly cleared by petrol-driven pumps. At almost all times of the year, the inflow of water into a deep excavation trench required pumping out every hour or so, and on some mornings two hours of such effort was required before excavation could resume. In times of seriously adverse weather -frequently in August -excavation was impossible due to the danger of trench collapse caused by water seeking the lowest levels.

The anaerobic conditions preserved virtually all the Roman debris, although it is believed that a few materials and environmental specimens may have perished. For example, flesh did not survive, nor did untreated hides, and the scarcity of fish bones suggests that they had been too fragile for even this medium. But although there was a large quantity of the normal finds which could be encountered in the higher levels -pottery, glass, iron and bronze objects, coins and bone -the finds lists came to be
dominated by wooden objects (and writing tablets), a considerable variety of leather, numerous textiles and enough prime environmental specimens to keep a large laboratory in work for decades. The pages of this volume testify to that quantity.

Perhaps the most arduous work-load of all has been that faced by Carol Van Driel-Murray, at Amsterdam University. The number of leather fragments she has had to deal with has been in excess of 8,000, and the tortuous process of transporting them to and from Amsterdam for research has tested the patience of all concerned, and not least the Customs Officers at Hull and Rotterdam. The abolition of the Customs controls on 1st January, 1993, has been a great relief to all concerned. Her Report in this Volume is but a taster before she is able to complete the final statement, but it shows, perhaps for the first time, how much vital evidence can be extracted from even the most unpromising of leather objects.

Dr. John Peter Wild, at Manchester University, has readily accepted a steady flow of textiles since 1973, and he reported on the items from 1973-76 in an earlier Report (Vindolanda Research Report no. 111, 1976). A few of the textile specimens have been magnificent pieces which any expert would have been delighted to receive, but the majority were badly worn and often small fragments, requiring great patience and skill to determine their significance. With the assistance of Dr. Bill Cooke, and a Leverhume grant, a major research project into these textiles is now in progress, and a substantial further report will appear in the future.

Professor Mark Seaward, at Bradford University, became involved with the environmental specimens during a casual visit to the site in 1973, and in spite of severe financial restrictions he and his assistants have undertaken much important work. An impressive bank of specimens has been isolated from the deposits and stored at the University (much of it by Mr. Stephen Manifold), in readiness for further progress when funds become available. His preliminary report shows the range and the quality of the Vindolanda material.

Thanks to the co-operation of English Heritage, who both sanctioned the work and paid for it, it has been possible to have a number of wood samples from the 1985-89 excavation analysed at Sheffield University, in the capable hands of Miss Jennifer Hillam. Her report on the dendrochronology provided one important dating check upon the start date for Period IV, although too many of the timbers submitted were either non-oak or too small for successful analysis. Currently a much larger range of samples, from the 1990-91 excavations, are undergoing research at Sheffield, and the results are awaited with great interest.

Finally, I must express my gratitude to the Trustees of Vindolanda for agreeing to publish this volume and for support over many years, and tribute must be paid to the laboratory staff at Chesterholm Museum for their prompt
and efficient processing of all the material. My secretary, Rosemary Cotton, has type-set the scripts on the Trust's aged word-processor, with great patience and no little skill, in spite of innumerable alterations at every stage. As always, my wife, Pat, has ensured safe keeping of all the finds and necessary documentation, and she has re-drawn for publication many of the figures in the reports.

Due to their specialised nature, the bibliographies for each contribution have been kept separate, and will be found at the end of the relevant reports.
THE LEATHERWORK

by C. Van Driel-Murray

Introduction

Though only extending over one wing of the early *praetorium* block, the excavations between 1985 and 1989 have resulted in over 2600 registered leather find numbers. These individual numbers range from a single off cut or shoe sole to whole groups of several tent panels the size of 1016 or 1200, depending on the closeness of the association in the field situation. On treatment in the lab, a single mass of leather might turn out to consist of several different items: these are simply given subsidiary numbers so that the original field number accompanies the find throughout all processes including registration, lab treatment, conservation, drawing, photography and further analysis. Leather forms one of the largest material categories at Vindolanda and the ratio between this and other groups such as pottery has important implications for the assessment of the organic contribution to the material culture of sites less fortunate in the condition of preservation.

To date just over half of the leather has been examined in detail and since material awaiting study will certainly both amplify and alter the impression gained so far, only a general introduction to the leatherwork will be offered here. Although for some contexts the leather awaiting analysis is likely to be 'more of the same' (in particular as far as the two ditches are concerned), quite marked differences are noticeable between the earlier room contexts. Even in the ditches, the find composition seemed to change year by year, as the excavations progressed northwards. Thus any interpretations of buildings or the activities carried on in them would, at the moment, be premature, and is likely to be radically altered by the finds from adjacent rooms. As it is, the amount of leather recovered is so large and the appearance of new or better preserved items so frequent that the study of the leather involved an almost continual process of re-assessment of previous finds. The feeling that what is now a puzzle is bound to be solved by finds still tantalisingly packed away and awaiting study means that relatively little time has been invested in an overall view or in analytical detail: there is little point in working out the percentages in which particular hems or seams are present in each period when only half of the available material has yet been recorded.

The leather is generally well preserved and the conservation method employed by the Vindolanda Trust has materially assisted in the interpretation of weathering and stress marks: slight differences in colour and surface texture proved to be of great importance to the assembly and reconstruction of Tent I (van Driel-Murray 1990b, III). Burial itself does not seem to have affected the leather very much. Of more importance is the condition in which it entered the soil. Footwear in particular is severely worn, sweat has deformed the soles (clear
imprints of the foot are often visible) and has adversely affected the insides of the uppers as well. Strapwork has become hard and brittle, while the leather of closed uppers has often split at the junction of grain/flesh sides and the inner side is badly decayed or even missing altogether. Footwear from the first four periods seems to have been sealed and waterlogged quite rapidly after being discarded and is in markedly better condition (except for 'original' wear) than the footwear from the two later ditches (outer ditch, Period VI and inner ditch, Period VII/VIII), some of which seems to have lain unburied for a while before being covered and sealed from the air. In general uppers have shrunk more than soles, partially due to wear which has deformed the leather and the thinness of the remaining split. In contrast, the goatskin tent panels are frequently so well preserved that stitch holes and slight impressions on adjoining panels can be matched (these are some of the criteria for joining panels which have become separated) and sometimes a sheen, suggestive of polishing or oiling (for waterproofing or conditioning?), is even visible on the outer surface.

Post-extraction shrinkage of adjoining panels is minimal and the consistency of dimensions suggests that after some expansion by absorption of water in waterlogged conditions, conservation treatment has returned the panels to more or less the original size except where stress is severe or repairs have interrupted that natural tension of the skin fibres. Fibre tension does seem to be one of the major factors influencing the extent of shrinkage. Complete panels tend to shrink less than smaller fragments or delaminated splits. This may be why many measurements conducted on smaller pieces or off cuts show relatively high values of shrinkage during conservation. Panels torn or repaired before burial also seem to shrink more severely. The two sides of some of the ripped panels of Tent I have shrunk quite independently of one another, resulting in considerable deformation. Extreme weathering or wear seems also to affect the tension, apparently loosening and destroying the structure which then contracts far more sharply on treatment.

The size of the Vindolanda complex, its variety and its excellent preservation is remarkable enough, but of greater importance is, perhaps, the fact that the waterlogged contexts comprise a long sequence, particularly well dated in the early phases, and extending into the 4th century. Previous attempts to define the dating potential of footwear have been based on collections of disparate well-dated complexes, each, however, with its own geographical, social and economic parameters. Vindolanda offers an opportunity of following fashion development at a single relatively isolated site, which is, moreover, set in a well defined historical context with textual evidence enriching the economic and social background to the interpretation of the finds. Such detailed knowledge about the contexts does, however, bring with it additional problems of scale.
Most 1st and 2nd century leather complexes have been treated as single entities, dated in only general terms, without consideration of the formation processes concerned and undifferentiated as to whether to fort or vicus origin. Major sites in this category are Zwammerdam, Vechten (unpublished manuscripts), Mainz (Gopfrich 1986), Saalburg (Busch 1965), Newstead (Curle 1911) and Bar Hill (Robertson et al 1975). Though providing useful parallels, these sites are less suited for analyses of a social or economic nature. At Vindolanda, on the other hand, contexts can be differentiated and sources of variation can be identified, quite apart from the sequence through time. Besides the three well defined periods dendro. dated to before AD 103, factors such as changes in garrison and ethnic composition of that garrison, whether the area is inside (Period I-V) or outside (Period VI-VIII) the fort perimeter and thus relating to the military or the vicus inhabitants respectively, must also now be taken into account. The nature of the deposition processes must be examined closely for each period before any conclusions can be drawn regarding the significance of finds, their location and, indeed, of the absence of items which might otherwise have been expected.

Since leather cannot survive on the surface for any length of time, the finds will generally relate to the activities immediately preceding the construction of the sealing deposit. In the short-lived successions of the earlier phases this may not be a problem, but for Period V and later, the date of the leather will relate rather to the succeeding feature than to either the construction or use of the context itself. Similarly, ditches will fill with rubbish only when they have gone out of use. The sequence of leather is, therefore, not continuous, and several major gaps occur, due mainly to the reduction of building activities after the end of the 2nd century. Aspects of dating are treated in more detail below, (footwear).

The character of the finds is also determined by the processes leading to deposition. In the first four periods the leather is incorporated in demolition and back-fill deposits used to prepare the area for subsequent constructions. At the close of Periods II, III and IV, equipment seems to have been rigorously sorted and refurbished; rejected items, pieces removed for repair and useless pieces cut from recycled material were simply dumped where the work was concentrated. In this, the situation is similar to that at Valkenburg (Groenman-van Waateringe 1967) a site which, despite its much earlier date, provides one of the few clearly circumscribed, military leather complexes from within a fort area that is directly comparable to Periods II-IV at Vindolanda. Also comparable is a leather complex from Castleford, only a little earlier in date than Vindolanda Period II (unpublished manuscript). At all three sites, the withdrawal of the garrison was preceded by careful inspection of equipment and wholesale dumping of material not up to scratch. At both Vindolanda and
Valkenburg anything not virtually perfect was either thrown out or cut up for re-use. At Valkenburg discarded equipment was left where it had been sorted, outside the small fabricae attached to the barrack blocks (van Driel-Murray, 1985, fig. 5), while at Vindolanda much of the sorting and refurbishment seems to have taken place in the praetorium. It will be interesting to see whether the character of the leather finds from these levels alters as barracks or the principia blocks are excavated in future seasons.

Clearly, when a garrison was preparing to withdraw there was no need to cart rubbish out of the fort as would have happened under normal circumstances. At Vindolanda the abandoned heaps of refuse were levelled out by demolition crews, resulting in the separation of items and the spreading of pieces belonging together across several of the demolished rooms (eg in Period III, the chamfrons and chamfron off cuts in rooms 6a, 11 and 12, the breastband 419 + 96 in rooms 2 and 6A, the strap 657 + 731 in rooms 5 and 8: tent panels 1128+1200+1547 in Period II rooms F, G, H and I, 900+1661 in Period IV rooms 4 and 15). Matching pairs of shoes were also spread apart. All this entails time consuming sorting and matching in order to reconstitute original assemblages. The effort is, however, well worthwhile in terms of the information retrieved, since the purpose of a leather catalogue must be to reconstruct and interpret functional equipment in a cultural context. Lists of unexplained hems and seams may, at this stage of what is still a very young branch of research, be unavoidable, but if they are presented correctly, future identification should still be possible. Reconstituting former associations is one step in the interpretation of the whole and allows less well preserved pieces to be positioned by analogy. More complete leather objects from Vindolanda have already shown that these analogies are not always correct, but at least previous work can be reinterpreted in the light of new finds. The distribution of tent panels from the association 1200 over several rooms (Tent II, see below) means that there is some hope of eventually assembling the complete gable end of this tent. In the case of footwear, the presence of pairs gives some idea of the completeness of the context as a whole and whether refuse has been transported. The number of pairs in Period III deposits, when compared to the ditches, suggests a relatively intact complex and this, in turn, gives an insight into the number and character of the individuals responsible for the deposition of the material (see below. Though the- deposits were spread out by the levelling process, marked concentrations evident in certain groups of finds suggests that they do to some extent reflect the activities in the building concerned. Redeposed or transported refuse would probably give a more homogenous pattern while pairs of shoes might be expected to become more widely separated than is actually the case (fig. 4). Furthermore, the marked clustering of the evidence for chamfron manufacture in Period III (in room II, with offcuts thrown into the yard 6, fig. 8), and for the location of women and children in
Period IV also points to more or less in situ deposits. A complicating factor is, however, the course of the later ditches, which have removed large areas of the earlier deposits. Occasionally earlier material was dug out and redeposited in the ditch berms, or left in the recut ditch bottoms which remained wet enough to preserve the leather. However, the considerable difference in date ensures that intrusive or upcast shoes at least can be picked out relatively easily from the ditch fills.

**Stitching**

The scheme of hems, seams and stitching established by Groenman-van Waateringe 1967, fig. 6, is adopted here, with some emendations (fig. 3). Because several associations of two or more panels occur amongst the finds from Vindolanda it has been possible to add to the known range of Roman hem and seam types. For instance, the tent association 1016 (p.24, Tent I) confirmed the existence of two seam types which had previously, in the absence of a clear association between the two matching sides, always been regarded as hems. As the distinction between hems (finished edges) and seams (joining edges) is crucial to the interpretation of the position and function of the leather panels, the recognition of these seams requires the re-interpretation of previously published complexes. Fortunately, the method of publication of several important leather complexes is such that retrospective identification is possible and the new seams can now be seen also to be present in Valkenburg and Bonn (van Driel-Murray 1990b, notes 7, 16-18, 21 for examples). The use of different seam/hem combinations may be linked to specific purposes, though time factors might also be involved. It is, for instance, notable that seam II is characteristic of Valkenburg, dated to the mid-1st century, but in later complexes is increasingly replaced by seam III and the narrow reinforced seam (NR). Until the appearance of joining series of panels, the two sides of the NR seam had been regarded as two unassociated forms, one side a seam IIIa and the other a bound hem (IVa). Combinations of NR seams and 111b would appear to be characteristic of the wall/roof junction on tents, and it is possible that seam III was also favoured throughout the roof construction. As the tent walls carried less weight, the lighter NR seams could be employed there. There appears to be a correlation between seam III and hem IV on the one hand and NR seams and hem V on the other, but in the absence of a reconstructable association of the former group, the significance of the differences cannot be appreciated. A functional explanation seems the most likely.

Though none of the categories has been fully worked out, a brief introduction to the various groups of leather items follows. Footwear apart, the largest group is formed by the tentage, both as recognisable sheets and as cut up fragments, discarded in the quest for reusable material.
Other than tentage, there is very little with an overtly military character and the contrast with the directly comparable context at Valkenburg is quite marked. The total absence of shield covers is particularly striking and the suspicion arises that the refuse left in the praetorium area is by no means representative of the fort as a whole. In Period III, chamfrons were being made and/or refurbished there along with some other horse gear, and tents seem to have been collected there for inspection. For the rest, mixed domestic refuse would explain the odd purse or cover. The situation is similar to Period II, though here there is only evidence for the sorting out of tents in the excavated corner of the building. Tents may have been handed over to specialists for maintenance, while other, more personal equipment may have been reviewed near the barracks, as it was at Valkenburg (van Driel-Murray 1985, fig. 5). The absence of certain types of equipment is, therefore, not necessarily significant as it may, as in the present case, be a consequence of the function of the buildings from which the leather comes. Where contexts are less well defined, such distortions in the find composition are less easily identified and undue weight may be given to presence/absence of apparently significant items in the interpretation.

Despite the large area excavated, the immense quantity of leather retrieved so far, and the detailed knowledge about the functions of the buildings, it is clear that the finds cannot be considered as representative of the site as a whole and future discoveries will not only extend the
range of items but will also alter the entire perception of the material.

Fig 4. (left) Period IV plan, showing the spread of associated footwear.
I. Chamfrons

The most spectacular piece of leatherwork from Vindolanda is undoubtedly the complete horse frontal or chamfron from Period III (1345). It is made of thick, specially smoothed cow hide of excellent quality, with a goatskin lining at the back to prevent chafing the horse's skin. The edges were originally bound, a small piece of such an edging is present in L97. The entire surface was covered by patterns executed in round headed brass studs of various sizes in conjunction with brass plaques. Most of these decorations are now missing, though the impressions of the studs are clearly visible and the occasional shaft or bell cap remains at the back. Three of the plaques with massive cast Bacchus-head studs are still present: the fourth was roughly cut away (van Driel-Murray 1989). Subsequent to this discovery, similarly decorated fragments of leather were recognised amongst earlier finds while new pieces still emerged from the excavations. Though the leather from 1988-89 has not been analysed in detail, preliminary examination has identified only one chamfron fragment from the areas excavated at that time. There is, therefore a clear concentration of chamfron fragments in Period III, in the areas examined in 1985-1987 (fig. 8). Minor differences in size, position and decoration indicate that most fragments found so far can be considered as separate individuals, thus bringing the total of chamfrons discarded in this limited area to at least 7 and perhaps 8 (I- VIII).

Evidence that chamfrons were being manufactured within the fort is provided not only by the condition of the leather but also by the presence of off cuts (fig. 25, p.61). The linings had all been ripped in such a way as to retrieve the metal studs, while the hastily removed bacchus head probably served to make moulds for a new series. The rigorous cutting up of some of the chamfrons is also to be associated with manufacture, perhaps using old ones as patterns. More specifically, from these rooms comes a collection of off cuts of thick, prime quality cow hide with signs of polishing and smoothing. The shapes do not fit easily around soles or shoe uppers, but they do resemble the expected leftovers from cutting out a series of chamfrons, including the eye holes (fig 25). One of these offcuts bears an inscription in cursive script, impressed on dampened leather with a blunt instrument (see below fig. 27 , p.68). There is a small suspension hole at the top and marks of the teeth of a vice at the edge which could have been used to stretch the leather smooth while the exact shape was drawn on the hide. It would appear to be a label, to identify the owner for whom the chamfron was being made. As is the case with saddles, the chamfron would have to fit the horse perfectly to avoid chafing and such equipment must be individually measured out. The name was apparently written next to the chamfron right from the beginning, as the inscription is placed on the off cut immediately below the wide cheek flange. In this case, as Birley surmised, Veldedius is the owner, not the maker, of the equipment.
I Chamfrons (2)

Chamfrons I, 11, IV and VIII lay on the floor of Period III. The find circumstances of III and VI are less clear, as local floor subsidence makes differentiation between fill of Period III and floor of Period IV difficult in places. It is likely that they too belong to Period III as it is improbable that such a rare item should occur in exactly the same restricted area in two consecutive phases, separated by 10 years or more and from such widely differing structural contexts (*praetorium* and barracks). Two pieces certainly come from Period IV, but both are clog tops cut from old and already somewhat decayed chamfron fronting leather, possibly from the same one. It would seem that soldiers in the barracks of Period IV had access to chamfron leather, or came across it while digging their refuse pits, even if they did not use them for their horses. Since the contexts of Periods III and IV are not comparable, it is impossible to say whether such equipment continued in use.

The Vindolanda chamfrons are virtually identical to the two contemporary examples discovered in 1910 by Curle at Newstead. These still preserve most of their metal studs, though none of the larger fittings, and give a good impression of the splendour of these frontals when new. That they remained unique until 1985 suggests a more than fortuitous link between the two sites. In contrast to the Vindolanda specimens, there was no attempt to salvage the smaller metal fittings from the Newstead chamfrons, which makes it unlikely that they were being manufactured there. As the chamfron would be individually made, it still preserves the proportions of the head of the horse it was intended for. It has already been noted that the complete chamfron does not fit the modern ponies which are regarded as resembling Roman cavalry horses (van Driel-Murray 1989, 283) and this has been confirmed by subsequent reconstructions and experiments (Junkelmann 1989; Hyland 1990). However, the chamfron did fit correctly on the relatively narrow and finely proportioned horse skulls available from the excavation, which led to the supposition that withers height alone is not sufficient to characterise ancient horse breeds. That the whole conformation of the skeletal structure should be taken into account was already obvious to J.C. Eward (in Curie 1911, 365) who remarked on the light and gracile build of some of the Newstead horses, attributing this to the introduction of Arab blood. Confirmation of an Arab connection comes from A. Hyland's recent attempts to fit a replica of the Vindolanda chamfron on various horses from her stud. Significantly, the best fit was on a pure bred Arab mare of 15.1 hands (155cms), with the shaping over the nose, cheeks and ears corresponding exactly to that of the original when tried on the Roman horse skulls.

The chamfrons are clearly a very special type of equipment, restricted in locality and apparently date. Evidently several were being made and repaired at the same time, which would seem to associate their use with a group of riders rather than a single individual. The location within the *praetorium* and the label referring to
the governor's groom is perhaps suggestive, but in the absence of leather from contemporary barracks or fabrica, not entirely conclusive. However, the absence of chamfrons from the Period II praetorium would seem to exclude a direct link with either the prefect or the Batavians, and leaves the Governor's grooms as the best candidates. Whatever the case, the size and proportions of both the Vindolanda and Newstead chamfrons indicate that the cavalrymen of the chamfron owning class had better quality mounts, probably improved with the introduction of Arab blood.
Fig. 6. Chamfrons II-V
1. L97 and 2. L1628, scale 1:4
3. L149 and 4. L989, scale 1:2

Fig. 7. Chamfrons VI-VIII
1. L1105, 2. L2203 and 3. L1619, scale 1:2
Fig. 8. (left) The location of chamfrons and associated offcuts, in the Period III structure.
II. Horse Gear

Other than chamfrons, direct evidence for the presence of cavalry units in any period is sparse: 5 fragments of saddles and some straps only tentatively identified as horse harness. Equally, few iron or bronze objects could be associated with horses. (See Vol. IV in this series, forthcoming, for headstalls).

The leather saddle casing 641 has, however, played an important role in the reconstruction of the Roman cavalry saddle primarily because careful conservation preserved the marks of wear and stress which provided conclusive proof for the use of a rigid wood saddle-tree (Connolly 1987; van Driel-Murray 1989; Connolly & van Driel-Murray 1991). No amount of padding could have produced these stress lines around the horn and crest, as comparison of modern replicas made to different specifications attests (Junkelmann 1989, Abb. 23-25). The two horn facings (340, 507) are both from the front position and both are similar to examples from Carlisle (Winterbottom 1989, fig. 2) with slits at the base and stitching of covering reinforcements over the entire horn top. The flat section of 507 suggests a less rounded horn than that reconstructed with the metal reinforcements and may indicate -as has been suspected on other grounds - that the metal horns were not necessarily used in conjunction with leather saddle casings. A fragmentary horn facing (882) and a strip torn from the front edge of the saddle casing (1441) complete the evidence for saddles.

From Period III comes a fringed strip of leather which has been speculatively identified as a breast band (van Driel-Murray 1989, 282). Two further fragments of the same piece have since been identified (418 + 96, 1608). Traces of stitching and the fact that it was worthwhile to cut the fringe away suggest it may have belonged to some larger breast cover or barding.

Find 665 appears to be a leather version of a metal strap junction, although the straps are arranged in a cross, and not at an angle as is usual with phaerae. It consists of four straps secured between 5 layers of leather, the whole being firmly thonged together. The heavy construction suggest traction rather than riding harness and some connection with the yoke may be implied by the curve in strap A, which looks as though it had been passed over a metal bar (Raepsaet 1982).

There are various straps which might be associated with harnessing, for instance 657 which had sewn-on tabs for an adjustable buckle fastening. The remaining tab (731 a) was lined (731 b) and faced in the opposite direction to the strap tongue: this and the evidence of the thread impressions suggests that this is only part of a composite piece, incorporating several layers of leather or webbing. There is no particular reason to include straps like 52 or 899 with harnessing, save that such items are to be expected. It is also possible that some of the large knots (see below) belong to harness, but
more detailed analysis of find locations will be necessary before such items can be ascribed a function on the basis of association with other, more obvious pieces of equipment. Yet again the absence of any straps which could definitely belong to girth, headstalls, reins and yoking is remarkable. It has been noted before that the only explanation for this curious lack on Roman sites in general would seem to be the use of oiled (not tanned) leathers, which do not survive waterlogging. However, the composite strap 657 raises the possibility that webbing or woven bands were used for harnessing instead of leather.

**Catalogue of horse equipment**

**Chamfrons**

I 1345 (period III, II) Complete cow hide chamfron with goatskin lining in part remaining. For description and discussion see van Driel-Murray 1989, 283-292, (fig. 5).

II 97 (Period III, 6A) Strip cut from the brow of a cow hide chamfron as I, preserving impressed guide lines and associated with off cuts from manufacture. A small piece of the goatskin edge binding also remains, (fig. 6, no.1).

III 1628 (probably Period III, II) Double chamfron lining ripped from front leather, impressions of washers and the bent-over tails of the small studs (look like continuous thread impressions). Decoration as I. 5 slits in the poll piece could be used to secure the chamfron to the bridle, but could also be used to attach a neck guard (crinet). (fig. 6 no.2).

IV 149 (period 111, 6A) Top flange cut from a cow hide chamfron as I, with two fastening slits. Bound edges and impressions of stud heads. Leather 3mm thick. (fig. 6. no.3).

V 989 (period IV, 5) Cow hide clog or slipper top cut out of an old chamfron. Leather spilt and delaminated, especially along the stud impressions. The condition of the leather is suggestive of the reuse of old and damaged material. (fig. 6. no.4).

VI 1105 (Period III or IV, room II or 4) Cut and torn piece of coarse goatskin chamfron backing leather incorporating part of the skin edge with holes of stud decoration but only impressions of washers on the grain side. Not of the tails of the studs as on chamfron I. Cheek curve with section of both eye and ear hole present. Not belonging to 1628, (fig. 7. no.1).

VII 2203 (Period IV, 8) Cow hide clog or slipper top cut out of an old chamfron. Possibly the same one as V. The usual point at the instep of clog tops makes use of the chamfron eye hole. Leather worn. Studs no longer present when reused. (fig. 7. no.2).
VIII 1619 (Period III. 12) Tom lining. hair-sheep skin. cheek flange. not belonging to any of the other specimens. Usual stud pattern with impressions of bell caps but not of 'tails'. Slight chaffing around the eye hole may reveal the use of a metal eye guard. the only chamfron to do so. How it was fixed is unclear. the chaffing occurs on the outside surface and there are no nail holes. so it may just have been wedged in. the natural flexibility of the leather holding it in place, (fig. 7. no.3).

Saddles

641 (Period II. C or Period III. 6A) Front of a saddle casing of goatskin, preserving the dart with stitching of reinforcement patches to either side (faint thread impressions on grain side only at inner stitching). one of the horns and the side and bottom edge of the casing. The edges of the dart are folded back (thread impressions on the outer side only. impressions of a beading strip on inner. folded side). leaving a small tab with a nail hole used in the preliminary securing of the leather to the frame. Horn is edged with seam I (plain seam) which extends a little way down the side. The rest of the side is wider and is folded back and stitched (hem V. thread impressions visible on both sides of the fold). Stitching along bottom edge has continuous thread impression on flesh -lap seam or seam I? The cover is severely deformed and tom along marked stress lines which coincide with the curves of the wooden frame. The 5 remaining crescentic slits with their covering flap occur right on the edge of the saddle thus reconstructed. One or both of the horn facings may belong to this cover. (fig. 9, no.1 and Plate III).

1441 (Period II. N) Strip tom from front of a saddle with stitched edge and two or three crescentic slits remaining, (fig. 9. no.2).

507 (period III. 5). Front left saddle horn cover with stitching of reinforcements over the top. around the two slits in the wide base and at the junction of the projecting horn with the dart of the main saddle cover (641). Plain seam around the

Plate III: Saddle casing L641, and fig 9.
projecting tongue. With some kind of bound and beaded seam around the curved bottom. The top is severely worn and deformed by pressure of use. The coarse tacking indicated the attachment of a repair over the scuffed area. Possibly fits to 641. (fig. 10, no.2).

340  (Period IV, 10) Front right saddle horn cover made of two thicknesses of leather, the outer worn but apparently cow hide, the inner goatskin, stitching of reinforcement similar to 507, but a single angular slit occurs at the bottom. Plain seam along the projection, bottom edge shows impressions of what is perhaps a beading strip on both front and back. The top edges are sharply curved back, giving a flat section to the horn front: any padding must have been at the back. The outer surface is scuffed and damaged at the point where the horn facing curves under the padded frame and the top is slightly deformed and flattened, (fig. 10 nos. I a & I b ).

882  (Period III, 10) Scrap of a front saddle horn cover with stitched edges and parallel stitching of an applique (fig. 10, no.3).

Breastband and fringes

418+96  (Period III, 2 and 6A) Fringed goatskin strip, with roundels separating trilobed pendants, cut and torn along stitching at the top but with a narrow tab at the end suggestive of a fastening at this point, (fig. II, no. 1).

1608  (Period IV, 15) Trilobe fringe, similar to 418, but slightly larger (not illustrated).

1356  (Period III, 11) Leather fringe secured by a brass stud - could this belong to a chamfron? In size the stud corresponds to those along the nose of chamfron I, though a series of fringes must surely have been uncomfortable for the horse, (fig. II, no.4).

Straps

657  (Period III, 5) Tongued strap, with three separate tabs, one of which remains (731), sewn to grain side, but as the thread impressions on the flesh are extremely faint the strap may have been attached to other layers forming the reinforced end to a girth made of webbing. The edges are bound and a rib is visible on the grain where the tongue narrows, possibly indicating the resting point of a metal buckle, (fig. II, no.2).

731  (Period III, 8) Rectangular tab with lining, matching the stitching on the tongue of 657 and so placed that the narrow strip points in the opposite direction to the rounded end of 657, (fig. II, no.3).

899  (Period III, 4) Thick cow hide belt or strap, 54 cms long, one end of which is slit. The other end is folded and secured by crossing lines of stitching, the tip is cut to a point and there are two holes
punched through the three thicknesses (not illustrated).

1369 (period II, F/G) Thick cow hide belt or strap, 31 cms long, cut or skived down at one end. The other end is folded and secured by crossing lines of stitching, the tip is cut to a point as 899. Impressions of two circular metal studs on the outside and traces of metal corrosion are suggestive of split pins (not illustrated).

665 (Period III, 9) Strap junction of thick cow hide consisting of 4 straps, each with a large, roughly cut hole at the end and two slits probably for metal studs. The straps are secured in a cross between 5 notched discs of leather (2 at the front, 3 at the back) thonged together. The front disc has two intersecting impressed crosses on the outer surface. Strap A (opposite the notch) curves as though over a metal bar just where it emerges from the discs, (fig. 12).

52. (Period II, C) Thick cow hide strip, 21 cms of which are widened, folded double and stitched (saddle stitch) to form an oval sectioned casing, flattened and thonged at the end. The remaining 32 cms is a narrower single thickness strip, decorated on the grain side by roughly applied crescentic punches, sometimes overstruck, the end of which is constricted and thonged, possibly fitting into the other end. The curved shape of the casing is clearly original, if the two ends were joined this would make a circular or D-shaped strap, one side apparently enclosing a rigid object (metal?), the other side presumably visible and serving to link the curved object. Could this be a yoke attachment? (not illustrated).

1301 (Stone Fort I) Stitched strap composed of goatskin folded around a narrow strip and stitched through all three thicknesses. Such reinforced stitched straps are common in modern and medieval harnessing (not illustrated).
Fig 9. Saddle Casing
1. L614 and 2. L1441, scale 1:2

Fig 10. Saddle Horns
1a and 1b. L340, 2. L507 and 3. L882, scale 1:2
Fig 11. Horse Equipment
1. L418 + 96, scale 1:4
2. L657, 3. L731 and 4. L1356, scale 1:2

Fig 12. Strap Junction (L665), possibly for traction purposes, scale 1:3
III. Tentage

Although many sites have produced rectangular panels belonging to leather tents, Vindolanda is unique in that a number of associations between panels have been preserved. Two groups in particular (1016, Period IV and 1200, Period 11) have resulted in a new reconstruction of the Roman army tent which, for the first time is based on surviving associations of whole series of panels, rather than on hypothetical arrangements of loose ones (fig. 13). The description of the panels and the methods employed to arrive at the reconstruction have been treated in some detail elsewhere (van Driel-Murray 1990a, 1990b), and here only the more general implications for the rest of the leather complex will be examined.

Find no.1016 (Period IV, Tent 1) is an association of 14 panels which fit to form the corner of a tent, preserving just over half the side wall, a section of the gable end and the bottom corner of the roof (fig. 14). The importance of the association lies in the fact that it preserves the full height of the tent wall as well as the angle of the roof, both subjects of dissent in previous attempts at reconstruction. The tent can now be seen to possess a wall of 95 cms and a roof angle of c 120 degrees, which results in about 185 cms head room at the ridge. Two major problems remain: the guy ropes and the form of the doorway. The gable association 1200 (Period 11, Tent 11) provides the solution to the doorway, showing it to be composed of two overlapping flaps, joined only right at the top by a heavily reinforced patch (fig. 15). This has been found to work well in modern replicas constructed on the basis of the Vindolanda finds. Similar gable ends and doorways can now be recognised amongst previously published finds and examples are to be found in Bonn, Valkenburg and Papcastle, all displaying the approx. 60 degree roof angle.

Matching dimensions and leather quality has now added several more sheets to the 1200 gable, including the missing top triangle and one of the bottom door panels which is hemmed both along the side and along the bottom. Though this might be expected, there is no corner reinforcement at the bottom. Five more panels have the diagonal bound edges of the gable top, but none can be directly related to either of the tents. The exact number of sheets used to construct the gable, cannot therefore yet be established, and the width of the tent in the reconstruction drawings is still based on the account of Hyginus.

Some kind of support for the tent is essential but no direct evidence is forthcoming from the leather itself. Experimental and reconstruction work plays an important part in this discussion: much has been learnt from Dr. M Junkelmann's tent reconstructions and new insights are yet to be tested in the tent at present being constructed by the Ermine Street Guard.

Hyginus gives the size of the contubernium tent as 10 x 10 Roman feet. For a tent of this size, with a wall of 95 cms and a roof angle of 60 degrees, the guy ropes would
have to extend 5 Roman feet on each side if the leather was to be suspended from the three roof poles generally envisaged as the only support. This is obviously impossible, particularly as the plans of early forts can be shown to employ the 12 x 12 space allotment described by Hyginus. Consequently, some other solution must be sought. On balance, the Vindolanda tent was probably draped over a frame with ridge and eaves poles: the obvious sag in the gable panels would seem to exclude the use of diagonal braces at the gable ends. The weight of the leather would be sufficient to keep the frames in place without any struts being necessary and the guy ropes served to keep the leather in place rather than to hold it upright. This is consistent with the marks of stress and wear on the surviving panels. In particular, the effects of stress would have been much more pronounced on the guy rope attachments if they had served to support the structure. As it is, only the comer eyelets are severely stressed, as would be expected in the absence of a gable frame.

An interesting feature is the flap inserted at the wall/roof junction. Lying over the guy ropes, this flap would protect both the ropes, the attachment patches and, to some extent, the wall foot from the effects of rainwater. It is also noticeable that the major horizontal seams avoid falling on the supporting poles: this not only reduces stress on the seams, but also reduces the chance of leakage.

These two large associations allow many of the loose panels to be positioned by analogy. Two gable corner sheets are virtually identical to that of Tent I and at least two of the appropriate corner reinforcements occur loose in other find numbers. In addition, five complete sheets can now be assigned to the roof, though no large areas can yet be reconstructed. Numerous narrow flaps, sometimes with part of the roof and wall attached, also occur. Examples of these standard panels occur throughout the first five periods, with little discernable difference in treatment. Roof panels identical to that from Tent 11, for instance, appear in Periods 11, IV and V.

Particularly interesting and useful for the placing of loose sheets, is the system of standard modules used to construct the various panels. Though the dimensions might differ, the principal remains the same. The primary unit is the largest clean rectangle which can be extracted from a batch of goatskins with any consistency. In the case of Tent I this is 76 x 52 cms, for Tent 11, 65 x 43; bisected, this gives the panels along the wall foot and the starting row of the roof. Other rectangular, geometric divisions provided all the necessary panels with the minimum of wastage. Often a single cutting line supplies two panels within the basic shape. What leather is left is of regular shapes, easily utilised for seam reinforcements, bindings and patches.

Clearly, very little in the way of off cuts will remain as witness to tent manufacture and it will be considerably
more difficult to identify tent making locations than places where shoemakers were active.

It is noteworthy that, with three exceptions, the leather sheets used in Tent I are appreciably larger than any of the other tentage. The dimensions of Tent II are more reasonable and many of the completely preserved rectangles are more or less similar, though there are also a number of smaller sheets which do not fit easily in either scheme. Experimental work confirms the exceptional size of Tent I: Dr. M. Junkelmann was unable to obtain goatskins of this size for his reconstruction and had to make do with skins approaching the dimensions of Tent II - which had not, at that time, even been recognised amongst the leather. Though this might be taken as evidence that Tent I is in some way exceptional, the fact of its location - it lined a refuse pit dug from one of the barrack rooms and the fact that the principles of construction accord so well with material from both Britain and the Continent does suggest it was the normal contubernium tent. This is not, however, to deny the presence of alternative tent constructions.

Indeed, there is growing evidence from Vindolanda itself that more than one kind of tent was in use. It is not possible to offer any firm reconstructions yet, but there are some panels from a tent with a more steeply pitched roof (50-55 degrees). From Period II there are three associations and several loose panels which differ considerably from the expected pattern. Three of the four complete panels of this group are equal in size to the sheets used for Tent I (c 15 x 52 cms). The sheets join to form long lengths edged with a bound hem (not the more common folded hem, as used on Tents I and II), with patches sewn at the junction of each panel. These patches do not seem to have secured guy ropes or tabs, and may only have served to reinforce the edge of the junctions. This rather implies that the lengths should be arranged vertically, perhaps as doors, and in one or two cases this is feasible. For the two largest associations, however, either the grain direction of the leather or the seam arrangement is wrong for such a position. Indeed, the seams on 1503 are best compared to the central roof panels of Tent II. How these long lengths could be fitted to form a tent roof is as yet unclear, but box tents with separate wall and overhanging roof sections are feasible. If different tents are represented, these were evidently in use at the same time as the standard associations such as Tent II. It is interesting to note that similar long lengths of hemmed panels with reinforcing patches also occur at Valkenburg (Netherlands), which might point to an earlier form of tent construction. Analysis of the hem and seam combinations may lead to a better definition of the differences, thus giving an indication of the type of structures involved.

The vast majority of sheet leather recovered from Periods I-V is a product of the maintenance and repair of existing tentage. Even damaged panels which had to be replaced retained areas of still serviceable leather which could be
re-used for all manner of purposes. The bottom panels were particularly vulnerable to water damage and the smaller sheets used here may have been a deliberate attempt to simplify repair. Even a damaged full-sized panel would be capable of yielding a useful replacement. Repairs utilising salvaged leather were carried out, though only sparingly and there must have been a point after which repair was no longer viable, the whole tent being cannibalised instead. The point at which equipment was discarded clearly varied according to circumstance. In a permanent base the tents seem to have been maintained for as long as possible, but the selection of equipment for transport was more rigorous. An association of roof sheets (709, Period 111) had been extensively and repeatedly repaired. It must have done duty in N. Britain for many years, but in the preparations for departure not even 667, a near perfect sheet, was good enough to be packed up and both were discarded in the same operation. Why the large area of good leather was not salvaged is a mystery, perhaps they already had sufficient stock to cover the expected needs. Clearly, the equipment used on the march to Dacia was to be of the very best quality and in top condition.
Fig 13. Tent reconstruction

Fig. 14. Location of the panels of tent L1016
Fig. 15. The gable reconstruction of tent L1200
**IV. Footwear**

As the analysis of the footwear has only just commenced and less than half of the *praetorium* area has been examined in detail, this can be no more than a preliminary review. Quantification of footwear categories, comparisons between the find composition of the separate Periods, the distribution of particular footwear types or sizes across the site are all aspects which have yet to be considered.

From Period I to IV, footwear occurs in almost equal quantities to general equipment, while from Period V on, footwear dominates absolutely. This is a very general tendency elsewhere, but it is unclear whether it reflects an actual decline in the use of leather for equipment by the army, or whether it is a consequence of the increasingly civilian nature of the complexes. Definitely military situations fort interiors such as Valkenburg, Carlisle, Vindolanda Periods I-IV, *fabricae* such as Castleford and the Bonner Berg - all produce quantities of leather equipment, while contexts outside the forts, such as the *vici* of Valkenburg, the Saalburg, Vindolanda VI-VIII or the mixed *vicus/fort* refuse from Zwammerdam and Vechten are dominated by footwear. Though changing patterns of use may be a factor, the fact that the large, wide and rather shapeless soles of Period I are closer to those of Period II (Plate VII. 1616), and, indeed to the earlier material from Castleford, than to the more densely nailed and shapely soles of Period IV, which implies that the factor time is more important in determining shoe fashion than unit time.

A large proportion of non-footwear would, therefore, seem to be a characteristic of military contexts, and may perhaps be used as a measure of the contribution of the respective populations to the find complex.

A few general remarks can be made on the footwear of each period but as new material is bound to alter the picture in detail, 'trade names' are used for characteristic styles in anticipation of a more logical typology. Well preserved shoes have been chosen for the illustrations, regardless of whether they actually belong to the period being described.

The amount of footwear assignable to Period I is at present too small for any characterisation or for any differences with the following period to be noticeable. Because both dating and the units concerned are known, Periods I-IV offer interesting possibilities for comparison, with developments through time being weighed against unit-specific tendencies. On the very limited evidence at present available, the large, wide and rather shapeless soles of Period I are closer to those of Period II (Plate VII. 1616), and, indeed to the earlier material from Castleford, than to the more densely nailed and shapely soles of Period IV, which implies that the factor time is more important in determining shoe fashion than unit time.
Plate IV Top, left to right: L910 and 1123, typical ‘Fell’ boots.
Bottom, left to right: LK 100 (‘Ramshaw’) and 2598
Period II is considerably better represented. Already the full variety of Roman footwear technology is in use: nailed construction with several styles of uppers, sewn construction unfortunately without surviving uppers, single piece shoes termed carbatinae for convenience, (cf. fig. 16, no.4. 1660), sandals, wooden clogs and a single caliga-like boot. It is curious that even in this phase there are no examples of the typical military boot familiar from Mainz, Valkenburg and Castleford, particularly as the later is securely dated to between 80-85. At Vindolanda, no more than a decade later, the caligae seem to have been superseded by closed boots, which, in view of the range of sizes were of types also shared by the civilians. Such boots would have had distinct advantages for cold and wet climates, and may also have been easier to make, though the early examples do exhibit a number of weaknesses, with uppers often working loose.

Four shoes apparently show a development from the caliga to an ankle-strap sandal which is also known at the legionary site at the Bonner Berg (van Driel-Murray & Gechter 1983, nos. 6, 7) and, furthermore is depicted on contemporary foot lamps. Earlier forms, with even lighter strapwork occur amongst the military footwear from Mainz (Gopfrich 1986) and these should perhaps be seen as a separate type of sandal, not as a true caliga with its close set strapwork closing firmly around the ankle joint and foot. The contrast with the footwear from Castleford is marked: there are only a few soles nailed in a similar, rather sparse fashion and the uppers are totally different. Castleford's parallels lie on the Continent, not with Vindolanda, a site only a few miles up the same road to the North and only a decade or two later. If such differences are part of a general pattern of changes to the supply system, these changes must have taken place very rapidly, right at the end of the century.

Period III preserves very much more material, a mixture of worn out refuse and still relatively serviceable footwear which was, presumably, just not good enough to warrant packing up. The mixture might indicate that this is not exclusively a once-off deposit, but that accumulated rubbish was also spread over the area. The deposit is notable for the amount of well preserved footwear belonging to women and children, including several fine carbatinae. This type of footwear is obviously well suited to the growing feet of small children, but two examples belong to a large, adult foot. At this date, sandals seem to be reserved for women and girls. In contrast to the other periods, the footwear from Period III exhibits several distinctive 'feet' and a degree of clustering in the smaller sizes which might represent actual individuals (see below). The majority of footwear employs the nailed construction with round-nosed soles a little more shapely than in Period II. Uppers, usually of cow or calf leather are cut separately, and are sewn to, or braced over, the insole unit. One or more complete
middle soles may be thonged to the insole, perhaps an early characteristic, as it seems to be replaced by the use of two laminae after Period V. The footwear is serviceable, reaching up to or above the ankle and closed up the front. The most common type, 'The Fell' boot (fig. 17, no.1) is remarkably akin to recent military boots. In fact, the cutting pattern is virtually the same for all styles, with variation being introduced by means of altering the size and shape of the lace holes, the addition of decorative openwork (the Croglin Plate VIIa. 1600) or even the removal of larger areas to make lacy strapwork reminiscent of the caligae (The' Allendale', fig. 18, no.1). Even the elaborate openwork 'fishnet' shoes adhere to the basic pattern ('The Balmoral' see Plate VIIb. 1506). These appear with the high status inhabitants of the praetorium in Periods II and III only. Though the style remained fashionable for some time (cf. Bar Hill, Robertson et al. 1975, fig. 23, 30-31; the Saatburg, Busch 1965, nos 220, 221, 262-4), only one fragment appears in the barracks of Period IV; it is hardly to be expected that the common soldiers appeared in such footwear. The stamped or sometimes even hand-cut designs would obviously look better on a coloured background and it is interesting that two of the Vindolanda examples show clear evidence for a sewn-in lining of cloth. Though they do occur in children's sizes (and these will tend to be over represented because they survive better and are more likely to be recovered intact) the 'Balmoral' is particularly common in larger sizes, leading to the suspicion that it was favoured by males of status. Indeed, unless women wore shortish skirts they would have been little point in them sporting such elaborate shoes. For the designs such as on 1506 to be effective, we must also suppose that these officers wore coloured socks. That a status shoe is involved is perhaps confirmed by the fact that the only examples of fishnet uppers from the Saalburg (indeed, considerably more elaborate than the Vindolanda examples) come from the few wells inside the fort, directly comparable to the situation at Vindolanda.

Wooden clogs are restricted to the early periods. They would have been useful for muddy terrain (over-shoes?) and also for the heated floors of the bath house. The leather strap is usually a makeshift affair, sometimes cut from an old boot upper (or a salvaged chamfron, cf. RIG.

Plate IV The Lucius Aebutius Thales slipper, probably the property of Sulpicia Lepidina.
6. 989), roughly nailed to the wooden sole. One or two are more elaborate and the wooden soles could be quite carefully made, with toes marked in, rather like contemporary sandals. Their declining use probably accompanies improved pathing, for late second century examples from the Saalburg show that they did not go out of fashion (Busch 1965, Taf.30) (Plates VIa&b).

Plate VIa A selection of wooden clogs from Period III.

The footwear of all Periods, but particularly the first four, is severely worn. The nail heads are worn down to the shafts. occasionally the soles are renailed and used until these too are worn away. but usually the unprotected sole is used until all the nails have fallen out and the leather is worn flat and featureless (Plate VIII. 1616). The outer sole may be worn right through and the person continued to walk on the lasting margins. and. eventually.

Plate VIb A selection of wooden clogs from Period IV

even the insole. by which time the whole construction begins to come apart. Despite this condition. patches might be thonged over the sole and upper to hold them together a bit longer. The most extreme case is no. 1357 (Period III. Plate VIII). where the back seems to have been removed completely and replaced as the front half was still considered to be serviceable. A new outer sole was added over the two halves. but even this wore through. and the state of the lasting margins and the exposed insole reveals just how long this boot was in service. Notwithstanding the quite extensive evidence for shoe manufacture in the fort at this time (see below, off cuts) it would seem that the Viodolanda garrison had to be extremely sparing of its footwear. This parsimony contrasts markedly with the Rhine forts, where repairs are
seldom and shoes seem to be discarded as a matter of course once the nails began to make the insole feel bumpy. Although not quite so desperate, the Period VI/VI inhabitants still wore their shoes to the limit. This may illustrate the problems of supply along a relatively difficult and isolated stretch of frontier in comparison with the Rhine forts which were better served by river transport.

What is surprising is that the thin lacy strapwork of the Allendale boots (the apparent successors to the *caligae*) survived this treatment well (fig. 18, no. 1). Only occasionally are loops replaced, or sewn together after a split; in most cases they outlived both the nails and the sole. As with the *caligae*, the distribution of stress over the foot was presumably so well arranged that no single strap is overburdened. Subsequent decay of the most stressed area (instep and heel seat) has caused the uppers to disintegrate while sweat seems to have hardened the leather, making these shoes particularly difficult to draw or reconstruct.

Soles of Period IV are similar to those of III, relatively naturally shaped and round nosed but the huge wide shapeless soles of I and II have gone entirely. Uppers are generally the same as Period III, the change of status possibly explaining the lack of fishnet openwork, though 'lacy' strapwork boots are well represented. In this period, boots display a marked asymmetry in the line of the front fastening. Instead of closing up the centre of the foot as our shoes do, the shoes fasten along the line of the big toe. Consequently the outside foot part of the upper is considerably wider than the inside foot and with openwork uppers, the effect over coloured socks must have been quite attractive. An unstratified fragment is particularly elaborate (BL7, fig. 18, no.3). The tendency for off centre fastenings is already apparent in Period III, but is much less pronounced and it has not been noted to this extent in Continental material.

In Period IV, the distribution of pairs or fragments belonging to the same shoe strengthens the supposition that the finds do indeed reflect the nature of the occupation of the barracks (fig. 4). The slight separation of the shoes or their components seems to exclude major transport of secondary material for levelling purposes. Though the footwear apart, it still preserves the generally north-eastern direction of demolition.

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Period V presents a mixed appearance, with most shoes following on from the previous types but with a clearly later component in areas excavated in 1985 and part of 1986, with the pointed soles and broader sandals typical of the Stone Fort I Ditch fill, along with uppers which can at present be best paralleled at Welzbeim (Germany, Planck 1979, dendro. dated to c200/220). Interestingly, this is the only place at Vindolanda where such uppers appear and it may therefore be the result of local disturbance. The size pattern of Period V also corresponds more closely to the later vicus pattern. It may be surmised that some areas were levelled off for building at a later date than the others and vicus rubbish became incorporated in the fill of the abandoned structures.

Quite a radical change occurs in the vicus-related contexts of the fill of the two major stone fort ditches and is indicative of a considerable gap in deposition between the closely linked Period I-IV sequence and these later deposits. The earliest impressions of the footwear had already suggested as much, for the absence of the highly characteristic 'Antonine Wall' group of footwear is particularly startling. But for a handful of examples, the latchet and bar shoes, as well as the rosette-decorated lace holes so typical of sites such as Bar Hill, Balmuildy, Newstead and Rough Castle are absent, even in derivative form. Considering the quantity of leather retrieved from Vindolanda when compared to the other sites, the lack is highly significant and can only mean that the entire fashion spectrum of c.140-60 is missing from the sequence. This is, indeed, what would be expected on current interpretations of the movement of garrisons from Hadrian's Wall up to the Antonine Wall at this period (Hanson & Maxwell 1983, 143).

Dating footwear from the ditches is problematical since both can be regarded as secondary contexts filled with dumped refuse. While in use, the ditches would be kept relatively clean and the majority of leatherwork must belong to the final phase: deliberate fill in the case of the Stone Fort I Ditch (Period VI) and more gradual silting up, Interpersed with attempts at cleaning, in the case of the Inner Ditch (Period VII/VIII). In both ditches, however, the material in the fill will, for the most part, relate to the final stages of use. The situation is comparable to that of Period V: the footwear in the fill reflects what was being used by the people building the succeeding features.

The footwear from the Stone Fort I Ditch is relatively homogenous in character, reflecting a rapid, deliberate fill. Sandals suddenly become more common and are now also made in male sizes. The broadening of the front is already well advanced and the close-set thonging also contrasts with the earlier method of construction. The absence of the Antonine component unfortunately robs us of the opportunity of tracing the transition between the early sandals, natural in shape with indents marking the toes (fig. 16, no.7, 1541), seemingly used only by women, and the beginning of the fashion development
apparently linked to the adoption of sandals by men, which gradually widens and exaggerates the front of the sole (Plate VIII. 1281 and 860). The extreme width seems to have been reached by c. 240 (van Driel-Murray 1986a, MacConnoran 1987), but relatively few of these sandals appear from the Inner Ditch, where they might have been expected. On the other hand, several do occur amongst the pre-1976 finds so this again may be coincidence, linked to the differing course of dumping in particular stretches of the ditches. This does, however, emphasise the fact that the two ditches do not represent a continuous sequence of later footwear. None of the uppers familiar from Periods I-IV remain in the Stone Fort I Ditch spectrum, which instead is characterised by eyelet boots with integrally cut laces of a type common in very late 2nd-early 3rd century contexts in both Britain and the Continent (the 'Ramshaw', fig. 17, no.2, LK100,
unstratified). In contrast to the basic uniformity of footwear in the earlier periods there is now considerable diversity with several new types represented by only one or two specimens. Such diversity is also apparent in the pretty well contemporary Saalburg material (Busch 1965). In addition there is experimentation with cutting patterns and fastening methods, entirely closed shoes appear and a greater choice of footwear is clearly available, even in relatively remote settlements such as these. The increase of sewn soles is in part associated with the appearance of fashionable slippers with a raised sole. This could be made either of cork or of a padding of scrap leather: the characteristic butterfly-shaped tops were simply goatskin at Vindolanda, but at Welzheim doeskin was used, and from Egypt even gilded examples are known (fig. 17).
Soles of nailed footwear tend to be natural to pointed, and some fiercely pointed examples begin to appear, often in combination with nails arranged in tendril patterns. Such pointed, often markedly swayed, soles become considerably more common in the Inner Ditch, and it is noticeable that they tend to occur in the larger, male, sizes. It is in fact remarkable that almost all the exaggerated or elaborate styles of footwear seem to belong to men. The women's shoes tend to be more restrained, with soles more natural in shape except, apparently, towards the end of the second century when straight, very narrow soles became fashionable, for both sandals and cork slippers.

Contrary to what might be expected, the fill of the Inner Ditch displays few developments: 'Ramshaw' boots continue, as do pointed soles and broad sandals, but as mentioned above, the very wide sandals are relatively rare. The nailing on sandals is sometimes arranged in distinctive patterns (Plate VIII, 860), with a sprig (Plate VIII. 1281) or a trident being favoured motifs.

Except for a number of clearly later shoes, the picture is much as for the Stone Fort I Ditch. Some rather straight soles with a wide blunt shape seem to belong to the later 3rd century as do some new carbatina forms. Some particularly fine carbatinae with rich stamped and impressed decoration resemble footwear best known on the Continent from later contexts such as Deume (Braat 1973). This shoe type is regarded by Dr. M. Spiedel, (pers. comro. 1990) on a plausible combination of pictorial, linguistic and archaeological evidence, as the 'campagi militares', the only specifically military footwear since the abandonment of the caliga at the end of the 1st century. The shoe is a foot covering in only the most minimal sense, with the smallest of vamps (more a toe cap), a low quarter tied at the ankle and, most curiously of all, a thong passing under the foot, which passes out through slits cut at the side of the shoe and is tied over the instep (Plate IV. 2598). The contrast with the strong and practical footwear of earlier centuries could not be more marked. The latest footwear can only be recognised from parallels elsewhere and there is little indication of the time scale involved. Leather in the upper levels of the ditches tends to be less well preserved, but as the situation seems to improve northwards better definition of these later contexts may yet be possible. Although the finely preserved, well dated leather from the early periods is more attractive, the later material is in fact more rewarding since relatively little footwear from these periods is available from other sites and the course of development is far from clear. Despite its somewhat unprepossessing nature, the footwear does seem to provide a tool for the better definition of the elusive 3rd/4th century component in the Inner Ditch.
Plate VIIIa (left) Badly worn footwear, with some distinctive nailing patterns. Left to Right: L1616 and 1357.

Plate VIIIb (right) Badly worn footwear, with some distinctive nailing patterns. Left to Right: L319, 860 and 1281
Fig. 16. Carbatinae and footwear of the Cerialis household.

Fig. 17. 1. The ‘Fell’ boot and 2. The ‘Ramshaw’, scale 1:3 slide 47.
Fig. 18. ‘Allendale’ boots:
1. L1050, 2. L 1549, 3. BL7. Scale 1:3.

Fig. 19. Shoes with ‘fishnet’ uppers, all from the prefect’s household.
1. L1568, 2 L397 and sole 882, 3. L1520, scale 1:3
Sizes

Though it is a relatively crude method of registration, plotting footwear sizes is a useful tool in obtaining some indication of the composition of the population responsible for the deposited material. At sites lacking burials it will often form the only means of assessing the contribution of males, females, children and to some extent juveniles to the total, and in favoured cases can even approach the individual household. At Vindolanda the well dated and short lived periods permit a more detailed analysis and the knowledge of the changing functions of the buildings adds a further dimension. On the other hand, because the praetorium can be regarded as a somewhat exceptional context, extreme caution is necessary and definite conclusions can only be drawn when other areas of the fort become available for comparison. A further complication is that it is not certain that all the refuse in the levelling off of the various phases pertains directly to the occupants of the buildings and them alone.

Fig. 20 is based on the preliminary registration of about half the material so far excavated from the praetorium area. Only complete soles are included, with outer soles being reduced by the average difference in length between the insole and outer sole of the available complete bottom units in order to make them comparable to the insoles. Though the insole is the closest guide to size, it is not directly equivalent to foot length, as in the closed footwear some allowance has to be made for movement and expansion. Different styles, such as rounded or pointed toes will also affect the length of the sole. Analysis of the footwear is as yet in its early stages and no account has been taken of these factors, nor has any attempt been made to distinguish pairs or to include the incomplete soles in more general size groupings. Also belonging to the future is the identification of shoes belonging to particular individuals: anomalies in gait and clusters of soles similar in shape and proportion suggest that this may be feasible in the early periods. Much depends on the nature of the fill and whether it is to be regarded as a one-off deposit or as a slower accumulation. This is particularly important for children's shoes. A child's foot grows by c. 1½-2 sizes per year, so the size range between 17-23 in Period III and 20-26 in Period IV could represent either the growth of a single child over several years, or the one-off discard of several children's shoes at the withdrawal of the garrison. A hypothetical study is presented below.

Period I preserved insufficient footwear for meaningful presentation, but all the other periods are well represented, Periods II, III and IV particularly so in view of the short occupation phases concerned. Even so, curious shifts and gaps in the graphs indicate that they must still be treated with caution. For instance, Period IV appears to be systematically one size smaller than all the other periods (peak in male sizes 37, elsewhere 38: moving the graph up makes it closer to Period III). This
suggests either shrinkage (if these deposits were not sealed as quickly as others), or a systematic shift in the relationship foot size/sole size. This would in any case depend on the roominess of the upper, whether socks were worn or not or whether fashion dictated a tighter fit. The absence of size 40 in Periods II and V and of 33 in Period VI, despite a fairly even line in the graph at these points perhaps identifies an error in conversion to shoe sizes, but also perhaps serves to emphasise that even 130 soles are insufficiently representative of the total when longer periods are concerned.

Assuming that the shoes from the two ditches contain the refuse (dumped or accumulated) of the *vicus* inhabitants, these should form the basis for the identification of the male and female modal size distribution (Groenman-van Waateringe 1978). For both ditches the male peak in size lies at 38 (25/25.5 cms length), falling off very rapidly to 44, while the female peak lies at 35 (23/23.5 cms length) with an equally rapid fall-off into the larger sizes (hence most soles above 35 are male), but with a gradual tailing off into the smaller adults and juvenile sizes. Groenman-van Waateringe employed the modal distribution to differentiate the overlap between small male and large female shoes, but from the obviously male dominated distribution of Periods 11, III and IV it would seem that strictly modal curves do not work for archaeological populations which appear to have a slower and more hesitant build-up to the optimum size, resulting in an asymmetrical curve. This makes it well nigh impossible to establish the exact line between the male and female component and only vague indications can be given. However, the combination of the two in a normal (1:1) population should result in a continuum of girls to women with the continuum boys to men superimposed to exaggerate the peak at the female optimum, with purely male sizes at a lower level thereafter. This is exactly the pattern of the footwear from the two ditches as well as in the comparable *vicus* rmd complexes from the Saalburg and Zwammerdam (van Driel- Murray 1987 p.34).

Superimposing all the graphs, there is a strong impression that the dividing line between adult male and female can be laid at 34/35 with back projection of the fall-off at size 36 perhaps identifying growing youths/small men.

For Period 11 the pattern suggests that here all sizes above 34 belong to the normal distribution of males, leaving one female, a juvenile and two children behind. This is a not unexpected pattern for the occupants of the *praetorium*, which will have included the commander, his family and servants. The remaining predominantly adult male population accords well with the picture obtained from other first century forts such as Valkenburg and Vindonissa (van Driel-Murray 1987, fig. 2).

Periods III and IV again reveal a predominantly adult male pattern, though with considerably more women and children present, indicating a larger household (possibly Period III) or more households (possibly Period IV). The significance of these observations for the composition of
the population within the fort at this time will be pursued further in a future article.

Even allowing for the small number of measurable soles, Period V fits most comfortably with the later *vicus* groups with the lack of discrete size clusters suggesting general rubbish, lacking the individual character possibly present earlier. The generalised nature of the fill must call into question the exact relationship of other finds in the level to the function of the building itself. From the leather, it looks as though *vicus* refuse was used to level off an abandoned area of the fort. This would also explain the presence of material certainly later than the actual abandonment of Period V buildings: like parts of the Stone Fort I Ditch, fill may have progressed sporadically.

The slower accumulation of rubbish in the two ditches covers a longer period of time: curiously, the footwear from west of LXXVI in the Stone Fort I Ditch (Period VI) is predominantly male, while in all other areas of both ditches the sexes are fairly evenly balanced which suggests it was backfilled with rubbish of predominantly military origin. This would tend to support Birley's recent re-interpretation of the 'Vicus I' as in fact an annexe to the fort itself (Birley 1991). Closer analysis of the transects may clarify the dumping processes and the origin of the refuse. In both ditches, the tail-off of smaller male sizes compensates for the apparent over-representation of females in size 35. Children are well represented: in this the graphs resemble those from many Medieval towns (Groenman-van Waateringe 1984, Abb 37-38). Many children will have gone barefoot and it is noticeable that early medieval sites (Haithabu) have fewer children's shoes than later urban complexes (Amsterdam and especially Lubeck), indicating a link between children's shoes and general prosperity and comfort. On this basis Period VI does quite well.

**Hypothetical reconstruction**

Further speculation is attractive if dangerous. Though in the case of adults only general information regarding proportions of males to females can be gleaned, for children there is the possibility of assessing age groups as foot size is related to growth stages, which can be related to age on the criteria presented by Martin & Saller (1958). The children's shoes of Period III are few in number, and are distinctive, allowing individual typing, something which is difficult elsewhere on account of the large numbers of shoes involved. It is obvious that a foot will require a larger and roomier fitting with a nailed construction than with a soft, adjustable *carbatina* or an open sandal. Individual typing takes account of such features, which will often be ignored in simple measurement, and is useful on assessing the number of children present in small groups of footwear which are suspected on other grounds of belonging to individual families (cf. van Driel-Murray, unpublished report on the footwear from Welzheim).
Six quite distinct groups emerge from close comparison of the footwear from Period III.

1. The tiny nailed shoe with elaborate fishnet upper, which is merely a miniature version of the adult's shoes, with no concessions to size in construction or nailing. Foot c. 10 cms, which is well below what can be expected of a child which can actually stand. As such, it can hardly have been used, (L67) (fig. 16, no.3).

2. Four carbatinae, 2 a pair, cut to different designs but all for the same child with a foot of 13/13.5 cms, size 20. (431 (fig. 16, no.2), 1106, 635, 1594).

3. Two sewn soles (both left foot), a carbatina and a nailed sole for the same child, with a foot of c. 14/14.5 cms, size 21/22. (729 (fig. 16, no.8), 1026, 1660, 1598 (not illustrated).

4. A carbatina for a rather older child, foot c. 16 cms, size 24 (398) (fig. 16, no.1).

5. Five shoes, but not necessarily belonging to the same person, as some are rather more elegant in their proportion than others. Foot length 18.6, size 29. Three are for a child with a tendency to severe (and in comparison with other phases, unusual) scuffing and wear at the tip and the outer edges of the toes. In one case this has been crudely repaired. The fine fishnet uppers of two of the shoes contrasts to the repair and the rather clumsy sole shapes.

These five, perhaps six, individuals must represent the youngest members of the commander's household, at this time known to be Flavius Cerialis, his wife Lepidina and their 'sons', with associates and slaves of various ages and sexes. The uniquely tiny shoe may perhaps be discounted as the equivalent of a 'christening shoe', cherished by the mother, but the clustering of the others reveals a child of 2 (individual 2), one of 4/5 (individual 3), one of 5 (the only one to be represented by only a single shoe and perhaps disqualified on these grounds) and possibly 2 children between 7-10 years old. For a single family the spacing is demographically unlikely (although possible) and interpretation depends on whether we have the accumulated footwear of one or two growing children, or the immediate, most recent throw outs of a larger household with several children of more or less the same ages. In theory the family could have been in residence for three years or more and the presence of household slaves further complicates matters.
Lepidina must surely be the possessor of a group of narrow, elegantly proportioned soles with a foot of c. 21/22 cms, size 32/33. Amongst the enormous quantity of footwear from Vindolanda, the shape is highly distinctive. Only two other examples occur, both in Period I11, but rather smaller in size: this is, in fact individual 5b. It is tempting to attribute the similarity to a mother/daughter relationship, though that would be stretching the evidence too far. Of this sixth group, two are sewn soles (not pairs), clearly from the wear, light outdoor shoes with either cloth or alum tawed uppers of which no trace remains (749, 920). A nailed sole of the same elegant shape bears the clear impression of the lady's foot (862) (fig. 16, no.6), and a slightly more swayed example still has its plain, well worn upper attached (1657). Also for foot size 33 and thus undoubtedly for Lepidina, is the fine, stamped sandal of Plate V, found before 1976. Slight differences amongst these five soles probably have to do with summer and winter wear. A pair of cork slippers should perhaps also be included, as they are of the correct length, except that this type of footwear does not seem to appear elsewhere (or indeed at Vindolanda itself) much before the last third of the second century: if these did belong to Lepidina, she might have been following the height of urban fashion, which only reached the provincials some 50-60 years later.

No individuals are immediately obvious in the larger foot sizes, except for an elaborately patterned openwork shoe (1568, fig. 19, no.1), which could belong to the luxury class fitting to the status of the commander himself. If such openwork is indeed a sign of status, individual 5 might be one of Cerialis' sons.

Though a satisfying family fiction we must be aware that more factors -such as shrinkage -need to be considered and it remains to be seen whether the footwear from the more recent praetorium excavations confirm this pattern. The identification of household slaves, many of whom would be no more than children themselves, will always be a problem. More detailed comparison of the complete range of footwear from the respective praetoria and the later barrack may clarify in how far it is justified to regard the Period III footwear as belonging to discrete individuals: the basic assumption that it does rests on the very strong impression gained while working on the finds, but first impressions can always be misleading.
Fig. 20. Shoe sizes in all the periods
V. Varia

Amongst the tentage and footwear are numerous pieces of leather equipment to which no definite function can yet be assigned. For some of these it will only be a matter of time before a complete association turns up to solve the problem, so speculation is rather pointless at the moment. For other items, analysis of location and of associated finds may provide clues as to their purpose. In any case, full publication of the leather is essential to permit retrospective attribution of obscure pieces which at present elude identification, but which future discoveries may make perfectly obvious. At present, most identifications are little more than guess work, and the study of any leather complex involves a continual process of re-interpretation of previous work. The complete associations making up the two Vindolanda tents have already shown several previous identifications to have been wide of the mark and more such changes are only to be expected. Assessment of function proceeds as the quality of the evidence increases and improves.

A few items of interest illustrate just how rich the material from Vindolanda is and how frustrating the lack of useful identifications can be. None of these items can be used in the interpretation of the site, its garrisons or the activities being carried on until their purpose is clear.

1. **Triangular tabs** (fig. 21 no.1) vary in size, are often roughly cut from reused tentage and show no sign of stitching or any method of attachment at the bottom edge which, however, looks as though it has been slashed through. The bottom could have been sewn in with a seam, but no such strips have yet been identified in surviving seam associations, and one or two stitched examples would surely be expected in such a large find complex. That they were attached to something is clear from the stress marks at the V-shaped slit at the apex which is usually distended to the right. Unfortunately the only example complete with its bottom edge is 2247, which is atypical both in its shape and in its circular suspension hole. The frilled bottom edge indicates that this example at least was free hanging.

2. **Large rolled knots** (falkoner's knot, Plate IX), though there is no direct evidence to link these to the triangles they do often occur in the same areas. It is perhaps unlikely that the two were actually used together as the tabs are of flabby, old goatskin, while the knots are of hard, thick cow hide, often utilising hide edge trimmings. This implies that they were made as needed in workshops where shoemakers off cuts abounded. The knots are also cut at the end, with no indications of how or to what they were attached. Both knots and triangular tabs are concentrated in Period III.

3. **Bags and Purses.** Of the large toolbags present at Castleford and the bags and covers from Valkenburg and Vechren there is no trace at Vindolanda. A small fragment of a concertina-pleat drawstring purse (fig. 21, no.2, Period III) compares poorly with the purses known
from other sites with much less leatherwork, though the fragment is interesting in that the best parallel comes from Bargercompacuum, outside the Empire. This contained 312 silver Roman coins dated to AD 190 (Schlabow 1956). From the pre-1973 excavations comes a leather version of the more familiar bronze armlet purse. It appears to be a tube of leather knotted at one side and expanded at the other: the conservation treatment used at that time makes further examination impossible (Plate X). Incidently, the contrast between this piece and the still pliable pleating of the other purse emphasises the enormous improvement in the quality of the evidence brought about by the conservation treatment developed by Mr. J. Jackman (then of Gamer Booth Ltd., now Leather Conservation Centre, Northampton) in 1974. Rough covers made from old tentage in some cases still incorporate the original seams (212, 1434, 1527). Such makeshift items were presumably made by the soldiers themselves as required: there is no evidence as to what was in the covers. The boxwood comb SF4308 (fig. 21, no.3, Plate X) was discarded together with its leather envelope, which is nothing more than a strip of old leather rather roughly shaped and folded round the comb. Plate X shows an even simpler cover from the pre-1973 finds. It is merely a roughly cut circle of leather 26.5 cm in diameter with slits around the edge. The leather was pulled up around a presumably spherical object by a thong passing through the slits. This has distended the cuts into their present form, in much the same way as on some of the simplest carbatinae. The people of
Vindolanda do not seem to have indulged in luxury leather goods like those found at Vechten (e.g. van Driel-Murray, 1986b, figs. 6, 7).

4. Knife sheaths. Sheaths of any kind are remarkably infrequent on Roman sites, even though leather must have been employed. The two knife sheaths are simply made, one with suspension slits, the other incomplete and in two pieces (fig. 21, nos. 4 & 5). There are no signs of metal fittings and neither is likely to be for a military dagger. The tip of a leather sheath decorated with lightly impressed lines (698, Period 111, fig. 21, no.6) somewhat resembles the niello designs of dagger sheaths. Though only a small fragment remains, it is clearly a better quality product than the other two.

5. Straps and thongs. In addition to the straps mentioned above under horse gear (Slides 27-33) there are numerous narrow strips of leather, used as expendable thongs, with odd pieces of scrap leather -off cuts or old leather - knotted together to make up lengths. Some of these strips are still pierced by nails or remain knotted around sticks (plate IX). All suggest opportunistic and casual use of leather for all kinds of swift fastenings and repairs as well as for tying up small bundles and packages. There does not seem to be much system in the highly complex knots, which seem simply to have been cut away when the packages were opened.

A further problem in identifying function is that leather was frequently used as a covering material for large items. With the disintegration of the stitching, the cover is now a flat sheet, requiring a considerable flight of imagination to transform it back to its original three-
dimensional shape. One of the most intriguing items from Vindolanda is an association of four panels (fig. 22), which, for convenience has been dubbed 'horse barding'. Once the large association 1289 had come to light, fragments of similar items were recognised in other periods at Vindolanda and also at other sites such as Carlisle (Winterbottom 1989, figs. 5 and 6) and possibly Castleford and Bonn. Characteristic is the long, tongue shaped end, with two circular holes at the apex, both reinforced by a leather ring sewn (usually) to the grain side. The edges of the tongue are stitched in such a way as to imply either the use of a reinforcement strip or of a cloth backing. The double stitched edge comes down 40 cms, broadening out to incorporate an additional panel. The 'body' is composed of at least 3 panels with four ansata slits on the central panel defining a square of 32 x 29. Assuming regularity, the body is at least 138 cms wide, with seams at the bottom and sides implying additional panels on three sides. The whole item was therefore of considerable dimensions. Indeed, the leather used in the 'tongue' is, at 86 x 46 cms, nearing the absolute maximum of any skin and extra pieces were inserted into this and other examples to replace poor quality areas. The skin used is often rather brittle and dark, with a polished appearance, and is predominantly sheepskin. Strength and quality were evidently of little importance and the suspicion arises that the leather functioned as a reinforcement to an item of equipment made essentially of cloth. The leather quality and the curved edges invite an association with panels with a slip-stitched hem. This hem does not seem to have been used in tentage at all, but it would be a good way of neatening edges hidden behind free falling cloth.

'Barding' is hazarded on account of a) the circular holes and the form of the top are somewhat reminiscent of the chamfron polls: indeed, this was the reason for classing the leather pieces from Carlisle as chamfrons in the first place, b) the shape and dimensions rather resemble a Medieval trapper with a crinet, or neck covering, c) the ansata slits resemble the horn arrangement of the Valkenburg saddle, making a 'seat' 32 cms long in both cases, though there is a difference of 10 cms in width, d) the a-seam used on both long sides of the central panels implies it was draped, with both sides pointing down. There are, however, a number of objections: the proportions differ considerably from both saddle and chamfron, it seems inconceivable that a barding would be hooked over the tender ears of a horse without any strapwork: joining either bridle or chamfron and it is difficult to relate the plump and solid saddle horns to the narrow ansata slits. It would be impossible to drape the 'barding' over the saddle so that the horns still protrude, but that some relationship might still be considered is suggested by finds from Newstead. CUrIe (1911, Plate XIX) illustrates an ansata which is associated with leather 'pockets': these are mounted wrongly on the photograph and should in fact stick up on the outside, like the saddle horns. Similar associations are known from
Carlisle. How such equipment functioned is impossible to guess and it may equally well turn out to be an element in, for instance, an as yet unknown type of tent. The two a-seams, for example, are standard features of the central roof panels, but how the 'tongue' and the protruding ansatae relate is a mystery. If it is horse equipment, it would provide evidence for mounted troops in almost all the periods, though most fragments seem to come from periods III and IV. The association 1289 may serve as an illustration of the problems in interpreting leatherwork, which are often only compounded by the discovery of larger, but still incomplete, associations. In view of the difficulties surrounding such a large item, all functions proposed on the basis of smaller pieces must be treated with great caution.

**Fig. 21. Varia I:**

1. Triangular tab, scale 1:4, 2. Purse,
3 Comb case, 4-6 knife sheathes,
scale 1:2
Fig. 22. Varia II:
Barding(?) L1289, scale 1:4
VI. Offcuts and Questions of Supply

With the exception of the worn out shoes and one or two other broken and discarded items, the entire leather complex at Vindolanda is, technically speaking, manufacturing waste. Almost all the leather attributable to tentage has been cut up for re-use and only the worthless areas were discarded. As such, the whole complex is the result of manufacturing processes, utilising not only new leather but also salvaging old. In general, old and new off cuts as well as cut up shoes, are all mixed up together with hide and skin edges, a combination which suggests that all operations were carried out in the same workshop, without much differentiation between shoemaking and other branches.

It is usually impossible to tell what was being made from the salvaged leather and most was probably just stored for future use. Of the three makeshift bags or covers, two still incorporate lengths of seam. Patches and reinforcements were usually made of scrap material, either old or new off cuts. The remaining shapes of the discarded leather indicate that the object was to extract large, serviceable areas, with the minimum of effort. Especially in Period III, there is evidence of haste and quite large pieces of leather were discarded which could, with more care have been salvaged. Several of the straps used for the wooden clogs seem to have been cut out of old boot legs, but why so many boots were so rigorously cut up is a mystery (plate I. 1600). Uppers were severed from soles, even though both were discarded, while in other cases only the front edge of the lace holes was removed. It must have been retained for some purpose, as it is the rest of the boot upper which ended up amongst the discarded material.

Indirectly, the state of the cut-up leather provides an insight into questions of supply. At Castleford, leather was salvaged with the utmost care, leaving only the narrowest of sewn or damaged strips behind. This was interpreted as evidence for uncertainties regarding the supply of leather to the fort, a conclusion supported by idiosyncracies in other find groups such as pottery and glass (V. Swann and J. Price, pers. comm). At Vindolanda the situation is more complex, because in addition to the remnants of careful salvage work, a measure of haste seems also to have been involved, particularly in Period III. Often only the largest and best pieces are kept and cleaning up was not particularly neat. Rapid, wide slashes remove strips along the seams and cut right across corners to avoid patches and reinforcements. Whole sections with awkward stitching or patches were removed which at Castleford would have been cut out individually in order to retrieve the maximum amount of re-usable leather. It is, however, possible that some of the larger areas of leather may actually have been used as covers or wrappings before being discarded, rather like the tent corner (Tent I, slide 38) which had been used to line a pit). If it is accepted that the fill deposits contain material from the very end
phase of each occupation, and is to some extent representative of the activities being carried out in the buildings, then the amount of cleaning being done in each period suggests that a systematic inspection of the unit's tentage prior to departure was a standard procedure. As at Valkenburg, preparations for a more distant placement prompted rigorous checking of equipment to ensure only the best was taken on the journey. Even so, the collection of old material for re-use must represent a normal activity, on par with the recycling of metalwork, for very much the same impression is obtained from the legionary fabrica at Bonn. From the tentage, it would be difficult to argue for any shortage of raw material, but the footwear of the first four periods present a totally different picture. The frequency and extent of repairs not only contrasts markedly with the later situation at Vindolanda (Periods VI-VIII), but also with contemporary Continental sites and is particularly curious in view of the evidence for footwear manufacture on the site (even though this is perhaps not very extensive). Though it might be that soldiers used the footwear which would otherwise have been deducted from their pay to the utmost, in combination with Octavius' letter (Tablet 946) this might indicate actual difficulties in obtaining the necessary supplies of leather. Notable too is that the iron used in repair nailing in the earlier periods seems to be of poorer quality than the original hobnails. It is much softer, and the heads flatten out to large, but thin and irregular discs, in contrast to the original nails which retain their domed shape. As the repairs were presumably local, the difference in quality may indicate problems in the supply of iron at this time too. It is, however, possible that the poorer quality of iron was used by soldiers for reasons of economy (they were after all, Dutch) and that the difference tells us more about the realities of a soldier's life in the northern frontier than about the higher matters of military supply.

Off cuts of new leather give a more direct insight into materials and manufacturing processes on site. Differentiation must be made between periods I-V which are inside the fort area and the later material from the Ditches which is more likely to reflect workshops in the vicus.

Because of its sheer size, find no 755 (period VI, with a scatter into other numbers, 776, 782, 813, 822: fig. 23) must provide the starting point for the discussion of the significant of off cuts. Yet the 2kg of shoemaker's refuse dumped on the edge of the ditch can represent no more than a single basket of workshop sweepings. Even so, the sheer number of snippets, trimmings, triangles and small pieces of hide edges emphasise the insignificant proportion of off cuts in the other levels: except in room 6A of Period III they are more a background scatter than signs of any particular activity in the building where they occur. The off cuts in 755 are, however, remarkably uninformative: they are certainly from shoemaking, but there is nothing decorative, no loop cut outs, and few
shapes which could provide a clue as to what styles of shoes were being made. The smallest of most pieces also goes to show just how little leather was wasted, even in shoemaking, at this period. Of course, by Period VI most of the openwork shoes had disappeared and the boots then popular could be fitted closely together on the hide, leaving less wastage than the earlier fashions. All the same, with the possible exception of Period III, the meagreness of off cuts and the thinness of their distribution over the site is striking. Other than providing evidence that items -shoes, mainly -were being manufactured somewhere on site throughout the occupation it is probably unwise to attach much significance into numbers or distribution.

The majority of new off cuts are cowhide, with some calf skin and relatively few sheep/goatskins. Rather than assume that the major goatskin equipment such as tentage was being made elsewhere, it should be remembered that the geometrical shapes used will leave even less in the way of waste than footwear. Despite careful arrangement, distinctive but useless shapes between the soles or around the loops of the upper (eg. 707 and 813 Plate X) will always remain. Larger and more recognisable off cuts come from the problem areas, towards the edges of the hide when the shoemaker ran out of space, or attempted to make use of even the most unpromising lobes (1254 and 1548). In contrast to modern practice the hides were not neatened up after tanning and the udders, necks and appreciable lengths of leg were left on. Shapes were arranged around any damage such as insect bites or wounds (eg. 154, 157), possible storage mange (160, 849, 854) and several udders remain, mostly cows but also a goat (737), some with underdeveloped teats, others with teats of 2-4 cms, suggestive of mature cows with 2 or 3 calvings behind them (eg 102, 247, 289, 1157, 1415 (fig. 24, no.4), 813). With a few exceptions, the hides seem to have a good dense structure with relatively few blemishes. There are no indications of warble infestation as occurs on some goatskins. Very occasionally clumsy fleshing rendered parts of the hide useless (585), but on the whole the hides are even in thickness c. 0.3 -0.5 cms. The animal was apparently flayed from a central belly slit, cutting straight through the udder and taking the legs down to the hoof.

Cattle hides do not seem to have been frame stretched after tanning, but the hide used for uppers (and sometimes also for soles) was compacted by pounding and burnishing (currying). Goatskins, in contrast, were stretched but do not seem to have been curried. A few thin, brittle calf skins (period 11, 1551, Period III 275, 122, Period IV 1157, 854) represent opportunistic tanning. As at Castleford, this was not particularly successful: due to putrefaction setting in before tanning commenced, quite large pieces had to be discarded. This probably points to local attempts to make use of the skin of any dead animal, while the excellent quality of the other leather, even after centuries of burial, is evidence of high standards maintained in professional tanning.
Though goatskin was occasionally used for shoe uppers, its most general employment is in tentage, for which large quantities must have been required - about 65 for Tent I and 94 for Tent II: translated into *centuriae* and *turmæ* the quantities are vast, and clearly account for the careful refurbishment of existing tentage. To ease pressure on resources, some kind of replacement scheme must have been in operation, since the supply of large numbers of new tents would obviously lead to problems. Quite apart from the transport and payment difficulties experienced by Octavius (tablet 946), Octavius speaks of 'leather' (*coria*) in general, without specifying whether cattle hides or goatskins are concerned but Tablet 85/51 (Bowman & Thomas, 1987, 141) actually mentions goatskins (*pelliculas caprinas*), albeit not in large numbers. In the absence of goat bones in archaeozoological reports, the leather identifications are frequently either called into question, or are taken as evidence for long distance trade (van Driel-Murray, 1985), so this definite reference to goatskins is particularly welcome. Analysis of several samples by Mr. J. Jackman (Leather Conservation Centre, Northampton) revealed that the majority are goatskin, with a small number of skins from hairy sheep breeds (hair-sheep) and confirmed the criteria on which previous identifications have been based. Jackman was also able to identify the healed scars of warble fly infection on the skin: he notes that warbles affect cattle and goat, but not sheep.

**Period I:** only 5 cow hide offcuts, but two of these are stamped (see below p.64), suggesting shoemaking using excellent quality hide, all from the same source.

**Period II:** well over 100 new off cuts, mostly small and mostly cow hide. There are several examples of soles being cut right up to the hide edge. The absence of openwork silhouettes or eyelet roundels is remarkable even though soles were being cut systematically and in series (1481, 1415, 1551), thus implying a fair scale of production. A concentration in room J shows the same combination of new cow and goatskin with reused tent panels and cut up footwear as appears in Period III room 6a.

**Period III:** a thin scatter of offcuts in every room, but apart from 6a there is little discernable pattern. Goatskin off cuts, usually leg/belly/neck strips left from preparing rectangles (cf.277 fig. 24, no.1) are more frequent here than in other periods. The number of registered examples gives a misleading impression of quantity for the 11 goatskin edges and 7 similar pieces of calfskin from 6A probably come from no more than 2 or 3 goatskins and at most two young (opportunistically tanned) calfskins (122, 156, 275). This is suggestive of stock in hand for repair purposes rather than supply for large scale manufacture. Taken with the much more extensive evidence for salvaging old tent leather these off cuts do, however, point to systematic refurbishment of tentage somewhere in this area, though the levelling off of the rubbish has
spread the offcuts into virtually every room. In contrast, a group of exceptionally fine, smoothed cow hide off cuts in room 6A, distinctive in shape and associated with the cut up chamfrons are almost certainly indicative of the manufacture of chamfrons in the praetorium itself immediately before the abandonment of the building (see below fig. 25).

**Period IV:** again a thin scatter of shoemaking off cuts (soles and uppers cf. 889) as well as a few goatskin belly/leg edges with the usual stretching holes. Most occur in rooms 3 (17) and 4 (21).

**Period V:** surprisingly few off cuts for a jabrica, only some small snippets and trimmings from uppers.

**Period VI:** yicus refuse, only 755 gives the impression of being a real dump of shoemaker's refuse, and in contrast the rest is insignificant. Other than showing that leather goods were being made in the yicus, the off cuts give little indication of either the scale or the products, nor whether military equipment was also made. The pieces are small and not distinctive, and they perhaps represent the background 'noise' of refuse which spreads over any site where leather is being worked.

Inner Ditch: has scarcely any leather other than footwear, only about 60 snippets occur in the entire length.

*Fig 23. Offcuts I:*
*Selection from cobbler's waste, L755, etc., scale 1:2.*
Fig 24. Offcuts II:
Including pieces with teats and waste from tent panels, scale 1:3.

Fig 25. Offcuts from Chamfron manufacture in the Period III structure, Scale 1:3.
VII. Inscriptions and stamps on leather

Stamps and inscriptions on leather appear regularly, if sporadically, usually on off cuts and on footwear. Five examples of marked footwear come for the early excavation campaign and though only three more came from the 1985-87 material, the preliminary examination of leather from the 1988/89 campaign has already identified at least five more. Except for one Impressed Inscription the marks are incised (numerals only) or, more commonly, stamped with a die. The stamps are placed on the insole of sandals (8 examples) or on the outer sole of cork slippers (2 examples), the usual position for stamps on comparable Continental material as well (van Driel-Murray 1977). No two stamps are exactly alike, and they vary from simple numerals (2294, 120) to elaborate settings of various different designs (319). Some of the stamps are so fine that it may be surmised that gemstones or metal rings could have been used to impress the designs onto the dampened (and probably warmed) leather surface. It is notable that stamps on early sandals are liberally scattered all over the surface (LK9, at least 7; 319 at least 9; 466 at least 8), while the decoration of later sandals is usually restricted to impressed defining or guide lines with only one or two additional marks (2294, LK79, LK63). Again this is comparable to Continental practice. The stamps on the late 2nd century cork slippers are placed three in a line down the middle of the sole; if letters are used these are die-stamped at the waist. In contrast to the earlier stamps, these always occur on the outersole. The letter stamps which occasionally also appear on ordinary nailed footwear, are frequently composite, recording individuals in various relationships, perhaps, on analogy with bronze vessels, the head of the workshop and the actual (slave) maker of the item. The large and elaborate stamp on 1945 can be completed from an identical example for York (Britannia, 1987, 347), applied in the same position on a similar cork slipper sole. The stamps are so distinctive that there can be little doubt that the same maker is concerned. Two finds, neither in a primary context, are perhaps insufficient basis for the assumption that luxury footwear along the Wall came from York, though this should be born in mind in the analysis of footwear complexes from the region.

Urns, leaves, florets and rosettes also appear amongst the designs used on contemporary footwear both in Britain and on the Continent (cf. London, Rhodes 1980, figs 60,66), probably representing a common repertoire of designs rather than any linkage. The stamps are too numerous and varied for some play on the Latin or native name of the footwear to be intended, yet they are not numerous enough for a rebus or pun on the name of the maker to be intended either. However, some connection with the function of stamping on terra sigillata and bronze work is plausible for the earlier multiple stamps. That the numerals indicate Roman size divisions is, alas, unlikely for the two sandals 120 and LK11 carry different numerals even though the soles are identical in size and
shape. Rhodes (op.cit. p.119) mentions the numerals VIII, X and XII from London. The practice would therefore seem to be widespread, though restricted to sandals.

The inscriptions on off cuts are of a different order. These are letters or numerals, usually neatly cut or stamped either before or immediately after tanning, and so placed as to avoid marring the useful parts of the hide or skin. No.482 (fig. 27, no.6) is exceptional in that the same stamp appears twice, once incised on the skin so that the cuts opened up during tanning. The second mark is die-stamped after tanning, which would imply that Sat to was either the overseer controlling a number of operations (from buying in skins to delivery of the finished product) or, if the stamps are regarded as check marks at various stages of the operation, that by coincidence the same man was responsible for both pre-tanning operations and for finishing off (currying). It is, however, unusual for tannery marks to be applied anywhere other than the skin edge or neck: 482b does seem to be near edge skin and may therefore be an off cut, but 482c was cut from old tentage, where it would originally have been clearly visible. This invites comparison with the series of 'brands' on a piece of tentage (probably a corner reinforcement) from York (Britannia, 1987 373~ no.31), which raises the interesting possibility that tents were actually marked by their occupiers.

The marks on edge off cuts are well formed letters made with a sharp die. Several interpretations have been offered (van Driel- Murray 1977, 1985; Rhodes 1987), but there is no conclusive proof in favour of anyone explanation. Most would seem to be associated with the tanning process, but the lengthy correspondence of Octavius concerning the acquisition of hides from Catterick (Vol. II, p.59-60), and the occurrence of Coh IXB stamps on hides raises the possibility that hides were designated for the supply of a particular unit at the tannery, at least in military situations. The Coh IXB could in this case be an address mark of a batch reserved for Vindolanda at the tannery. If, as has been supposed, hides were delivered in batches of 30, the chances of finding many of these address marks would be remote. The connection with Catterick is particularly interesting in that quite considerable quantities of leather are appearing at that site, and a link between the products made there and the worn out items recovered at Vindolanda would greatly enlighten our understanding of the system of military support. Octavius' letter is a curious record of private initiative, yet he deals with such large quantities of money and materials that only military supply can be concerned. It perhaps shows that despite the presence of military supply bases, quartermasters were still at the mercy of middlemen: the supply system may not even have been under military control at all.

AR occurs twice in Period II (1595, 2481)
C0 occurs twice in Period II (1416, 1471), once possibly with two additional strokes, though these might be
merely cracks in the leather.

CIX/CIXB occurs three times, once in Period 11, twice in Period III (430, 617, 2155), all are cow hide edges. Knife slashed and therefore more angular is 315 apparently IX (or XI), and though from the inner ditch it probably belongs to one of the lower in situ levels (Period III or IV).

VIII occurs twice in Period II (671, 1468), both on stitched items and probably pertaining to the use of the item rather than to tanning procedures. 1468 bears various cuts and impressions from metal attachments preceding the slashed VIII, which suggests that a full title or unit number was applied to this (unidentifiable) item. It is interesting that VIII seems to have been used by the soldiers of Period II, while IX occurs as an address on the hides for Period III. Though this may reflect a change in writing practice, it might conceivably be a convention used to express the difference between the Ninth Cohort and ninth century and/or turma.

Plate XI (right) Inscriptions and brands: top row – 1595 and 466; second row – 1419 and 2288; third row 617 and 2294; bottom row – 319, 1945 and 2582.
Inscriptions

Period I

1. 1595, Cow hide edge off cut, carefully serifed letters, 1.0 cms high: AR Applied after tanning (Plate XI).

2. 2481, Cow hide edge off cut, carefully cut serifed letters, 1.0 cms high: AR applied after tanning (fig. 26, no.1).

Period II

3. 1419, Small secondary off cut with partially preserved knife cut (?) letters, serifed CO with further marks above and to the right, which may be the remnants from a longer 2 line inscription (plate XI).

4. 1471, Cow hide edge off cut with two lightly impressed lines like IV followed by CO scored into the tanned hide. (fig. 26, no.2).

5. 1427, Lacerated fragment of goatskin with fragment of seam stitching remaining, surface covered by small rips and holes, the angular shapes of many of which seem to be too exact to be mere coincidence. Metal attachments may have been involved (fig. 26, no.4).

6. 1468, Tom fragment of goatskin with either a bound seam or seam I, with various marks and impressions suggestive of metal fittings and studs, as well as a series of cuts which from the grain side read VIII. (fig. 26, no.3).

7. 2155, Cow hide edge off cut with CIXB neatly stamped in letters 8mm high, and overstruck at right angles by the same stamp but not fully in contact with the leather. From the silt in the bottom of the Period II water tank (fig. 26, no.5).

Period III

8. 430, Cow hide edge off cut, a lobe with incised CIXB in letters 9mm high, the B awkwardly knife cut. (Reported in Britannia, XIX, 1988, p.503, no.74) (fig. 27, no. I).

9. 617, Cow hide edge off cut with CIX twice overstruck in letters 1.0 cms high with beginning of a third stamp visible. Neat serifed letters (Plate XI).

10. 671, (either III,6A or II, C) Reuse goatskin off cut with seam IIIa and distended cuts right through the leather: VI. II (i.e. VIII?) (fig. 27, no.2).

11. 1344, From the floor of room XI in the Period III praetorium, within 60 cms of the almost complete chamfron, a cow hide off cut with a nail hole and marks of the teeth of a vice probably used in chamfron manufacture, with an inscription impressed on the damp leather with a blunt instrument. The reading of the first word of the inscription is clear; the remainder less so:

VIILDIIDII SPONDII

VELDEDIUS must be the same man who received the letter from Chrauttius (T470), which was found 10 metres
VII Inscriptions (5)

to the south, in the yard VIA. He was described on the address as an *equisio consularis*, or Governor's Groom, which may have been a title carried by the Governor's postal orderlies. The second word is more difficult, because the first letter is not an orthodox capital, and the end of the word is partially obliterated by the vice marks, but SPONOE/SPQNSA seems to be a reasonable interpretation. Or. M. Hassall (letter 10.9.1991) suggests a link with SPONOEO "I pledge" and hence "pledged or promised to Veldedius" which would make good sense in the context of chamfron manufacture (fig. 27, no.4).

**Period IV**

12. 482, SATTUO stamped into two associated goatskin patches in letters 1.0 cms high, a) cutting the skin and probably a pre-tanning mark, on the other b) from a thick metal die not penetrating the skin and hence applied after tanning. The patches are cut out of old leather and neither stamp is in an original position. (rig. 27, no.6).

**Period IV or V**

13. 2526, Cow hide off cut with carefully cut letters 0.5 cms high: M.VER (retrograde) (fig. 27, no.7).

**Period VI/VI**

14. 150, Cowhide sole off cut with some meandering lines, doubtful whether an actual inscription (fig. 27, no.8).

15. 185, Cow hide off cut with possibly a deliberately cut out hole and scores of a large X; though the position towards the edge is to be expected, this is perhaps a doubtful mark. (fig. 27, no.9).

16. 315, Calfskin off cut with slashed inscription: XI (or IX), (fig. 27, no. 10).
Fig. 26. Brands and graffiti IL see slides 74-76
L2155, scale 1:2

Fig. 27. Brands and graffiti I, see slide 74-76
L319, 11. L2207, 12. L606, 13. L120, scale nos 3 and 7
1:1, remainder 1:2
Stamps and inscriptions on footwear

Period III

17. 604, Insole of a small sandal with lightly pricked IX at the seat. Two punched crescents may be associated, but are probably trials as they are punched with the same tool and in the same relationship as the punches used to cut out the peg hole in the seat. (fig. 27, no.3).

18. SF863, The soles and strap of a lady's left sandal, 22.8 long and 6.6 wide, from the Period III floor in room IV of the praetorium. The sole has been stamped seven times, thrice with the inscribed die and twice each with a vine leaf and a device of two comucopiiæ interlocked across an ear of corn (see Plate IV no.1). The die was provided with an ansate frame. The text reads:

L (lunette) AEB/THALES .T .F
L(ucius) Aeb(utiuss) Thales T(iti) f(ilius), who was presumably the maker of expensive footwear. In this Period III context, the slipper probably belonged to Sulpicia Lepidina. (Reported by R.P.W. in Britannia, IV, 1973, p.332 no.28) Birley, 1973, p.121.

Period IV

19. 319, Nailed and thonged sandal sole with at least 5 circular stamps with a two handled urn in relief, and at least 4 circular stamps with beaded edge surrounding an eagle with spread wings looking left. In addition, there are two impressed lines around the edge and a line down the middle of the sole and at each point where the thongs emerge is a small circular stamp. At the outside waist the stamps do not actually coincide with the thongs and the design is faintly visible. It appears to be a floret within a circular border. (footwear Plate XI, detail fig. 27, no.5).

20. 466, (though from the Stone Fort I ditch, probably dug out from an earlier level). Nailed and thonged 4 layer sandal sole similar in shape to 319, but smaller, with at least 8 stamps, most worn beyond recognition, depicting a two handled urn within a circular border, differing slightly from that on 319. (Plate XI).

Period V

21. 606, Nailed and thonged 4 layer sandal, with on insole at tip an impressed X partially crossed by a series of small slashes, and at tread a complex, lightly impressed cursive inscription.

SVITIISI.VTIIII / SVIITII SC.
SVIT is perhaps to be associated with sutor/cobbler, but otherwise the inscription is unintelligible (fig. 27, no.12)

Period V /VI

22. 2588, Nailed and thonged sandal sole with two circular stamps apparently depicting a griffon or pegasus (Plate XI).
Period VI

23. 120, Numeral VIII incised on a 3-layer, broad fronted sandal insole, left foot, 23.2 cms long (fig. 27, no.13).

24. 2207, Numeral IV incised on heel of a sandal insole (fig. 27, no.11).

25. 2294, Poor insole of a sandal with parallel impressed edging lines and the numeral III neatly stamped at the waist. (Plate XI).

26. 1945, Outer sole of a cork slipper (enveloped edging and butterfly shaped top remaining) with three faint floral stamps in the length and at the waist, partially worn away, a deeply impressed elaborate stamp.

QFI[..] / ESV[...]  
An O is very faintly visible under the E (Plate XI).

Both stamp and sole are almost identical to an example from York (Britannia, XVIII, 1987, 374, no.32) which can be read as

QFIMCV /ESV/[ORM[..]

27. 2582, Outer sole of a cork slipper with two elaborate palmette stamps (originally probably three in usual position up length of sole). (Plate XI).

Unstratified

28. LK71, (post Period V), Identical to 120, nailed and thonged 3-layer sandal sole of broad fronted type, with, at the waist, a thonged repair to the instep strap. A small incised cross near the slits for the toe strap is probably a guide line for laying out the proportions of the sole. At the waist, die stamped, seriffed III. Left foot, 23.2 cms long (fig. 28, no. I).

29. LK63, (post Period V), Nailed and thonged 2-layer sandal sole of broad fronted type with a single large circular stamp surrounding a knife pricked floret at the tread. Towards the edge is a semicircular die stamp, probably produced with the die used for cutting out decorative roundels on carbatinae. (fig. 28, no.2).

30. LM1, (Period III/IV shape) Small nailed and thonged sandal sole with at least 4 circular stamps with beading around an 8-petalIed flower. (fig. 28, no.3).

31. LM9, (Period III/IV shape) Incomplete sandal with 1 leaf shaped stamps (fig. 28, no.5).

32. Unmarked, pre 1913 (Period III/IV shape) Nailed and thonged 4 layer sandal with toe indents, extremely worn down at the outside seat and repaired with 8 nails hammered in from the top, possibly to prevent the quarter working loose. At least three groups of circular stamps, worn, but apparently depicting a floret surrounded by two concentric circles (fig. 28, no.6).
33.  842 Period VI. Heel stiffener cut from cow hide bearing large seriffed capitals, partially worn away.

CRS...

Probably a tanning mark, incorporated by coincidence on the stiffener which was cut from an off cut (fig. 28, no.4).

Fig. 28. Stamps on footwear: see slides77-79
Acknowledgements

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Bibliography

BIRLEY, R. Vindolanda guide book (Greenhead, 1991)
CURLE, J., 1911. A Roman Frontier Post and its People. The Fort of Newstead in the Parish of Melrose (Glasgow, 1911)


DRIEL-MURRAY, C. van, 1990a. 'The Roman Army Tent'. *Exercitus* vol.2, no.8, 1990, 137-144


SCHLABOW, K. 1956. Der romische Munzschatz von Bargercompacuum (Drenthe) II. Der Geldbeutel.' *Pa/ehistoria* 5, 1956, 81-87

WINTERBOTTOM, S., 1989. 'Saddle covers, cham frons and possible horse armour from Carlisle.' in, C. van Driel-Murray (ed), 1989, pp. 319-336
VINDOLANDA 1985-1988
THE TEXTILES
by J. P. Wild

Introduction

The Vindolanda textiles are of exceptional importance on two counts: they are closely dated to the four earliest phases of the site's occupation (broadly c. AD 85-120. see slide 10) and they constitute the largest extant group of Roman textiles in the western provinces. The textiles from the first-and second-century legionary rubbish dumps between Mainz-Kistrich and the Rhine would have rivalled them, had they escaped destruction in the Second World War. As it is, only a small and unrepresentative selection of perhaps 1000 original finds is preserved (1). There are comparable or rather contrasting contemporary collections from the eastern provinces which serve to emphasise Vindolanda's isolated position in the Roman West (2). There can be no doubt that while individual finds may have an intrinsic worth, the composition of a large assemblage has more to tell us about the workings of the Roman textile industry.

From the 1973-75 excavations I studied and published fully about 60 wool textiles, which I took to be a fair cross-section of what was being worn and jettisoned at a typical northern Roman fort (3). When excavation was resumed in 1985, 106 more fragments or amalgams of textiles or textile-related material (cloth, rope, yarn and fleece) came to light (inventory nos. T/I- T/I06). In 1986 there were 35 more (T/107-T/I40). in 1987 292 (T/142-T/461) and in 1988 194 (T/463-T/681) -a total of about 627 new items. During excavation and conservation fragments of several different textiles sometimes received the same inventory number; conversely, the same web of cloth appears in its constituent pieces under several numbers. Until detailed study and analysis is further advanced, it will not be possible to quantify the textiles adequately either as a count of fragments or as a minimum number of webs of cloth represented. The figures quoted in the text below are provisional. based on a count of inventory numbers after textiles which are obviously the same have been reduced to a single entry.

To date the extant material has been examined once and listed. Only a few pieces have been fully recorded. Closer visual inspection coupled with analysis of fibre diameters, dye residues and evidence for wear and function will take much longer. For that reason only a brief interim statement is offered here, and that may be subject to revision. For the time being the first four site periods are treated as one except where the context of a particular item may be revealing: finer distinctions may emerge during further research.

Basketry and rope have not been included in this report: Dr. Willemina Wendrich is currently examining them.
Structural Characteristics

For ease of comparison the headings adopted below reflect those used in reporting in 1977 on the 1973-75 finds (4). Where possible I have tried to avoid repeating discussion of common features of the Vindolanda material; for lengthier comment the reader is referred back to the 1977 publication (5).

a) Fibres

Wool is the only fibre present in the woven textiles, although a few lengths of twisted cord and a 'button' of felt appear under low magnification to have a plant origin. The lack of flax (linen) in bog-found textile collections is normal and explained by differential survival (6): even if linen garments were more expensive than woollen, Lepidina in Period III at least could have been expected to shed some!

Stitch holes lacking thread in T/59 (1985) may indicate where a plant fibre has disintegrated.

b) Spin

Traditionally the Iron-Age and Roman spinners of northern and western Europe rotated their spindles to the right, and the resulting Z-spun yam dominated at Vindolanda, as elsewhere in the region. For 2/2 diamond twill cloth, however, the weavers chose Z-spun warp, but specifically S-spun weft: there are just 9 Z/Z as opposed to 217 Z/S diamond twills. About half of the handful of plain 2/2 twills are Z/S. but only 3 of the 54 plain tabbies. One curious tabby (T/620) may have S-spun warp and Z-spun weft.

Spin patterning involving the introduction of alternating stripes of Z-spun and S-spun yams in the weft has been noted in 3 of the diamond twills; there were 3 instances, too, in 1973-75 (7). But throughout the collection the quality of the spun yam is remarkable, prepared with care for the specific end-use of the woven cloth.

c) Weaves

The percentages quoted below are based on the finds of 1987 and 1988; those of 1985 and 1986 were fewer and less well preserved and admit to less clear-cut interpretation.

Plain 1/1 tabby (15%)

The character of the new Vindolanda tabbies is markedly diverse. There are some coarse fabrics, but at the same time several with high counts (T/568a 12/20-26, T/553 18-20/16) and fine yarn. A few are weft dominated (T/648 9/18-20, T/677c 6/30), but the majority are more evenly balanced. Demonstrable or probable band fragments (see below) exhibit a higher warp count (T/40 25/9-10, TJ91 15/11)

Basket weave and half-basket weave (14%)

While full basket weave is uncommon (1%), the textiles in half-basket weave ('extended tabby') (13%) are
probably the most interesting in the Vindolanda assemblage. In general character (quality of yarn and density of cover) they have much in common with the finer tabbies, but form a much more uniform group. The warp is moderately hard Z-spun (c.20° angle of spin), but the paired weft has the minimum of Z-twist inserted. Counts as high as 18 single warp threads by 40 weft pairs per cm were noted (eg T/531) and even the lower counts (T/630 7 single/8-9 pairs) reflect a more open weave than a coarser yarn.

Interestingly, analysis of the internal selvedges on T/545 (see below) shows that the weft was not inserted as a pair, but as two independent yarns that went their separate ways at the edge of the fabric.

Reinforced selvedges,corded edges and tapestry-woven bands are all found on the half-basket weaves (see below).

2/1 twill (28%)

No 211 twill was found in 1973-75, and even the most recent finds may prove ultimately to stem from fewer than 6 distinct webs. The finest has a count of 14 presumed warp by 20-23 presumed weft-threads per cm. Two medium fine fragments (T1359, TI599) are in warp(!)-chevron 2/1 twill, so far unique for the western Roman provinces; but for the plain 211 twills the most obvious parallels are in the Corbridge hoard of &. AD 120 (8).

2/2 twill: plain (5%). chevron (0.5%) and diamond (62%)

It is evident from the shared characteristics that the same weavers or weaving milieu was responsible for all three variants of 212 twill. Plain 212 twill was comparatively rare and chevron twill almost ignored, while diamond twill was the preferred structure, despite the extra demands which it makes upon the weaver. There can be no doubt about its dominance of the Vindolanda clothes-chest, even if a straight fragment-count may have led to some exaggeration of the present declared proportions. About two thirds of the diamond twills were of medium weight with a count of about 14 closer-set warp threads and 12 weft-threads per cm (eg T/622); but there were occasional coarser scraps (eg T/586 7/6). The pattern units have so far not been studied, but among the finer pieces free of nap or felting the reverse was frequently after 10 threads of the Z-spun system (presumably warp), 7 of the S-spun (weft).

The popularity of 2/2 diamond twill is what marks most sharply the difference between this northern corpus of textiles and those of similar early Roman date in the Nile Valley and Palestine. The trend towards diamond twill at the expense of less complex structures can be observed in Roman Iron Age Scandinavia, too, but it is slower to make itself felt there and reaches its peak later (9).
d) Woven decoration

Subtle stripes created by weft yams in contrasting spin-directions are visible in three diamond twills (f/392, T/412, T/629). A plain tabby (f /568b ) may have strips in yams of varying degree of natural pigmentation. But pride of place must go to the tapestry-woven decoration on a limited range of plain tabbies and half-basket weaves. T/296 and T/230 are fine tabbies carrying fragmentary bands woven in darker brown ('purple') single yams, while T/215 is now a black half-basket weave with a 'purple' band of paired weft yams. Only the tapestry band in the half-basket weave T/248 (probably the same web as T/250) is woven over grouped warp threads (2/I/2/I etc.). Outside the usual range is T/545, an assemblage of pieces of fine half-basket weave, one...
of which is distinguished by a tapestry-woven notched gamma symbol inserted into it (fig. 29). Within the gamma both warp and weft are paired, but there are innumerable faults (fig. 30) (10).

e) Selvedges

**Transverse edges**

No flat-woven starting borders of the type made famous by Marta Hoffman and associated by her with the warp-weighted loom have yet been recognised at Vindolanda (II); but on the diamond twill T /9 (1985) an edge in which 8 Z-spin yams pass I/lover pairs of S-spin resembles at first sight the classic type (fig. 31). The spin direction of the yams, however, implies that the border is parallel to the warp, i.e. that it is a reinforced side selvedge.

The fine basket weave T /269c sprang a surprise: for the single sheet of basket weave divided on the weft axis to become two sheets of half-basket weave. Unfortunately the edges of the half-basket weave were torn after about 1 cm; but they can be regarded as the residue of a hollow tube. This might once have enclosed the horizontal rod at the beginning or end of a web woven on a vertical two-beam loom. (The spin of the yarns enables us to distinguish the warp and weft in this piece unequivocally). Alternatively, as a parallel from Masada indicates, the tube may have been a constructural feature within the main web (12).

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*Fig. 31. Diagram of selvedge on T/9 (1985)*

An odd coarse half-basket weave (1'/639) has single weft and paired warp, each pair ending as a simple closed loop.

The diamond twill T/635 ends in a warp fringe (two Z-spun yarns S-plied into a long strand); but on three half-basket weaves there is a corded closing border in which groups of warp-threads are S-twisted into strands and the strands then Z-twisted into a cord which lies close to the edge of the cloth (13).
Se1vedges

Simple selvedges in which the weft-thread returns directly into the next shed and where there is no attempt to reinforce the outer warp-threads survive on three diamond twills, a plain 2/2 twill and on tabby bands which retain both selvedges intact. More commonly, the weaver has taken pains to protect the edge of the cloth against heavy wear by adding one or more extra bundles of yarns alongside the main warp. A single such bundle was recorded on 4 diamond twills and on one half-basket weave; two bundles appear on 2 diamond twills. 5 half-basket weaves and a plain tabby; three bundles are found on half-basket weaves alone. but five times; one web of 2/1 twill is reinforced with 6 bundles. The bundles on diamond twill normally incorporate no more than 4 yarns each. but on half-basket weave there are up to 10 fine yarns present. In several cases the warp of the main web is rearranged to build up gradually to the thicker bundles. in sequences such as 1/1/1/1/2/3/9/9. 1/1/1/1/2/8/8. and 1/1/1/1/2/2/9/9. Instances can be seen (eg T/626) where the weft wraps the bundles before returning into the web (14); there is at least one example (1/499) of three weft-yarns leapfrogging over each other at the selvedges. On diamond twill T/564 the two warp-bundles were S-twisted between passes of weft. possibly on a tablet.

f) Hems, seams and stitching

Raw edges were often merely oversewn, but occasionally an extra cord was laid against the edge to be embraced by the stitches and give a strong, neat, finish. There are many examples in the new material of the folded (rolled) hems already encountered in 1973-75 (15). On three textiles cr/203 half-basket. T/289 fine diamond twill and T/555 medium diamond twill) a plied cord was laid into the angle formed by the inner edge of the hem and the cloth itself (fig. 32). It was not visibly retained there by any special device, although in T/555 it was caught up by occasional hemming stitches, apparently accidentally. A decorative purpose seems the most plausible.

![](image)

Fig. 32. Folded hem with added plied cord of T/555

'Footweaving' is attested twice: on the raw edge of a 2/1 twill (T/468, T/471b) and on the folded hem of diamond twill T.555. On T/468 12 'weft-threads' of bard S-ply running along the edge are beld by 7-8 sewn 'warp' threads per cm penetrating the fabric (16).

Seams

The constituent parts of the gamma-decorated T/545 were joined with a run and fell seam (fig. 33) (17). On other textiles folded hems are tacked edge to edge (18). The
sewing thread is regularly 2-ply, S-plied from Z-spun yarns.

**Some complete objects**

Given the nature of the deposition it was hardly to be expected that complete garments would be recovered. Three, however, came to light that are worth describing here.

**a) the insole (T/15) (Plate XII)**

In 1985 a complete child's insole was found in Room II of the Period III *praetorium*. It measures 16.5cm long by 7cm wide under the ball of the foot and has been neatly cut from an old piece of fine compact diamond twill (Z/S, 14/16. reverse after 16 warp, 7 weft-threads). Dr. W. D. Cooke identified signs of considerable wear on the original garment, perhaps a cloak, but could see none resulting from its secondary use as an insole (19). It might have been made for one of Lepidina's older children, but rejected as just too long to fit a shoe of Group 4 in C. Van Driel-Murray's classification (see above).

**Fig. 33. Run and fell seam on textile 545**

**b) the sock. (T/316) (Plate XIII)**

What was recognised as a child's sock (or slipper) (T/316) came from Room XI of the Period III *praetorium*, and part of another possible example (T/125) was recovered from the yard outside. The 'upper' and the 'sole' of T/316 are of separate pieces of medium-weight diamond twill, the latter being of notably lustrous wool. Maximum length is about 16cm, and width about 7cm, intriguingly close to the dimensions of the insole. The component parts are roughly tacked together. The upper edge is frayed through wear, and there are signs of wear on the outer side of the heel, as Dr. Cooke pointed out. Closer examination may reveal whether it is a sock worn inside a shoe or a separate slipper (20).
c) the moss cap (Plate XIV)

An unusual object perhaps better classified as basketry rather than textile came from the Period III praetorium. It is composed of the cleaned cores of the stems of hair moss (*poly trichum commune*) woven into the form of a round cap &..17cm wide, from the edge of which bare strands project as a fringe for a further 28cm. Construction began with 7 bundles of stems (each 6-8cm thick) knotted into a central cone, root edge outermost. Treating these bundles a warp (or basketry stakes) the maker plaited around them (1/1) narrower bundles of moss strands as weft, working out from the centre. Almost at once he anchored with the weft an extra warp bundle at an oblique angle to one side of each of the principal bundles, and added to the series progressively as he worked outwards, gradually filling the six segments of the cap. A total of 54 warp bundles was counted around the cap's brim.

There is a close parallel for the cap from the late Flavian context at the fort of Newstead: it is the same size, but slightly different in construction because it uses shorter stems of moss (21). Neither of the objects can now be convincingly claimed as unfinished baskets: 'cap' is perhaps a better term, though it still begs questions.

Questions arising

a) Functions of the textiles

The Vindolanda documents frequently mention clothing: tunics, at least four different styles of cloak, leggings, underpants, and several sorts of rug and blanket (22). It should theoretically be feasible to assign textiles to some of these categories: but the task is frustratingly difficult.

Few fragments measure as much as 2<km by 2<km; the majority are far smaller. A number were clearly (sub-)rectangular patches: others were patched. It has been suggested that some pieces served ultimately as toilet paper. The long torn strips look like (used) bandages and strapping. Several pieces obviously had a complex history: T/545 began as a cloak (see below), was carefully remodelled for another, unknown, textile
function and finally (perhaps after a tertiary use) was jettisoned in Room XII of the Period III praetorium with many other rags.

Nevertheless, on the positive side, the insole and sock described above can be so labelled with confidence, the moss 'cap' more tentatively. The tapestry-woven gamma motif on T/545 can be paralleled in the eastern Roman provinces on cloaks (23).

Reviewing the surviving features of the other pieces of half-basket weave from the site, one could reconstruct a hypothetical original textile woven with reinforced selvedges and a corded finishing border, and decorated with 'purple' tapestry-woven bands. (The putative 'hollow' tube on T/269 is on a basket weave, though of the same quality as most of the half-basket weaves). The features in sum are more consonant with a tunic (or tunics) with clavi or items of soft furnishing than a heavy-duty outer garment.

Several of the plain tabbies resemble the half-basket weaves in all aspects except the paired weft; but the general class of tabby exhibits a more varied character. The narrow tabby bands with two plain selvedges are probably to be construed as leg-wrappings rather than girdles as I once thought (24); they might have served eventually as bandages like the torn strips of cloth. The best parallels are from Mainz, another early military site (25).
Nearly two thirds of Vindolanda's textiles were diamond twill, and this means that everyone must have worn twill garments. But the fragments themselves give virtually no pointers to their precise function. One hesitates to offer an identification based on fabric weight alone or the present shape of the fragments. Wear analysis could prove to be the way out of this cul-de-sac.

b) Dyes and colour

From his analysis of the 1973-75 finds Dr. George Taylor was able to prove that at least one fifth of all the Vindolanda textiles had been dyed, although in only 9 cases could the dyestuff still be identified (26). A tapestry band (17/34c) was shown to have been dyed red with madder; but, more surprisingly, 5 of the diamond twills were red, too. Evidently clothing at Vindolanda was not drab. The only piece of check cloth (10/53) contained traces of a lichen-purple dyestuff (27).

c) Origins of the textiles

None of the Vindolanda textiles is manifestly intrusive, a recognisable product of another part of the Roman Empire. But the documents indicate a fair degree of personal import of textiles to the site, and many must have arrived on the backs of each new garrison, their officers, families and camp followers (28). Uniforms and bedding as a rule were compulsorily purchased by the unit and supplied direct to its members (29). Local sources would soon have dried up, though the weavers would certainly have been as keen as other crafts people to supply the army, if there was profit to be made from it (30). Rather, it is reasonable to assume that the resources of the whole province would have been tapped, if the processes of pottery supply to the army in the North are any guide (31).

In previous publications I have suggested that northern weavers working in the Iron Age tradition were responsible for most of the Vindolanda textiles (32). But with hindsight that is possibly too narrow a view. The range of wool fibres represented on the site would fit a hypothetical spectrum of fleece types for northern Britain (33); on the other hand a closely similar range has recently been published by Dr. M. L. Ryder for the finds from the salt mines (34). All one can conclude for Vindolanda therefore is that wools are typical for Iron Age and early Roman western and central Europe which leaves plenty of scope. The known garrisons of the fort all came from that area and particular wool imports would therefore not be detectable.

The hair moss 'cap' and the lichen-dyed check fabric are presumably from the highland zone of Britain. The gamma-decorated tunic T/545 is paralleled in the eastern provinces, but the gamma motif appears frequently in western art (35) and the textile has no distinctively eastern features. The uniformity of the half-basket weaves would suggest a single broad regional source, whether British or Gallic, for all of them. The fact that all
The tapestry-woven ornament occurs on rags from the Period III praetorilU1 -on all except T/545 from Room X -may mean that they were the personal property of Cerialis and Lepidina; but they were not eastern exotica.

The bulk of the clothing was in 2/2 diamond twill, much of it of medium weight, a little very fine. One should probably see here the principal product of the Romano-British weaver. Admittedly, fine pieces were dyed with cultivated madder, which does not grow in Britain; but its importation in dried root form would be easy (36).

Interestingly, the proportions of the weaves represented in the Hadrianic Corbridge hoard, though few in number, fit the Vindolanda pattern exactly (37) That British weavers supplied most of the needs of the army of Britain seems inherently probable.

Notes


(5) Ibid., 26-37.
(6) J. P. Wild, Textiles in Archaeology, Aylesbury 1988, 7-8; K. A. Jakes,
(9) Bender Jorgensen 1986 (note 7), 346-349.
(10) To be published in detail by J. P. Wild in L Bender Jorgensen, E. Munksgaard (edd.), The 4th NESAT Textile Symposium: Rungsted Gaard 1990, forthcoming; for western Roman tapestry see J. P. Wild, L. Bender Jorgensen, 'Clothes from the Roman Empire: Barbarians or Romans' in L Bender Jorgensen, B. Magnus, E. Munksgaard 1988 (note 1), 79 fig. 3.
(12) M. Hald, Ancient Danish Textiles from Bogs and Burials, Copenhagen 1980, 167-176: see Wild 1970 (note I), 69-72. I am grateful to H. Granger- Taylor for information about the Masada 'double cloth'.
(13) Wild 1970 (note I), 56 fig. 49; Yadin 1963 (note 2), 202, fig. 68 type 3; Wild, Bender Jorgensen 1988 (note 10), 78 fig. 2.
(16) Verulamium-St Albans: Wild 1970 (note I), 99 A49, fig. 27; Mainz (R61,1): Wild 1982 (note I), 12.
(18) Ibid., 21 BS 4.03.

(20) Like that from Les Martres-de-Veyre, Puy de D'Ome: A. Audollent, Les Tombes gallo-romaines a Inhumation des Martres-de-Veyre, Memoires presentes a l' Academie des Sciences et Belles Lettres 13, 1922, 46 no. 49, pl.X, 3 (2/2 twill).

(21) A. S. Henshall, 'Textiles and weaving appliances in Prehistoric Britain', Proceedings of the Prehistoric Society 10, 1950, 152; J. Curie, Newstead, a Roman Frontier Post and its People, Glasgow 1911, 108, 358, pl.XV; for other close links between the two sites see p.10 on the leather chauss frons.

(22) Kind information from Dr. A. K. Bowman: to be published in due course by A. K. Bowman, J. D. Thomas and J. N. Adams.

(23) Cloaks: Yadin 1963 (note 2), 227-232; cloak converted to tunic: unpublished information from L. Bender Jorgensen (Mons Claudianus); Wild forthcoming (note 10).

(24) Wild 1977 (note 3), 6-7; but see Audollent 1922 (note 20), 13, tombe D, coffm I for girdle in situ in grave.


(27) Taylor 1983 (note 26), 119-120.


Environmental Evidence

by Professor M. R. D. Seaward

Exposure of the pre-Hadrianic deposits at Vindolanda provided an unprecedented opportunity for environmental reconstruction, in view of the diversity, remarkable state of preservation and indeed sheer volume of biological material recovered, enabling quantitative as well as qualitative analyses to be carried out. Furthermore, information gleaned from the chance preservation of a very considerable number of artifacts, particularly writing tablets, offers many exciting possibilities for advancing our knowledge not only of the general nature of the local environment, but more particularly of the living and working conditions obtaining within a Roman frontier settlement.

Although biological materials have been preserved under similar anaerobic conditions at many other archaeological sites, Vindolanda is unique in terms of the immense scale of the environmental evidence there. Inevitably, the report which follows can provide only a broad outline of that evidence, highlighting specific areas where specialist knowledge has already been brought to bear. Initial interpretations of biological evidence by Seaward (1976) and Hodgson (1976) have been amply corroborated, with few modifications, by subsequent work.

However, much remains to be done: there is considerable scope for palynologists, dendrochronologists, botanists and zoologists, as well as soil scientists and others with the requisite specialist knowledge to determine the chemical nature of the very medium which has so remarkably preserved the artifacts and biological evidence. One major component of that evidence, namely the huge quantity of bones recovered, is still considerably under-researched, due to the untimely death of the specialist involved. Current research at Bradford University is mainly directed towards the separation/extraction of the individual biological components of the deposits and further identification and quantification of the macrophytic evidence, particularly the seeds and bryophytes, and publication on this work will be forthcoming.

Occupational Levels

The occupational debris uncovered at Vindolanda is in distinct layers, each of which is characterised by a very high organic content. Occupational debris levels are sandwiched between compacted clay (or turf) strata, an indication that the floor of the particular building had degenerated to such an extent that a new and more permanent floor was the answer to the problems. This new floor may possibly have coincided with partial or total reconstruction and/or replacement of the superstructure. It is the clay compactions which have created the pockets of anaerobic and chemical conditions (see below) that have preserved such a wide and varied range of both natural and man-made materials representative of the period.
Pollen Analysis

Detailed pollen analyses for the Vindolanda deposits and the adjacent soils have yet to be undertaken, but preliminary work on two deposits from a section below room IV of the mansio dated c. AD 90-100 undertaken by Dr. J. Turner of Durham University in 1970 has shown the dominance of *A/nus* amongst a tree component including *Betula, Quercus* and *Corylus*, a high grassland component (Gramineae and *Plantago lanceolata*) and the presence of a variety of ruderal species; there were also strong similarities between the two deposits sampled, but the presence of cereals in only one of the deposits warrants further investigation. Preliminary studies by Dr. K. E. Barber at Southampton University on the deposits from occupational level III, however, have shown pollen assemblages mainly composed of grasses and cereals to be present. More detailed data are available from Muckle Moss, 3 km ENE of Vindolanda (Pearson, 1960) which show to good effect the vegetational changes before and after the advent of Roman occupation in the area. Pearson has adopted the designation "VIII modern" for a pollen zone which begins at a depth of 150 cm and continues to the present surface. Conway (1947) dates this demarcation at AD 100 for Ringinglow Bog in the southern Pennines, and Pearson (1960) gives a date of AD 1000 for Muckle Moss. A noticeable change also occurs at a depth of 270 cm within zone VIII, where an increase in spores of *Pteridium* and pollen of ruderals such as *Plantago* spp. and certain *compositae* corresponds to a date of AD 110 according to Pearson. Occasional grains of cereal crops are to be found to a depth of 270 cm, but their presence is much more dramatic after AD 1000. However, it should be noted that the dates suggested by both Conway (1947) and Pearson (1960) are estimates based on the assumption of uniform peat growth; they have not yet been confirmed by 14C dating.

Further detailed pollen diagrams, and their interpretations, are provided by Davies and Turner (1979) for Fellend Moss, 9 km to the W of Vindolanda, and for three other sites in Northumberland. There is evidence from this work, for example, that small temporary clearances in the woodlands had occurred at all four sites prior to Roman occupation, with major forest clearance, primarily for pasture, at Fellend Moss where grassland predominated from AD 2 plus or minus 40.

Davies and Turner's work on Fellend Moss cores show that at 176 cm (dated AD 2) the curves for Gramineae, *Plantago lanceolata* and *Rumex* pollen and *Pteridium* spores begin to rise and at 168 cm they rise to very high values. Moderately high values are maintained until 132 cm (dated AD 620). These values indicate that much of the forest was cleared and that the land was being used partly for growing crops, for there is cereal pollen at 169 cm, but mainly as pasture. The period embraces the Roman Iron Age, the Romano-British period and early Anglo-Saxon times. With 176 cm dated to AD 40 plus or
minus 45 (corrected) and 168 cm, by using the estimated rate of peat accumulation to approximately AD 148 plus or minus 45, it is tempting to associate the very high values for the herbaceous pollen types at 168 cm with the construction of Hadrian's wall, immediately to the north of the moss, between AD 122 and 130.

Jobey (1966) suggests that the native population of Northumberland increased during the Romano-British period as the result of the degree of political and economic stability which the Roman military presence encouraged. Certainly at a number of native settlement sites whose occupation spans late Iron Age and Romano-British times, the number of hut circles increased during the latter period. This being so, and given the demands for food from the garrisons, it is not surprising that forest clearance should have taken place on a larger scale than hitherto. What is interesting from the work of Davies and Turner (1979) and others is that forest clearance occurred over so wide an area, that the intensity of farming was maintained and that there was a degree of political and economic stability in the region for some considerable time after the withdrawal of the Roman garrison in AD 410.

From the results of all the above workers, the change in the flora of the mineral ground for the Vindolanda area may be interpreted at follows: (I) the development first of more open woodland conditions of mixed Quercus, with considerable Betula, probably interspersed with thickets of Corylus and Alnus in the gullies (following a climate change c. 500 BC) favouring the spread of Pteridium, (2) the continuing forest clearance, and the establishment of dense stands of Pteridium, and (3) the appearance and spread of ruderals associated with the Roman occupation.

**Analysis and Origin of Floor Materials**

The organic material of the pre-Hadrianic deposits proved to be composed mainly of Pteridium (plates XV & XV) - the fronds being easily recognisable from the mode of branching, and the sori running all round the margins of the pinnules (the latter indicating a collection date of July or August). Further constituents of the deposits included considerable quantities of straw, the junctions between this and the bracken providing the most suitable niche for the preservation of stable-fly puparia (see below), twigs of ash, hazel, oak, pine, rowan and willow (cf. tree pollen spectrum in zone VIII of Muckle Moss analysis -Pearson, 1960) and bryophytes (see below).

Other macrophytic remains of the deposits include hazel nuts, acorns, gorse pods, heather stems, puff-balls (see below), and unidentified leaves and stems. The greenness of the bracken, heather and gorse materials on immediate exposure has been erroneously described in the press, for although traces of chlorophyll-like compounds have been isolated from these plant remains, they are unstable on exposure and the phenomenon emotively referred to is probably attributable to the considerable quantity of bryophytes which have olive to light green colouration.
due to chlorophy breakdown-products (phaeophytins); alternatively, iron in a ferrous state is oxidised to the brown ferric state on exposure (G. Hendry *in litt.*).

From the thickness of the pre-Hadrianic deposits, it would appear that bracken-harvesting was a major occupation of the community at Vindolanda, for one small area (c. 30 m²) would have required at least 1 ha (2.5 acres) of well-cropped *Pteridium*. This measurement has been derived from a calculation involving a determination of the volume and dry weight of the deposits and the magnitude of the bracken contained therein, and a knowledge of present-day frond productivity and spatial distribution in a *Pteridium* determined from analyses undertaken in lowland heaths in North Lincolnshire (Seaward, 1973) and upland moorlands in Yorkshire, and from numerous literature sources (e.g. Pearsall & Gorham, 1956). It is interesting to consider here the possible uses to which bracken was put at Vindolanda, during a period when so little is known of the plant's economic importance - although Virgil (in *Georgics* Book III, lines 297-9) recommends its use as winter bedding material for penned sheep - and to relate these to pre- and post-Roman practices in Britain (see Rymer, 1976); for example, bracken is still used as bedding material in some byres of northern England. There are also strong reasons to support the view that the spreading of bracken on the Vindolanda floors functioned to some extent as a sponge for the absorption of water at times (mainly or solely seasonal) of high water-table levels.

There is some evidence to support the theory that the bracken was stored before use, and that layer upon layer...
was built up within particular rooms at Vindolanda over many months without periodic "mucking out". In a few cases, the bracken layer also contained considerable quantities of straw and other debris, including some domestic excreta (including human), the whole being impregnated with urine (probably widely used for tanning and not necessarily confined to a single workshop); one such area of the Period III buildings has been interpreted as an open yard where animals may have been penned.

Originally this medium proved to be a most suitable environment for the development of the larvae of the stable-fly (*Stomoxys calcitrans*). The puparia of this fly (Plate XVI-b) were found in abundance throughout the organic deposits -the majority being empty but quite a few containing the fully-developed imago (Plate XVI-c.3) (one could consider here the insecticidal property of the bracken). Productivity measurements showed there to be well in excess of a quarter of a million puparia within the deposits of the 30 m² area (VIA of Period III) studied (Seaward 1976a). The standard of hygiene can be well imagined, with the adult fly sucking the blood of warm-blooded animals such as cattle, horses, poultry and occasionally man.

Other arthropods were extracted at York University from the organic deposits, following the standard procedures developed by the York Archaeological Trust, whereby the animal remains are floated out of the fragmented plant debris by agitation, in a fine jet of water, after mixing the materials with paraffin. In addition, a careful visual inspection was made of a large number of intact fronds.

Entomologically, the results were extremely disappointing; the bracken had obviously been cut fairly late in the season, given the state of the expanded pinnae (Plate XVI) and a reasonable faunal diversity might have been expected. Of the species found, however, only one (*Dasyneura fricicina*) is a normal bracken herbivore, and even here, only four galls were found despite the large number of frond fragments searched. With one other possible exception, all the other arthropods were almost certainly associated with the debris on the floor of the building, rather than being brought in on the bracken. These included the beetle *Anthicus quisquilius*, a very common species in vegetable refuse, numerous dipterous pupae, and at least three common species of Cryptostigmata (oribatid mites). One of these appears to be identical with a *Chamobates* sp. found on living bracken fronds at the present time, but because of the problems involved in specific identification of this group it is by no means certain that they are the same species. However, this is certainly not impossible, particularly in view of the fact that the *Chamobates* sp. found on the fronds may, in any case, be more typically a member of the litter fauna which 'wanders up' on to the fronds (see Lawton, 1976: Appendix I).

The apparent scarcity of "normal" bracken arthropods in the Vindolanda material prompted a simple experiment at
York University, in which a sample of bracken was cut from Skipwith Common, Yorkshire (see Lawton, 1976) on 13 September 1973, and divided into two halves. One half was sorted immediately to extract arthropods, and the other half was spread on the tiled floor of an outhouse and walked on and disturbed for a minimum of five minutes at least once every day for three weeks; this material was also then sorted. *Dasyneura* galls remained readily recognisable. The approximate recovery rates of the other, free-living species are given in Seaward (1976a). It is clear that recovery rates tended to be very low with the exception of those of the mite *Chamobates*, which showed every sign of having survived, and possibly even reproduced, during the experiment. This makes it more likely that the specimens from the Vindolanda material may be the same species that is found on the living fronds, and that they alone were able to survive once the fronds were cut and spread on the floor.

Furthermore, as the bracken dried out and was trampled on in the above experiment, it filled the whole room with a very unpleasant smell. It seems unlikely that the Romans would have tolerated this, and it is therefore likely that the bracken was air-dried before it was spread on the floor. If this was the case, it would undoubtedly have led to an even greater loss of animals, and it is hardly surprising that so few typical members of the bracken fauna were discovered.

It may be concluded from the York University work that *Dasyneura ji/icina*, and perhaps the mite (*Chamobates* sp.) have been associated with bracken for at least 1900 years. There is no reason to suspect that the apparent absence of species other than these reflects anything but the treatment of the bracken prior to its being spread on the floor.

The pre-Hadrianic deposits also contain a large quantity of molluscs, including oysters, mussels and snails, bird feathers, hair, and considerable quantities of bone, including cattle (Celtic Shorthorn variety), sheep, goat, boar(?), red and roe deer, horse, dog and a diversity of birds of varying sizes (including game and poultry -see below). These bones, together with their unused adjoining tissues, and probably offal, would have been lying around and presenting a somewhat unpleasant environment; the availability of this material to the carrion bird feeders may be reflected in the large number of their feathers found.

**Bryophytes**

Within the occupational debris, two strata (Periods II & III) dated AD 90-97 and 97-102 are characterised by a very high organic content composed mainly of bracken, straw and bryophytes. The bryophytic component of these two strata is summarised in Seaward and Williams (1976). For 20 m² of the pre-Hadrianic site investigated, the volume of organic deposits has been calculated to be c. 10.2 m³, within which the most abundant species,
forming 55% of the bryophyte volume so far analysed, is *Hylocomium splendens* - the good branching material, which is several centimetres long in most cases, makes it easily recognisable in the Vindolanda deposits. Furthermore, this and other mosses in the deposits have retained much of their green colouration, which makes them relatively easy to detect and separate from the otherwise complex medium. The large quantities of *H. splendens* leaves one to speculate that it had an economic value: although it would be common in the vicinity of the settlement, it is hardly likely to have been accidentally cropped in such bulk during bracken-harvesting (see above) especially as it is not a normal associate of the Pteridietum. A limited quantity of this moss may, however, have been picked up during the collection of birch for the construction of partition walls for buildings.

Dickson (1973) refers to the frequent recovery of *Hylocomium splendens* from archaeological sites and its possible use, with other species, as packing and stuffing material. As can be demonstrated from a comparison of 19th and 20th century bryofloras, *H. splendens* is less frequent today in many parts of the British Isles. Its availability in the past, as gauged from its frequency in peat and archaeological analyses, made it, no doubt, an ideal material where quantity was of major importance. Where a large quantity of moss occurs in a Vindolanda sample, it is almost wholly composed of *H. splendens*.

The next commonest moss encountered is *Calliergon cuspidatum*, a moss with a wide tolerance of soil reaction; in all probability this moss was accidentally picked up through (1) foraging (perhaps for hazel nuts) over richer soils to be found in the gullies which supported *Corylus* and *Alnus* thickets, and/or (2) the collection of clay soils for compacting as floors over occupational debris.

A complete list of the bryophytes so far determined from, and their frequency in, the pre-Hadrianic deposits at Vindolanda is as follows:

*Brachythecium rivulare* occ  
*B. rutabulum* freq  
*cf. B. velutinum* r  
*Calliergon cuspidatum* ab  
*C. cf. stramineum* r  
*Campylium stellatum* var. *protensum* r  
*Cirriphyllum crassinervium* r  
*Climaciwn dendroides* occ  
*Dicranoweisia cirrata* r  
*Dicranum scoparium* r  
*Drepanocladus aduncus* r  
*D. cf. unciatus* r  
*Eurhynchium praelongum* freq  
*E. swartzii* r  
*Fissidens adianthoides* r  
*Hylocomium splendens* ab  
*Hypnum cupressiforme* ab  

(some collections referrable to the next species)
Environmental Evidence (8)

H Jutlandicum freq
Isothecium myosuroides occ
Neckera complanata freq
N.pumila r
Plagiomniwn affine r

(according to Dixon (1973), doubtfully found in British Pleistocene deposits and records should be referred to P.ellipticum; the Vindolanda material is not referrable to the latter, and ratification awaits collection of further material)

P.rostratum r
P.undulatum freq
Plagiothecium denticulatum r
Pleurozium schreberi freq
Polytrichwn commune r
Pseudoscleropodiwn purum com
Rhynchostegiella tenella occ
Rhynchostegiwn confertum r
Rmurale occ
Rhy tidiadelphus squarrosus ab
R.triquetrus r
Sphagnum palustre r
Thuidium philiberti r
T.tamariscinum corn

(ab = abundant; corn = common; freq -frequent; occ = occasional; r = rare)

Plate XVI-a Pre-Hadrianic (left) and modern (right) bracken pinnae view form beneath to show mature sori indicative of a similar date of collection (i.e. August).

Plate XVI-b Imago of stable-fly (Stomoxys calcitrans) dissected out from puparium to show labella (A), proboscis (B), swollen bulbous base of proboscis (C), and the third antennal joint (D).

Plate XVI-c Intact puparium of a stable-fly (Stomoxys calcitrans) from pre-Hadrianic deposits (length c. 8.5mm)
It is not possible at this stage of the investigations at Vindolanda to determine bryophyte measurements in absolute values. Nevertheless, it is apparent from the preliminary analyses of occupational levels described above that mosses were harvested in significant quantities to furnish economic needs, and furthermore, that selective collections of certain hypnoid mosses from specific habitats (heathlands, wet grasslands and woodlands) may also have been made.

The uses to which these mosses were put is not as yet clear, although there is strong reason to believe that at Vindolanda they were employed for their bedding, packing, insulatory and absorbent qualities. They may have provided not only packing but also insulation (especially when moist) for the storage of perishable materials such as fruit and vegetables. However, the value of mosses as packing material between wall timbers, many of which are unfashioned, needs primary consideration. This hypothesis is strongly supported by present-day practices. Specific insulatory and/or fire-proofing qualities, provided in much the same way as Fontinalis antipyretica has been employed in Sweden for filling spaces in chimneys and walls to exclude air, may be of further importance. Consideration should also be given to the use of mosses for general bedding material for man and his domestic animals, and/or the absorption of water (and perhaps urine?); bryophytes may well have been usefully employed as wound dressings and for sanitary purposes. There are strong reasons to support the view that the spreading of bracken and bryophytes on the Vindolanda floors functioned to some extent as a sponge for the absorption of water (Seaward, 1976a).

The impression gained from an examination of the literature on bryophyte remains recovered from archaeological sites is that these plants, although widely encountered, have been given scant attention in terms of their possible economic importance to man. A review of the uses to which bryophytes have been put in the past is provided by Dickson (1973, Chapter 8) and Seaward and Williams (1976). From the authors' experience of material examined from sites at Vindolanda and at York it is, however, apparent that mosses were often collected in considerable quantities and were therefore in all probability put to economic use.

Finally, one should not forget the value of bryophytes to the archaeologist in his interpretation of the prevailing environment. The mosses recovered from the Vindolanda site are indicative of a diverse vegetational cover (grassland, heathland and woodland) on acid and clay soils around the settlement. The bryophyte assemblages recovered from the deposits match plant communities known to have occurred over wide areas at this site, as can be gauged from our knowledge of 19th century bryofloras.
**Fungi**

Two species of puff-ball, *Bovista nigrescens* and *Calvatia utriformis* of the Lycoperdaceae have been discovered in the pre-Hadrianic deposits (Watling & Seaward 1976). *Bovista nigrescens*, a species also recorded from archaeological sites at Skara Brae, Orkneys, at Stanwick, North Yorkshire, and in a Roman well at Scole, Norfolk, is more numerous than *Calvatia utriformis* in the Vindolanda deposits.

*Bovista nigrescens* (Plate XVII) was identified by the warted, distinctly pedicellate basidiospores, 5-6 cm in diameter, and the free capillitium threads with acute branching. Furthermore, the purple-chestnut colour of the spores had been retained during preservation, as had the overall purple-brown colour of the fruit-body. *Calvatia utriformis* was identified by the smooth basidiospores up to 5 ~m in diameter with very short pedicel, and the capillitium threads. The important single distinguishing character is the large sterile base which constitutes the larger part of the subglobular fruit-body.

All fruit-bodies were fully mature and showed no signs of the two-layered peridial structure of the immature specimen. It is particularly interesting that over a period of nearly 2000 years no morphological differences could be detected between the fruit bodies of the two species from both archaeological and the modern collections (Plate XVII).

The Vindolanda material agrees approximately in age with that found at Stanwick (i.e. first century AD). This discovery was perhaps a chance fruit-body, being associated with willow, hawthorn and elder debris (Wheeler, 1954). The Norfolk find also probably refers to a chance fruit-body, the associated material in this case being Roman sandals and pieces of fashioned woodwork, all in a good state of preservation. The well in which they were found was probably ruled in during the second century AD (P. W. Lambley, *in litt*). To date, 13 fruit-bodies of *Bovista nigrescens* have been recovered from Skara Brae (Watling 1975) and three of *B. nigrescens* and two of *Calvatia utriformis* from Vindolanda; in these numbers they cannot be regarded as chance occurrences.

A varied range of fungi was widely eaten in Roman times, more usually as a luxury food, and their collection and use are referred to by Horace (c. 65-8 BC) and avid (c. 43 BC-AD 19). However, the puff-balls found at Vindolanda may have arrived there naturally or, more likely, they had been collected for some purpose other than for eating. Surgeons in the late part of the 19th century used puff-ball powder as a haemostatic; in more recent years the use of puff-balls as a styptic in veterinary work has been proposed. Ramsbottom (1953) quotes the Romany phrase "*Quanda mandi chivs moilee ke vindi morripude*" (when a man cuts his finger he uses a puff-ball) and also indicates that a string of dried puff-balls may occasionally still be seen strung by the fireplace in farm kitchens in case of emergency. There is strong
reason to believe that puff-balls were used as tinder at Vindolanda; perhaps the farmhouse puff-balls might also have been used for this in addition to, or alternatively, for medicinal purposes.

Presumably puff-ball mycelial "wool" would be suitable for stopping up draughts in walls constructed of interwoven branches of various tree species (Seaward, 1976) or as packing between unfashioned woodwork in much the same way as bryophytes are used in some countries to this day. Smoke leaks in fire-places may have been treated in much the same way as the moss Fontinalis is used. However, the first suggestion, while feasible, would depend on reasonably large quantities of such "wool" being available, which seems unlikely and the second would seem to be ruled out on the grounds of sparks causing smouldering and eventually fire. Other uses for puff-balls are discussed by Watling and Seaward (1976).

**Recovery of Viable Bacterial Spores**

The pre-Hadrianic occupational layers seemed to be an ideal substrate in which to look for Thermoactinomyces endospores since those of *T. vulgaris* have been isolated from present-day bracken litter, and are commonly associated with stored cereals and straw, and exhibit longevity. Sections about 13 cm long (c. 700 cm³ in volume) were cut from a freshly exposed vertical face of an excavation trench wall from a Period IV floor in room XVI. These were stored in tightly sealed polythene jars at room temperature. Samples for microbial analysis were removed from the centre of each section after slicing it from top to bottom with a sterile knife. High numbers of *Thermoactinomyces* spp. were recovered from the occupational layers and smaller numbers from the compacted clay between these layers and from the infill above the deposits (fig. 1).

Since stratum I can be dated between AD 90 and 97, there is strong evidence that spores have survived for 1900 years. The chemical conditions of the deposits have contributed to the survival of viable *Thermoactinomyces* endospores. The persistence of biodegradable materials in these deposits suggests low or non-existent microbial activity, brought about by anaerobic conditions, a high water table and a low temperature. There is a highly significant correlation between the colony count and the presence or absence of occupational strata (Seaward et al. 1976).

It seems therefore that counts of microbial taxa with specific environmental demands may prove valuable in archaeological interpretation. In the case described above, the high temperature and oxygen requirements of *Thermoactinomyces* spp. reflects the prevailing environmental conditions within the organic media before the suppression of endospore germination by encapsulation of the deposits.
Conditions in the bracken layers have contributed to the survival of a high number of viable thermoactinomycete endospores. The persistence of materials usually considered biodegradable, e.g. leather and cloth, suggests that microbial activity in the deposits was very low or non-existent because of anaerobic conditions brought about by the compacted clay layers, the high water table and low temperatures. Endospores are unlikely to have begun to germinate, and so have survived until provided with more favourable conditions for growth in the laboratory.

Thermoactinomyces vulgaris, T. sacchari, T. dichotomica and T. candidus have been identified among the isolates. Taxonomic investigations have also revealed that the relative frequency of the Thermoactinomyces spp. differed markedly between the pre-Hadrianic deposits and recent soil strata. Furthermore, strains of both T. vulgaris and T. dichotomica which differ from those considered typical of the currently recognised species are sometimes found within the deposits (Unsworth et al. 1977). The endospores recovered from Vindolanda are true remnants of the ancient microbiota. Since 1900 years is an appreciable period in the evolution of bacterial species, the organisms may also provide interesting information about their own evolutionary history.

Recent work has confirmed our hypothesis based on the Vindolanda work (Unsworth et al. 1977) that Thermoactinomyces spp. can be effectively employed in palaeoecological studies: Nilsson and Renberg (1990), for example, have demonstrated that T. vulgaris can be used as a palaeoindicator of agricultural activity, complementing pollen analysis.

Fig. 34. Recovery of thermoactinomyces

1. Highly organic, composed mainly of straw and bryophytes
2. Moderately organic, with high percentage of mineral soil.
3. Compacted clay
4. Highly organic, composed mainly of bracken, straw and bryophytes.

(Adapted from Unsworth et al. 1977)
Seeds

The following methodology for the separation of macrobiological material from the pre-Hadrianic deposit has been developed by Mr. Steve Manifold, currently working for a higher degree at Bradford University (sponsored by the Vindolanda Trust); he has also been responsible for a considerable amount of sorting/separation of a wide range of materials and for the identification of the seeds.

Extraction

Due to the small volumes of samples, bulk sieving techniques were considered inappropriate (cf. Kenward et al. 1980). The samples from Vindolanda are, as described above, very rich in a wide variety of macro-botanical material. In certain cases these materials, due to their low density compared with their soil matrix, can be separated by one of several flotation techniques (Butter, 1982; Keeley, 1978; Wa~on, 1976). Many of these techniques are both cumbersome and time-consuming. When confronted with heavy soils, such as clays, such techniques (e.g. froth flotation) prove difficult to manage and are better suited to lighter soils with low organic concentrations. Initial examination of the Vindolanda samples showed that abundant biological materials were present.

On the basis of previous work at this site (Seaward, 1976), a method for the retrieval of the biological material based upon a particular characteristic of the deposit was employed, since within a given context (and therefore a sample) there was lamination due to the settling effect of the material within the deposit which does not appear to be due to any deliberate taphonomic processes. Furthermore, the method employed in the excavation of the samples ensured that the deposits investigated were in the form of blocks, with the integrity of the original deposit intact.

The suggested method therefore was a relatively straightforward one, with the added bonus of throwing light upon the taphonomic processes involved in the build-up of the deposit. The method involved the dissection of the sample along its line of sedimentation. In this way, material could be extracted and examined layer by layer. Unfortunately, although it was realised that this method would be slow, it was not envisaged that it would be as time-consuming as it proved to be. In fact it proved so inefficient in terms of time that it was abandoned and replaced by a less labour-intensive method.

Several alternative methods were considered, but the paraffin flotation method, originally devised for the extraction of terrestrial arthropods and later developed for Pleistocene insect analysis (Southwood 1978, Coope & Osborne 1967), was eventually adopted. The main advantages of this method are that it is cheap (in terms of materials), easy to operate and, above all, highly
effective. Even so, the operator must be well practised in the method, otherwise total recovery cannot be guaranteed (Kenward et al. 1980). This technique has proved very satisfactory for the recovery of insect remains and carbonised material, such as seeds.

Sorting

After complex procedures for the disaggregation of samples, and the flotation, sieving and decanting of biological components, the separation of the latter into their constituent parts is the most time-consuming aspect of the entire operation, a point acknowledged by a number of authors, e.g. Pearsall (1989). Even so, hand-sorting, although time-consuming, is still the commonest method employed. The aim of this sorting is to remove the biological material of archaeological interest or biological artifacts from the general detritus and any contaminants carried forward by the extraction techniques.

Each retent of a sample is sorted separately by placing it little by little into a shallow petri-dish. This aids identification in three ways. Firstly, the material is of a similar size, so that sorting and identification is quicker as most dissecting microscopes, as in this case, have a narrow depth of focus. If one had to look at a range of sizes of material simultaneously, continual refocussing of the microscope would be necessary and the rate at which the material was processed greatly reduced. Secondly, material of the same type, e.g. a seed of a particular species, will be of a similar size, and therefore grading by eye to aid identification will also accelerate the sorting process. Finally, by placing only small amounts of material in the petri-dish for sorting, the chances of missing important items is greatly reduced. Furthermore, the psychological benefits cannot be ignored as it allows the observer to see progress being made (Bohner & Adams, 1977).

A dissecting microscope with combined magnifications of x 10 to x 30 was employed, which proved ideal for the sorting of materials down to 250 microns in size. The performance of the microscope was greatly enhanced by
the use of a fibre-optic light source, which reduced eye-fatigue and increased sorting reliability. Sorting was limited to a maximum of two hours to reduce the chance of eye fatigue (Pearsall 1989). A further advantage of this light source is that it emits a cold light, thereby reducing considerably evaporation associated with a normal light source. It was therefore very unlikely that the petri-dish would have to be refilled, a process which invariably led to the redistribution of material about the dish.

In order to further reduce the risk of overlooking material, a grid system drawn upon acetate sheets, in the manner suggested by Bohner and Adams (1977), was placed under the petri-dish, thus allowing a more systematic examination of the material.

**Identification**

At this stage the level of identification was very broad. Material was classified in the following manner: general plant material, seeds, glumes, bryophytes, wood, insect remains, carbonised material, molluscs and small mammal bones. These objects were picked out with lightweight forceps to ensure minimal damage in order not to hamper subsequent identification. Modern contaminant seeds, which can be identified but with great difficulty, were also removed at this stage. The general rule therefore was that expressed by Pearsall (1989): "If in doubt, pull it out". This held true for all categories of biological material, not just seeds. All such material was then placed in flat-bottomed glass tubes, being preserved in a standard solution of industrial methylated spirit to prevent any subsequent deterioration of the biological remains.

To date, almost 9000 seeds have been recovered from a mere 2.5 x 104 cm² of the pre-Hadrianic deposits examined, of which only 0.60l. appear to be carbonized; there are, in addition, numerous leaves, stems (some with nodes) and pericarps, most of which have proved difficult to identify. At least 136 taxa are represented, the more interesting of which are as follows:

- *Aethusa cynapium*
- *Agrostemma githago*
- *Agrostis* sp.
- *Alisma* sp.
- *Anethum graveolens*
- cf. *Aphanes arvensis*
- *Atriplex hastata/patula*
- *Brassica* cf. *napus*
- B. cf. *nigra*
- B. cf. *rapa*
- *Bromus* spp.
- *Calluna vulgaris*
- *Caltha palustris*
- *Carduus* cf. *nutans*
- *Carex* cf. *acutiformis*
- C. cf. *caryophyllea*
- C. cf. *curta*
- C. cf. *dioica*
- C. cf. *distans*
C. echinata
C. flacca/ericetorum
C. cf. flaya
C. cf. hirta
C. nigra
C. cf. otrubae
C. cf. panicosa
C. cf. psudocyperus
C. cf. remota
Carlina vulgaris
Centaurea spp.
Cerastium cf. fontanum,
Chenopodium cf. album
Cirsium arvenseldissectum -
C. cf. vulgare
cf. Chenopodium album
Coriandrum sativum (?condiment)
Corylus avellana (fracturing indicative of human
carbonized; only two of a very large sample gnawed)
cf. Crepis biennis
Eleocharis cf. palustris
E. cf. uniglumis
Ficus carica (imported fruit)
Filipendula ulmaria
Galium sp.
Juncus spp.
Gentianella campestris
Heracleum spondylyium
Hieracium spp.
Hordeum vulgare (all material carbonized)
Humulus lupulus (one specimen only)
Hypericum spp.
Juncus spp.
Leontodon sp.
Linum catharticum
Luzula spp.
Ly chnis flos-cuculi
Molinia caerulea
Myosotis sp.
Papaver cf. somniferum
Pastinaca sativa
Plantago cf. lanceolata
P. cf. major
P. cf. media
Polygonum cf. aviculare
P. cf. convolvulus
P. cf. lapathifolium
P. cf. persicaria
Potentilla cf. anserina
P. cf. erecta
P. cf. palustris
Prunella vulgaris
Prunus cf spinosa
Ranunculus bulbosus/repens
R. flammula
Raphanus raphanistrum
Rhinanthus sp.
Rorippa palustris
Rubus cf. fruticosus
Rumex acetosella
R. cf. conglomeratus
(Plate XVIII)
There is a strong possibility that wheat was processed on site at Vindolanda: the cereal debris and the seeds of the arable weed assemblages represented above are indicative of 'fine cleaning waste' resulting from sieving and characteristic of stages 12-14 of the model proposed by Hillman (1984).

The above plants are representative of a wide range of wet and dry habitats (calcareous and non-calcareous) with both light and clayey soils, including shallow still waters, stream-sides, fens, bogs, open woodland, grasslands, waste places and cultivated ground. Although several 'economic' plants which were undoubtedly cultivated locally are also represented, some species (a few awaiting confirmation) were imported from southern Britain or from Europe. It would appear, however, from these preliminary investigations that the main habitats present in the immediate vicinity of Vindolanda were either acidic damp places dominated by sedges or disturbed ground created by deforestation, building projects and cultivation; these data complement the pollen analyses (see above) which are more dependent on the identification of particular tree pollens and are less discriminating of certain non-tree pollens, particularly aquatic plants, sedges, grasses, weeds and ruderals.

**Other Macrophytes**

Other macrophytic remains identified from the deposits include walnut shells, hazel nuts (a few shells and contents of which have remained intact), and to a lesser extent, acorns, gorse pods, heather stems, and as yet very limited remains of unidentified leaves and stems. The medium has preserved a unique collection of writing tablets, the main form of which are thin slivers cut from fine-grained deciduous and coniferous wood (the former probably including lime (*Tilia*), presumably imported since this genus appears to have been rare in this region at that time according to pollen analysis -cf. Pearson, 1960; Chapman, 1964; Oavies & Turner, 1979). Similarly, the various timbers and unfashioned wood
used at Vindolanda for buildings, artifacts, etc. have yet to be subjected to detailed examination in terms of the species employed and their frequency of usage. Such data, together with that derived from the writing tablets, will hopefully shed more light on the Vindolanda economy, particularly in respect of importation of particular materials, and on the nature and extent of relatively local wooded areas, and on the nature of the landscape in general.

Animal Remains

The sections on domestic animals and game are compiled from edited extracts from the late George Hodgson's general accounts, published in 1976 and 1977. The nature, extent and whereabouts of the original notes on which this account was based are unknown. Furthermore, a very considerable amount of additional animal material, mainly bones, has subsequently been obtained from excavations. A detailed analysis of this material is crucial for a more complete understanding of the role of animals in the life and economy of Vindolanda.

Several tons of bones and bone fragments have been recovered from Vindolanda, mainly from animals eaten as food; however, the material represents the waste remains discarded after slaughtering and the butchery or dressing of carcasses; the remains of meals; the skeletal remains of animals that died or were killed on the site and which were not there for their food value - e.g. rats and mice; animals that were not concerned directly with the supply of food but were kept alive as working animals, pets and mascots - e.g. horses, mules, cats and dogs; parts of animals kept for keepsake value, such as trophies, emblems, curios, charms, symbols and medicines; or artifacts - i.e. objects fashioned by man from bone, antler, horn hoof or tooth.

It seems that at Vindolanda, as at many other Roman sites in Britain, the frequency of meat according to species was beef, mutton, pork, goat, venison, bird (including goose, duck and fowl), fish, shellfish and other molluscs. We
cannot be certain to what extent, if any, horse and dog were eaten. The evidence for the eating of these two animals is conflicting - the bones of horse often appear to have been smashed as though to extract marrow while those of dog are usually whole. It seems reasonable, therefore, to assume that horse-flesh was eaten (at least by dogs) when horses died but that dog-flesh was not normally eaten.

Once we know more about the optimum size, age and weights of the animals slaughtered, the better able we shall be to understand the market forces obtaining at Vindolanda. The direct evidence of the animal bones, taken in conjunction with the immediate local evidence of the writing tablets (quarter-master stores accounts), provides the potential for an interdisciplinary study of the economy of the whole site and its hinterland as well as a study of Roman animal husbandry and dietary habits.

Further quantitative analyses of the Vindolanda bone material are wanting, particularly in respect of bone dimensions, which may answer some important questions relating to domestication - and why do certain bones of a particular species turn up more often than others? The Vindolanda material has also yet to be subjected to other investigative techniques; for example, teeth scrapings sometimes reveal the remains of cells from the grasses that the animals ate. These cells are often well preserved because they have silica-impregnated cell walls. It should also be possible to identify the grass species from which they came, to gain some idea of the type of grazing available. Attempts should also be made to identify some of the amino-acids present in bone remains and to discern differences between wild and domesticated strains of the same species, e.g. pig, or to discover if the animals of one species came from a common genetic stock e.g. a closed herd or flock.

Many other questions relating to animal husbandry at Vindolanda have yet to be addressed; animal breeding, slaughtering methods, summer grazing and winter feeding arrangements are just a few of those areas requiring further study.

Care must be taken not to claim too much from the bone evidence, since the bones preserved represent only a sample of the animals reared and hunted during the Roman occupation. Of the bones preserved in the ground, only a sample (several tons) has been recovered, so we are dealing with a sample of a sample. However, since this sample is so large and so well preserved, it gives us the chance to learn more about Roman food habits, the practice of butchery and animal husbandry, the animals themselves and something of the economy and ecology of Vindolanda.

For general accounts of the Roman diet see Brothwell and Brothwell (1969) and Wilson (1973), and for a more detailed analysis of the mammalian bones at Vindolanda see Hodgson (1976).

**Cattle**

The cattle from Vindolanda are apparently all from Celtic Shorthorn stock (*Bos brachyceros*). The horn cores of the
Vindolanda cattle are small, but some of the long bones from cattle are massive - almost as large as those of the wild Aurochs. One of the research problems is to try to discover if this massivity is inherited from an ancient huge ancestor (possibly the Aurochs) or whether it is the result of the Romans introducing new specially bred animals, e.g. large draught oxen. The cattle were used as transport and to provide meat, calves, milk, hides, tallow, horn and hoof as well as possibly having some religious significance.

Just how meat supplies were arranged is as yet unclear. One possibility is that attached to the fort at Vindolanda was a regimental grazing ground (pratum-te"itorium) on which cattle were grazed under the care of herdsmen (cf. writing tablet 943 relating to the supply of grain to "the herdsmen in the woods", see Volume II p.58). Whether cattle were actually wintered and bred on such pasture is not known - it seems more likely that they were bought from civilians and kept on the hoof until needed, being fattened up meantime. The military zone between the vallum and the Wall may have been used as a safe grazing ground or vivarium for military-owned animals. It follows therefore that if cattle were provided for the Roman army by some of the native population, these cattle need not necessarily have been raised locally but could have been driven long distances from where the collaborators lived. A study of place names may throw some light on the subject.

Sheep and Goats

The skulls of these animals are readily distinguished, but it is difficult to separate some of the long bones of sheep from those of goat. At Vindolanda, the Romans certainly kept both animals. The sheep were prized mainly for their wool, the main source of raw material for making warm clothes, and in some cases for the supply of leather for shoes (see above - footwear); presumably for this reason they were kept in larger numbers than were goats. Goat hair was used to make ropes and a rough coarse haircloth (cilicium) which may have been used to make tent coverings. Both sheep and goats were used to provide milk (from which cheeses were made), lambs or kids, meat, skins, horn, hoof and fat. Both species may have been used to "knock the top off" rough pasture and prevent it from reverting to the wild, thereby keeping it available as pasture for the softer mouthed cattle and horses.

The sheep of Roman times were tiny by comparison with present-day common breeds and seem to have had small spindly legs that supported a body no bigger than that of a small terrier dog. These sheep have often been likened to the So ay sheep found on the island of St. Kilda in Scotland. Dr. Michael Ryder in reviewing the history of sheep breeds in Britain has suggested that the Romans may have crossed this indigenous "So ay" type of sheep with the ancestor of the Spanish fine woolled Merino. They could have produced improvement in fleeces sufficient to explain the presence of the fine wool retrieved from Roman textiles on northern sites, including Vindolanda, without producing any great increase in size of carcass.
The data from Vindolanda suggest that most of the animals died or were killed in the summer months, and not, as might have been expected, in the autumn. Of the sheep dying within their first two years of life, most seem to have died or to have been killed in their second summer. This may be due to sheep being grazed on high ground and brought down to be killed at the end of summer grazing. About a third of the sheep seem to have survived into their third year of life. This figure may be on the high side, since until we know more about the methods of animal husbandry, we cannot be certain that the sample of bones includes those from the ewes and lambs lost prior to and during lambing away from the site of Vindolanda.

**Horses**

Surprisingly few horse bones have been recovered from Vindolanda, in view of the fact that the Fourth Cohort of Gauls stationed at Vindolanda probably numbered among its ranks 120 cavalry and 360 infantry. In addition to the horses and ponies of the cavalry, it seems reasonable to assume that there would be mules or asses at Vindolanda to be used in connection with the nearby lead mines and other transport tasks (cf. writing tablet 946, showing Octavius' reluctance to wear out his mules when the roads were in a poor state -see Vol. II). Just what the stabling and grazing arrangements were at Vindolanda is far from clear. So far no Roman fort buildings in northern England are known with certainty to be stables.

The horse bones from Vindolanda are mainly from ponies of both slender and broad-boned types. Some of the Vindolanda ponies seem to have been of what Professor Ewart has called the native Celtic type. We know from the writings of Caesar and the words of Dio Cassius that these active wiry horses were a very effective war tool in the hands of the British, so there is no reason to suppose that the Romans found them any less useful. The Vindolanda material will probably allow us to compare 1st and 4th century horse remains and thus to test Ewart's hypothesis that the native breeds of horses in Britain were improved by foreign horses brought from Spain, North Africa and Gaul.

It was previously mentioned that it is surprising how few bones of horses have been recovered from Vindolanda. The same may be said of horse-shoes. Although horse-shoes have been found on the site, they are by no means common. It may be that some of the horses were not shod. Horse and cow-hairs are frequently to be found in the Vindolanda deposits, together with combs containing these hairs and no doubt used for grooming.

**Deer**

The bones and antlers of deer have been reported from several military sites in the region of the Roman Wall. The antlers of deer are shed each year, therefore unless the antler is attached to the skull, it cannot be taken as representing an individual animal.

At the nearby Roman site at Corbridge, over a period of ten years the annual excavations have revealed only some
half dozen deer bones among the thousands of bone fragments from other food-forming animals. In contrast, at Vindolanda, only a few kilometres away, the percentage of deer bones is much higher, suggesting that deer were hunted more often by the soldiers at Vindolanda.

The antlers of red deer (*Cervus claphus*) from ancient sites are often much more massive than those obtained from British red deer today. This reduction in antler size may be due to the nutritional insult deer have received in the form of calcium deficiency since they have been forced from wooded lowlands to upper moorland. This change in habitat was brought about since Roman times and was primarily due to the destruction of woodlands. Often when red deer are released in regions of more lush wooded vegetation they show a marked increase in antler size. One deer antler from Vindolanda was reported in the last century as being 23 cm round the base. This specimen has been lost and may have come from elk (*Alces alces*), for these animals have been reported from nearby Roman forts of Newsteads and South Shields.

The bones and antlers of red, roe and fallow deer have been recovered from Vindolanda. Some authors have maintained that deer were hunted merely for sport and were sacrificed only on festivals associated with hunting, e.g. the annual festival of Diana, the Goddess of Hunting, on 13th August. The Vindolanda writing tablets make it clear however that venison was issued to the troops as part of their rations. Whether venison was procured by official or unofficial military parties or by civilian providers of meat matters little, for the fact remains that it was eaten at Vindolanda when it was available.

**Pig**

We know from the Vindolanda writing tablets that pork and bacon usually constituted part of the military diet. The pig remains from Vindolanda are mainly those from young animals (piglets to yearlings) and there is very little evidence of older breeding stock or of wild boars. Wild boars undoubtedly did exist in some numbers in the surrounding countryside and they were probably hunted as food as well as for sport.

What the system of pig rearing was is rather obscure. From an analysis of the bones from nearby Corbridge, it would appear that the Romans had an athletic free-running type of pig present on their military sites (cf. writing tablet 943, where grain is supplied to t. Lucco with the pigs”). Comparison of bone structure with modern pigs is made the more difficult because pigs have changed shape so radically even over recent years: a pre-Second World War pig was typically 'hog’ or 'round backed’ while today's farm pig is long and flat-backed.

**Other mammals**

The bones from various small mammals such as cat, mole, hare, fox, badger, mice and voles are present. Some of these, e.g. hare, would constitute regular items of diet, whilst others would only occasionally figure in the diet or were perhaps never eaten.
Surprisingly, we have as yet no evidence of bear, wolf or beaver, all of which are reported from some other Roman forts in Britain.

**Birds**

The bones from several species of bird (wild and domestic) have been recovered from the site. These bones are in remarkably fine condition and many of them would appear to be the remains of meals eaten by soldiers or civilians. The bones represent species which range in size from small birds about the size of a sparrow (*Passer passer*) to those the size of a large bird such as a goose or swan. The majority of the bird bones, however, compare vary favourably in size, range and shape with those of the present-day domesticated hen or fowl (*Gal/us gal/us*). A detailed study of the bone dimensions may lead us to understand something of the commercial forces operating on chicken production in relation to meat supply.

Although more detailed work on the identification of individual bird species has yet to be carried out, we may anticipate with some confidence that the Vindolanda bird bones represent the remains of: birds raised in captivity, e.g. chickens (cf. writing tablet 839, see Volume II) and geese; birds hunted, trapped or snared, e.g. wild duck and goose; birds that died or were killed on the site and whose carcasses did not contribute materially to the food reserve, e.g. carrion crow, whose feathers are found in association with some of the debris on rubbish tips; and occasional delicacies, possibly of an exotic variety.

Several bird feathers have also been extracted from the Vindolanda deposits, but as yet have not been subjected to detailed examination. However, the numerous carrion bird feathers found may reflect the availability of discarded bones and attached meat, inedible material, etc. which would have contributed to unpleasant elements of the Vindolanda environment.

**Fish**

Fish remains are poorly represented, but we know from the Vindolanda writing tablets that fish sauces were much prized by the Roman soldier, and that food poisoning from fish was not unknown (Bowman & Thomas, 1974). Until fish scales are unearthed, it will be difficult to make certain diagnosis of the species of fish present.

**Shellfish**

Shellfish at Vindolanda are represented by oyster (*Ostrea edulis*), mussel (*Mytilus edulis*) and winkle (*Littorina littorea*), but so far limpets, which turn up at other northern Roman forts, are absent. It must be remembered that some of the shells of shellfish may be present on site because they were used to make lime for mortar or cement and are not necessarily indicative of what was being eaten. Some of the oyster shells studied bear the skeletons of bryozoan colonies inside the shell, indicating that the oyster was dead when the shell was harvested. This could mean that the shell was collected in error or for its lime value.

However, the large number of oyster shells, and to a lesser extent mussel shells, at Vindolanda bears witness
to the Roman liking for sea-food, especially shellfish; both oyster and mussel shells are widely distributed in Roman sites (Davies, 1971), and efforts were made to send them considerable distances inland (Vindolanda, being less than 60 km from the east coast, would present no major problems in catering to the Roman palate).

So far there are no remains of the freshwater mussel (*Anodonta cygnea*), a source of high quality freshwater pearls in Roman times.

**Other molluscs**
The acidity of the medium (see below) would not have been conducive to the preservation of the more delicate snail shells. A specialist report on land and freshwater snails is lacking, but the following species have been identified/confirmed by Dr. K. D. Thomas:

**Freshwater shells**
These are represented by the bivalve genus *Pisidium* and by the gastropods *Lymnaea truncatula* and *Planorbis leucostoma*. *Pisidium* shells are very difficult to identify to species level and since only one valve was represented here it was not identified beyond genus. The two species of gastropod may be found in a wide variety of aquatic habitats, from shallow well-aerated waters to temporary ponds or marsh habitats. Although it is dangerous to argue about "absence" in any context, and especially one such as this in which the evidence is sparse, the presence of only these species may indicate marshy or temporary aquatic habitats rather than permanent water bodies. Of course, the shells need not have been *in situ* but could have been dumped in with aquatic vegetation brought onto the site from elsewhere. Thus, we should not necessarily postulate that these shells indicate that the deposits below them were waterlogged.

*L. truncatula* is the intermediate host of the liver fluke *Fasciola hepatica*; this may be of some significance to the health and vigour of the sheep and cattle which lived on and around the site.

**Land shells**
These were fragmentary and only one genus was identified with a high degree of certainty. *Cepaea hortensis* and *Cepaea nemoralis* were present. Other species resembling *Cepaea* were found but they may also have been of *Arianta*. In view of the absence of other shell fragments attributable to *Arianta*, it is suspected that all should be assigned to *Cepaea*. The species of *Cepaea* may be found in a very wide variety of habitats and so are not very useful in ecological interpretation. No smaller species were found, either because they were missed in excavation or because they were not preserved in the rather acid (pH 5.3-5.6) medium (Seaward, 1976). In some cases the outer protein layer covering the shells (the periostracum) has been preserved, although the colour has darkened. It is surprising to find calcareous and proteinaceous materials preserved in the same environment, especially where the environment is moderately acid. Anaerobic and chemical factors may have contributed to the preservation of the organic materials.
It is not possible to reconstruct the environmental conditions from these few shells. Certainly, the marine ones tell us nothing about the environment of the site. Until we know more about the hydrography of the site it will not be possible to interpret the freshwater molluscs found in the deposit.

The Romans are well known to have enjoyed eating snails and it may be that the so-called Roman Snail found locally owes its name to their influence on its spread. Land snails are easily transported over vast distances because they can close up and survive desiccation during a long journey without dying or needing to be preserved.

Preservative Qualities of the Deposits

The predominantly bracken deposits (strata II and III) and the straw and occupational debris deposits (mainly IV, and parts of II, III and V), between the compacted clay or turf strata of the pre-Hadrianic period are encapsulated in anaerobic but not water-logged conditions, and together with the urine impregnation provide a remarkable medium for the preservation of a range of natural and man-made materials. Strata II and III are characterised by a very high organic content, 61-89%. by dry weight; this and the adjacent mineral soil have a water-holding capacity of 68-72% in situ.

The chemistry of this medium warrants further investigation. It would appear that its preservative quality is connected with the large amount of organic material; the production of "tannins", on the death of plant cells, is anti-bacterial. Further tannins are contributed in this instance by the considerable quantity of leather material present in these deposits, and there is the further possibility that tannins may have been purposely produced on these and other premises for leather-work, as is indicated by the extensive number of off-cuts present, and the urine-impregnated medium.

Vivianite, a form of iron phosphate, is much in evidence; the enormous quantity of bones present in the deposits(see above) would contribute to phosphate availability. The pH measurement of the organic deposits and occupational debris from all the pre-Hadrianic levels so far studied were remarkable in their homogeneity, all being within the limited range of 5.3-5.6.

Two major factors need consideration in the interpretation of the nature and content of the pre-Hadrianic deposits at Vindolanda: the first concerns the chemical complexity of the bracken, and the second concerns the chemical complexity of the organic deposits in toto. Bracken has an interesting chemistry and contains a wide range of secondary plant products. Its chemistry varies with its development, and it is worth considering the stage at which the harvested bracken was utilized on the Vindolanda floors. The chemical composition of the organic deposits in toto and its role in the preservation of these materials is even more complex; bracken may contribute much or little to this phenomenon. It remains to be seen if bracken is a common constituent of further pre-Hadrianic exposures at Vindolanda, and how the knowledge gained from this work can be applied to other comparable archaeological sites.
**Acknowledgements**

Environmental work at Vindolanda has drawn, and indeed continues to draw, upon a wide spectrum of knowledge and support from specialists in many fields, including Dr. K. E. Barber, Mrs. E. Broadhead, Mr. S. Davidson, Dr. A. Headley, Ms. V. A. Hinton, Prof. J. H. Lawton, Mr. S. Manifold, Dr. M. E. Newton, Dr. A. R. Perry, Dr. K. D. Thomas, Dr. J. Turner and Dr. R. Watling. We are extremely grateful to all those named above and to the many others, too numerous to mention individually, whose help in many ways amply demonstrates the interdisciplinary nature of this approach to archaeology. The author is also grateful to the Vindolanda Trust, the Yablon Trust and the University of Bradford for financially supporting much of the research upon which this report is based.

**Bibliography**


Hillman, a. (1984) Interpretation of archaeological plant remains: the application of ethnographic models from


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TREE-RING ANALYSIS OF ROMAN TIMBERS FROM VINDOLANDA, NORTHUMBERLAND

by Miss Jennifer Hillam

Summary

Tree-ring analysis of thirty-one wood samples from Vindolanda was undertaken to provide an independent dating framework for the site. Of the fourteen samples suitable for dating purposes, twelve were dated and produced a 351-year chronology for the period 248 BC - AD 103. The resulting felling dates were less precise than had been hoped due to absence of sapwood, although at least one of the Period IV timbers was felled in AD 103/4.

Introduction

Tree-ring analysis of 31 wood samples from Vindolanda was undertaken as a pilot study to provide an independent dating framework for the site. The existing dating evidence is based on coins, writing tablets and general archaeological or historical data. Dendrochronological analysis of Roman timbers from Carlisle Annetwell Street has already proved that such evidence can be misleading (Groves 1990). There the tree-ring dates indicate that the construction of the first fort was begun in AD 72/3 and not in AD 79 as had been implied from the writings of Tacitus.

The provisional chronology for the multiple occupations of Vindolanda is detailed on slide 10.

Period I produced no tree-ring samples, but four were obtained from Period II and nine from Period III. Of the eight Period IV samples, W107, 118, 200, 201 and 713 were thought to be contemporary, as were the five water pipe samples which could belong to either Period IV or V. Of the five samples from Period V, W556 was definitely reused and W460 possibly reused from Period IV.

Methods

The samples were identified so that they could be divided into groups of oak and non-oak. Dendrochronology in the British Isles uses oak for dating purposes since it is the only type of wood found in sufficient quantities to enable long reference chronologies to be constructed. Other species such as ash or elm can be crossdated against oak chronologies but research into this aspect of dendrochronology is still in its infancy (Groves & Hillam 1988, 1990). For this study all the oak, ash and elm samples with more than 50 rings were measured but only the oak were used for dating. (The non-oak data will be stored and used if more non-oak samples from Vindolanda become available.)
The wet samples were prepared by freezing them for at least 48 hours and then cleaning their cross-sections with a surform plane; the dry samples were surfaced using a Stanley knife and a nailbrush. The ring widths of those samples with more than 50 rings were measured on a travelling stage connected to an Apple II microcomputer (Hillam 1985, fig. 4). (Ring patterns with less than 50 rings are unlikely to be unique and might not produce reliable dates - see Hillam et al 1987 for further details.) The ring sequences were plotted as graphs using a graphing program on the Prime mainframe (Okasha 1987). The graphs were then compared with each other on a light box to check for any similarities between the ring patterns which might indicate contemporaneity. For crossmatching purposes, the ring width data were also transferred to an Atari ST microcomputer with hard disk. The tree-ring software for the Atari was written and developed by Ian Tyers (pers comm 1990). The crossmatching routines are based on the Belfast CROS program (Baillie & Pilcher 1973; Munro 1984), and all the t values quoted in this report are identical to those produced by the first CROS program (Baillie & Pilcher 1973). Generally t values of 3.5 or above indicate a match provided that the visual match between the tree-ring graphs is acceptable (Baillie 1982, 82-5).

Dating is achieved by crossmatching ring sequences within a site or structure, combining the matching sequences into a site master, and then testing that master for similarity against dated reference chronologies. A site master is used for dating whenever possible because it enhances the general climatic signal at the expense of the background noise from the growth characteristics of the individual samples. Any unmatched sequences are tested individually against the reference chronologies.

If a sample has bark or bark edge, the date of the last measured ring is the year in which the tree was felled. A complete outer ring indicates that the tree was felled during its dormant period in winter or early spring. This is referred to as "winter felled". If the ring is incomplete, felling took place during the growing season in late spring or summer (referred to as "summer felled"). In the absence of bark edge, felling dates are calculated using the sapwood estimate of 10-55 rings. This is the range of the 95% confidence limits for the number of sapwood rings in British oak trees over 30 years old (Hillam et al 1987). Where sapwood is absent, felling dates are calculated using as termini post quem by adding 10 years, the minimum number of missing sapwood rings, to the date of the last measured heartwood ring. The actual felling date could be much later depending on how many heartwood rings have been removed.

At this stage of the study, factors such as reuse, stockpiling, or repairs have also to be taken into account. Thus whilst the tree-ring dates for the measured rings are precise and independent, the interpretation of these dates often requires other archaeological evidence.
Results

The four posts from Period II were identified by Ruth Morgan as two oak (*Quercus* spp) and two alder (*Ainus glutinosa* (L) Gaertn). None were suitable for dating purposes. Most of the Period III samples were also unsuitable (Table I). E92 and W509 were elm (*Ulmus* spp), W439 and W711 were alder, and W170 was ash (*Fraxinus excelsior* L). W513 was an oak sample with only 30 rings and W533, also oak, had been conserved in such a way that it was impossible to surface its cross-section. The remaining oak sample, W714, contained 241 rings and the heartwood-sapwood transition was visible on the outside edge (Table 2).

All the Period IV samples were oak and all but W421, which had only 19 rings, were suitable for dating purposes. The measured samples contained 72-147 rings. Bark edge was detectable on W200 and W438, whilst W107, 118 and 713 retained some sapwood rings. The ring patterns of W107, 118, 138 and 713 were almost identical, suggesting that each pair of timbers had come from the same tree. Computer comparisons between the ring sequence produced t values greater than 11 in each case. The ring widths of each pair were averaged so as not to bias any master sequence into which they might be incorporated.

The only sample from the Period IV/V water pipes which was suitable for measurement was W645C. The remainder were either oak with less than 50 rings or alder. W645C had 114 rings, 14 of which were sapwood. The outer edge was possibly bark edge.

W712 from Period V had only 36 rings and was rejected. The other four oak samples had 80-199 heartwood rings.

Dating

Comparison of the ring sequences produced two matching groups. W107/118 matched W438 (t = 6.0), whilst W201, 460, 556, 605 and 714 formed a group of five (Table 3). When master curves were made for each group they were found to match each other with a t value of 5.6. W383 also matched the two masters, so that a new master containing data from nine samples could be constructed. When the unmatched sequences were tested against the new master, W318/713 and 655 were found to match but W200 and W645C remain undated.

The final 351-year master curve contains data from twelve samples and represents 10 trees (Table 4). When it was tested against dated reference chronologies, an excellent match was found between it and the Carlisle Annetwell Street chronology (Groves 1990) over the period 248 BC - AD 103. The Vindolanda master also correlated well with other "local" sequences such as Northern Ireland, Papcastle, and Walton-le-Dale, and with chronologies from further away such as Droitwich or London (Table 5).
Once the Vindolanda master had been dated, calendar dates could be assigned to the ring sequences from each dated timber (Table 6). The heartwood-sapwood transition of the Period III timber WI74 dates to AD 49/50. Using the sapwood allowance of 10-55 rings produces a felling date range for the timber of AD 59-104.

W438 from Period IV was felled in AD 103/4, probably during winter or early spring. Most of the other dated timbers from Period IV may have been felled at the same time (fig. 35). A possible exception is W201 which has an outer ring dating to 110 BC and was therefore felled some time after 100 BC. This timber may have been cut from the inside of the tree trunk; it could also have been reused.

The same is true for the dated timbers from Period V which also appear to be earlier than expected. W556 is known to be reused and W460 thought to have been reused. However even taking reuse into account, the timbers must have come from the inner part of the tree trunk; it could also have been reused.

With average ring widths often less than 1.0 mm (Table 2), removal of 150 mm from the outside of the trunk could result in the loss of 150 tree-rings.

**Conclusion**

Although this pilot study on timbers excavated during the last two decades at Vindolanda has been successful in that twelve of the fourteen samples suitable for dating purposes have been dated, the resulting felling dates are generally not precise due to the absence of sapwood and bark edge on most samples. A precise date was obtained for the Period IV timber W438 which was felled in AD 103/104. This date corresponds well with the provisional date suggested by Birley for the Period III/IV transition.

In order to confirm this date and to provide dates for the other Periods, it will be necessary to examine many more timbers from the site. At Carlisle Annetwell Street, for example, where the precise tree-ring dates have thrown new light on previously accepted historical fact (Groves 1990), more than 600 samples were examined. From these were selected those timbers with bark edge so that felling dates precise to the year could be produced.

The present study had produced a well-replicated chronology spanning the years 248 BC - AD 103. This will provide a basic reference chronology with which to date timbers in future excavations at Vindolanda. Such a study would consolidate work carried out on timbers from other sites along the Roman North West Frontier such as Carlisle Annetwell Street or Ribchester, on which tree-ring analysis is due to start in 1991.
Fig 35. Bar diagram showing the relative positions of the matching ring sequences. White bars – heartwood rings; hatching – sapwood; broken lines – unmeasured rings; HS heartwood-sapwood transition; B – bark edge; R - Reused
### Table 1: Details or samples Unsuitable for dating purposes

<table>
<thead>
<tr>
<th>Sample</th>
<th>Period</th>
<th>Function</th>
<th>Species</th>
<th>Total No of Rings</th>
<th>Sapwood Rings</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>E91</td>
<td>II</td>
<td>Posts</td>
<td>Oak/Alder</td>
<td>-</td>
<td>-</td>
<td>Insufficient rings</td>
</tr>
<tr>
<td>E92</td>
<td>III</td>
<td>Plank covering Period II water tank</td>
<td>Elm</td>
<td>97</td>
<td>-</td>
<td>Non-oak</td>
</tr>
<tr>
<td>W421</td>
<td>IV</td>
<td>Room III post re-used</td>
<td>Oak</td>
<td>19</td>
<td>13</td>
<td>Insufficient rings</td>
</tr>
<tr>
<td>W439</td>
<td>III</td>
<td>Post, room XIV</td>
<td>Alder</td>
<td>-</td>
<td>-</td>
<td>Non-oak; insufficient rings</td>
</tr>
<tr>
<td>W509</td>
<td>III</td>
<td>Plank from ash pit, Room XII</td>
<td>Elm</td>
<td>84+</td>
<td>-</td>
<td>Non-oak</td>
</tr>
<tr>
<td>W513</td>
<td>III</td>
<td>Post with mortices, Room XII</td>
<td>Oak</td>
<td>30</td>
<td>-</td>
<td>Insufficient rings</td>
</tr>
<tr>
<td>W553</td>
<td>III</td>
<td>Door threshold, room XVIII</td>
<td>Oak</td>
<td>-</td>
<td>-</td>
<td>Unmeasurable</td>
</tr>
<tr>
<td>W645A</td>
<td>IV/V</td>
<td>Water pipe, Connector 1</td>
<td>Oak</td>
<td>35</td>
<td>-</td>
<td>Insufficient rings</td>
</tr>
<tr>
<td>W645B</td>
<td>IV/V</td>
<td>Water pipe, pipe 1</td>
<td>Alder</td>
<td>-</td>
<td>-</td>
<td>Non-oak</td>
</tr>
<tr>
<td>W645D</td>
<td>IV/V</td>
<td>Water pipe, pipe 1</td>
<td>Alder</td>
<td>-</td>
<td>-</td>
<td>Non-oak</td>
</tr>
<tr>
<td>W645D2</td>
<td>IV/V</td>
<td>Water pipe, pipe 2</td>
<td>Alder</td>
<td>-</td>
<td>-</td>
<td>Non-oak</td>
</tr>
<tr>
<td>W710</td>
<td>III</td>
<td>Plank from allow Period II water tank</td>
<td>Ash</td>
<td>75</td>
<td>-</td>
<td>Non-oak</td>
</tr>
<tr>
<td>W711</td>
<td>III</td>
<td>Pegs</td>
<td>Alder</td>
<td>-</td>
<td>-</td>
<td>Non-oak</td>
</tr>
<tr>
<td>W712</td>
<td>V</td>
<td>Base beam, room XII/VI</td>
<td>Oak</td>
<td>36</td>
<td>7</td>
<td>Insufficient rings</td>
</tr>
</tbody>
</table>
Table 2: Details of measured oak samples. Sketches are not to scale; sapwood is represented by shading; cross-sectional dimensions are not given since some were wet and others dry.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Period</th>
<th>Function</th>
<th>Total No of Rings</th>
<th>Sapwood Rings</th>
<th>Av.ring width(mm)</th>
<th>Sketch</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>WI07</td>
<td>IV</td>
<td>Beam slot, II/III No.1</td>
<td>107+</td>
<td>4+</td>
<td>0.78</td>
<td>+ 5 very wide rings</td>
<td></td>
</tr>
<tr>
<td>W118</td>
<td>IV</td>
<td>Beam slot, room II</td>
<td>100+</td>
<td>3+</td>
<td>0.88</td>
<td>+ 3 very wide rings</td>
<td></td>
</tr>
<tr>
<td>W138</td>
<td>IV</td>
<td>Beam slot, room II</td>
<td>+98</td>
<td>-</td>
<td>0.75</td>
<td>knot at inside</td>
<td></td>
</tr>
<tr>
<td>W200</td>
<td>IV</td>
<td>Beam slot III/IV No.2</td>
<td>72</td>
<td>18</td>
<td>1.22</td>
<td>felled winter</td>
<td></td>
</tr>
<tr>
<td>W201</td>
<td>IV</td>
<td>Beam slot III/IV No.1</td>
<td>139</td>
<td>-</td>
<td>1.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W383</td>
<td>IV</td>
<td>Door threshold, room VI</td>
<td>193</td>
<td>5</td>
<td>1.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W438</td>
<td>IV</td>
<td>Wall post</td>
<td>92</td>
<td>25</td>
<td>0.87</td>
<td>bark edge</td>
<td></td>
</tr>
<tr>
<td>W460</td>
<td>V</td>
<td>Base beam, room III; probably reused</td>
<td>+ 199</td>
<td>-</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W556</td>
<td>V</td>
<td>Reused base beam</td>
<td>90+</td>
<td>-</td>
<td>0.97</td>
<td>+ at least 20 rings</td>
<td></td>
</tr>
<tr>
<td>W605</td>
<td>V</td>
<td>Plank, room XIV</td>
<td>175</td>
<td>-</td>
<td>1.19</td>
<td></td>
<td></td>
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<tr>
<td>W645C</td>
<td>IV/V</td>
<td>Water pipe, connector 2</td>
<td>114</td>
<td>14</td>
<td>1.44</td>
<td>bark edge?</td>
<td></td>
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<tr>
<td>W655</td>
<td>V</td>
<td>Plank from courtyard structure</td>
<td>80</td>
<td>-</td>
<td>2.37</td>
<td>knotty</td>
<td></td>
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<tr>
<td>W713</td>
<td>IV</td>
<td>Beam slot, room IV</td>
<td>147</td>
<td>7</td>
<td>0.93</td>
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<td></td>
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<tr>
<td>W714</td>
<td>III</td>
<td>Base beam, room XVIII</td>
<td>241</td>
<td>-</td>
<td>0.61</td>
<td>heartwood-sapwood transition</td>
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</table>
Table 3: Relative dating. t values between the Vindolanda ring sequences which formed the first matching group of five. (t values less than 3.5 are not printed).

<table>
<thead>
<tr>
<th></th>
<th>201</th>
<th>460</th>
<th>556</th>
<th>605</th>
<th>714</th>
</tr>
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<tbody>
<tr>
<td>201</td>
<td>*</td>
<td>6.1</td>
<td></td>
<td>836</td>
<td>4.3</td>
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<tr>
<td>460</td>
<td>*</td>
<td>3.8</td>
<td>7.2</td>
<td>4.1</td>
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<tr>
<td>556</td>
<td>*</td>
<td>5.3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>605</td>
<td>*</td>
<td>4.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>714</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>
Table 4: The Vindolanda tree-ring chronology, 248 BC – AD 103

<table>
<thead>
<tr>
<th>Date</th>
<th>Ring widths (0.20 mm)</th>
<th>No. of trees</th>
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<tbody>
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<td>248 BC:</td>
<td>90 76 75 125 53 56 51 65</td>
<td>1 1 1 1 2 2 2 2</td>
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<td></td>
<td>70 68 57 62 57 66 52 54 52 52</td>
<td>2 2 2 2 2 3 3 3 3 3</td>
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<tr>
<td></td>
<td>58 53 61 70 52 70 61 54 54 65</td>
<td>3 3 3 3 3 3 3 3 3 3</td>
</tr>
<tr>
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<td>63 42 44 55 50 57 66 51 49 47</td>
<td>3 3 3 3 3 3 3 3 3 3</td>
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<tr>
<td></td>
<td>57 53 44 34 58 56 59 69 54 54</td>
<td>3 3 3 3 3 3 3 3 3 3</td>
</tr>
<tr>
<td>200 BC:</td>
<td>57 48 48 51 50 65 55 56 59 54</td>
<td>3 3 3 3 3 3 3 3 4 4</td>
</tr>
<tr>
<td></td>
<td>39 54 53 45 54 55 57 53 40 62</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td></td>
<td>62 57 63 39 55 60 58 50 53 54</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
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<tr>
<td></td>
<td>52 36 45 39 48 50 44 53 43 56</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td></td>
<td>56 48 47 41 57 49 43 58 55 57</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>150 BC:</td>
<td>48 47 54 58 71 60 43 46 39 52</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
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<tr>
<td></td>
<td>47 50 49 50 51 56 39 27 41 46</td>
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<td></td>
<td>49 49 44 47 46 62 51 32 34 45</td>
<td>5 5 5 5 5 5 5 5 5 5</td>
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<tr>
<td></td>
<td>50 59 53 55 51 58 66 57 66 76</td>
<td>5 5 5 5 5 5 6 6 6 7</td>
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<tr>
<td></td>
<td>79 74 68 72 52 58 51 60 77 71</td>
<td>7 6 6 6 6 6 6 6 6 6</td>
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<tr>
<td>100 BC:</td>
<td>80 80 84 80 71 84 55 57 50 58</td>
<td>6 6 6 6 6 6 6 6 6 6</td>
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<tr>
<td></td>
<td>58 60 66 64 58 67 58 79 77 77</td>
<td>7 7 7 7 7 7 7 7 7 7</td>
</tr>
<tr>
<td></td>
<td>69 85 76 67 71 68 85 67 69 62</td>
<td>7 7 7 7 7 7 7 7 7 7</td>
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<tr>
<td></td>
<td>64 80 61 57 61 63 62 49 36 42</td>
<td>7 7 7 7 7 7 7 7 7 7</td>
</tr>
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<td></td>
<td>44 47 40 55 58 56 44 43 53 54</td>
<td>6 6 6 6 6 6 6 6 6 6</td>
</tr>
<tr>
<td>50BC</td>
<td>42 44 40 54 44 53 63 58 59 62</td>
<td>6 6 6 5 5 5 4 4 4 4</td>
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<td>38 31 37 40 56 48 41 45 57 52</td>
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<td></td>
<td>40 36 34 46 50 52 45 47 50 46</td>
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<td>45 46 41 37 40 38 36 44 53 38</td>
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<td></td>
<td>41 47 31 41 52 44 49 47 49 44</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
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<td>AD 1</td>
<td>57 48 43 45 35 46 41 37 47 38</td>
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<tr>
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<td>40 44 32 39 39 37 36 49 48 48</td>
<td>4 5 5 5 5 5 5 5 5 5</td>
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<td>49 41 39 49 50 50 56 48 48 45</td>
<td>5 5 5 5 5 5 5 5 5 5</td>
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<td>56 61 61 48 46 50 50 54 55 45</td>
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<td>56 59 53 54 50 59 61 56 56 54</td>
<td>5 5 5 5 5 5 5 5 5 4</td>
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<td>43 46 47 47 55 51 55 38 39 42</td>
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<td>49 59 56 56 52 57 46 56 52 53</td>
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<td>40 38 51 67 44 56 57 62 69 66</td>
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<tr>
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<td>66 75 63 49 33 44 51 61 46 46</td>
<td>3 3 2 2 2 2 2 2 2 2</td>
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<tr>
<td></td>
<td>52 64 70 44 63 72 66 59 81 77</td>
<td>2 2 2 2 2 1 1 1 1 1</td>
</tr>
<tr>
<td>AD 101</td>
<td>64 47 40</td>
<td>1 1 1</td>
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Table 5: Dating the Vindolanda chronology. \textit{t} values with dated reference chronologies

<table>
<thead>
<tr>
<th>Chronology</th>
<th>\textit{t} Values</th>
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</thead>
<tbody>
<tr>
<td>Alcester (Baillie &amp; Pilcher pers comm)</td>
<td>3.2</td>
</tr>
<tr>
<td>Carlisle, Annetwell Street (Groves 1990)</td>
<td>12.6</td>
</tr>
<tr>
<td>Carlisle, Castle Street (Groves 1988)</td>
<td>8.9</td>
</tr>
<tr>
<td>Castleford (Hillam unpublished)</td>
<td>5.8</td>
</tr>
<tr>
<td>Droitwich, Upwich (Groves &amp; Hillam 1990)</td>
<td>5.6</td>
</tr>
<tr>
<td>London, City/Southwark. (Tyers pers comm)</td>
<td>4.0</td>
</tr>
<tr>
<td>Northern Ireland (Brown et al 1986)</td>
<td>10.4</td>
</tr>
<tr>
<td>Papcastle (Hillam 1988)</td>
<td>5.6</td>
</tr>
<tr>
<td>Walton-le-Dale (Groves 1987)</td>
<td>6.9</td>
</tr>
</tbody>
</table>
Table 6: Details of the tree-ring dates. The sapwood estimate used is 10-55 rings (Hillam et al 1987). The date of the heartwood-sapwood transition, where present, is given in brackets.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Phase</th>
<th>Date of ring sequence</th>
<th>Fell date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>WI07</td>
<td>IV</td>
<td>12 BC- AD 95 (AD 92)</td>
<td>AD 102-146</td>
<td>same tree as 118</td>
</tr>
<tr>
<td>WI18</td>
<td>IV</td>
<td>6 BC -AD 95 (AD 93)</td>
<td>AD 102-146</td>
<td></td>
</tr>
<tr>
<td>WI38</td>
<td>IV</td>
<td>73 BC -AD 24</td>
<td>AD 59-104</td>
<td>same tree as 713</td>
</tr>
<tr>
<td>W201</td>
<td>IV</td>
<td>248 BC -110 BC</td>
<td>after 100 BC</td>
<td></td>
</tr>
<tr>
<td>W383</td>
<td>IV</td>
<td>111 BC -AD 82 (AD 78)</td>
<td>AD 87-132</td>
<td></td>
</tr>
<tr>
<td>W438</td>
<td>IV</td>
<td>AD 12 -AD 103 (AD 79)</td>
<td>AD 103/4</td>
<td>winter felled?</td>
</tr>
<tr>
<td>W460</td>
<td>V</td>
<td>244 BC-46 BC</td>
<td>after 36 BC</td>
<td>re-used?</td>
</tr>
<tr>
<td>W556</td>
<td>V</td>
<td>137 BC -48 BC+</td>
<td>after 18 BC</td>
<td>20 unmeasured rings; re-used</td>
</tr>
<tr>
<td>W605</td>
<td>V</td>
<td>235 BC -61 BC</td>
<td>after 51 BC</td>
<td></td>
</tr>
<tr>
<td>W655</td>
<td>V</td>
<td>114 BC -35 BC</td>
<td>after 25 BC</td>
<td></td>
</tr>
<tr>
<td>W713</td>
<td>IV</td>
<td>91 BC- AD 56 (AD 50)</td>
<td>AD 59-104</td>
<td>same tree as 138</td>
</tr>
<tr>
<td>W714</td>
<td>III</td>
<td>192 BC -AD 49 (AD 49)</td>
<td>AD 59-104</td>
<td></td>
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</tbody>
</table>
Acknowledgements

The work was funded by English Heritage. I am also grateful to Mike Baillie, Jon Pitcher and Ian Tyers for providing unpublished data; Ian Tyers for unpublished computer programs, and Cathy Groves for comments on the results and the text.

Bibliography


End Notes

1. See Volume I in this series for the main report, and Volumes II, IV and V.


3. The excavations of 1991-92 have brought the total up to 3897.

4. After careful washing in tap water, to remove the surface dirt, the leather is conserved over a five hour controlled period, using the following method: 1 hour in 5% EDT A solution; 1 hour continuous tap wash; 1 hour 1% acetic acid solution; 1 hour continuous tap wash; V. hour first acetone bath; ’I. hour second acetone bath. The leather is then allowed to air dry, and it can be kept flat under glass plates (for tent pieces) or padded with tissue paper (for boots or shoes with uppers). The original shape of the leather can thus be maintained. When fully dry, the leather is lightly brushed and a leather dressing applied.
The Vindolanda Trust
Roman Vindolanda & The Roman Army Museum
(Registered Charity No. 500210)

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Director: Patricia Birley