THE PRODUCTION AND SUPPLY OF MILITARY LEATHERWORK IN THE FIRST AND SECOND CENTURIES A.D.: A REVIEW OF THE ARCHAEOLOGICAL EVIDENCE

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This paper will be principally concerned with Roman military leatherwork as represented in the archaeological record. Various aspects will be reviewed, but more in the hope of stimulating discussion and research than of offering any all-embracing answers to the problems in this particular field.

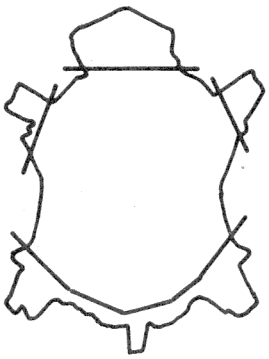
The place of leatherwork in the Roman army can be approached from two different points of view: there is the primary, archaeological level, with the identification of the pieces of equipment represented by the finds, and the direct evidence which this provides as to form, construction and development of individual pieces of equipment, and the secondary, interpretative level in which systems of manufacture and mechanisms of supply of both the raw material and of the items made from it are deduced from internal evidence. All aspects are, however, to a great extent governed by the nature and characteristics of leather as an organic product and the severe bias in the available evidence which this entails.

In the first place, leather is only conserved under special environmental conditions, which means in practice that the waterlogged deposits of wells, ditches and river courses form by far the richest source of Roman leatherwork. But these deposits, being in the main rubbish dumps, in themselves introduce considerable problems in the interpretation of the finds incorporated in them and their dating, quite apart from the northern and consequently military bias displayed in excavation of and research into this type of context. Furthermore, what leather survives in these contexts was almost invariably discarded as worn-out or useless: the off cuts of manufacture, damaged pieces removed and discarded on repair and the final jettisoning of worthless equipment. The evidence must be pieced together from what was consciously thrown away, and the problems of rubbish disposal and basic conservation are interwoven with any interpretation of the surviving material. Thus in an examination of Roman leatherwork we must be continually aware of the shortcomings of the available evidence: the lack of comparative material from Italy and Gaul especially, the paucity of leather other than footwear after the mid-second century, the difficulty in isolating military from civilian products and methods of manufacture in the rather mixed contexts of the Limes

forts and their vici, the absence of comparable find complexes from civilian sites and especially the fact that the conditions required for preservation virtually exclude the possibility of identifying the location of a workshop and its products. In addition, a whole category of leatherwork is missing from the record, for it is only the vegetable tanned leathers which are able to survive in waterlogged deposits. Alum-tawed[1] and oiled leathers - which may have been particularly important in the military context - fail to survive at all, save in dry and airless conditions.

The evidence for the manufacture of Roman military equipment is, therefore, severely restricted not only as a result of physical considerations, but also because of the lack of quantitative publication. Consequently, the discussion will be based principally on the evidence from six sites. This is not very much, although they do provide a fairly balanced picture, and future work will inevitably modify the conclusions reached here. For the first century we have the legionary fortress Vindonissa[2] (Switzerland), the auxiliary fort Valkenburg[3] and the outpost Velsen[4] (both in the Netherlands), while the second century is represented by the military fabrica on the Bonner Berg[5] (W. Germany) and also the auxiliary sites Zwammerdam[6] and Vechten[7] (Netherlands), although neither of these contexts is as well defined as one could wish.

Despite all the limitations, leather, because it is one of the few organic materials to be preserved in any quantity, is an unequalled source of information for many items of clothing and equipment otherwise known only from pictorial sources, if at all.[8] Problems of interpretation of function remain due to the disappearance of other organic components such as glue, wood or stuffing, while the disintegration of larger items into their constituent parts makes the accurate reconstruction of complex articles such as tents difficult. Still, the essential identification of a large number of items is clear enough, and emphasises the role of leather in an army which seems to have been unfamiliar with tarpaulin. Shoes, shield covers, tents, baggage covers and kit bags, saddles and horse trappings, briefcases, letter and tablet envelopes, cushion covers and purses,[9] are all certainly attested on military sites: the function of many other fragments can only be guessed at and many more purposes may be expected: awnings, smith's aprons, furnishings, wine and water skins,[10] flask covers,[11] sheaths and quivers as well as innumerable straps and fittings. The use of oiled or alum-tawed leather may be responsible for the otherwise unaccountable lack of horse harness, straps, belts and sheaths on Roman sites. Both kinds of leather were certainly widely used for these purposes in the 18th and 19th century cavalry and artillery regiments in the Netherlands and the use of oiled



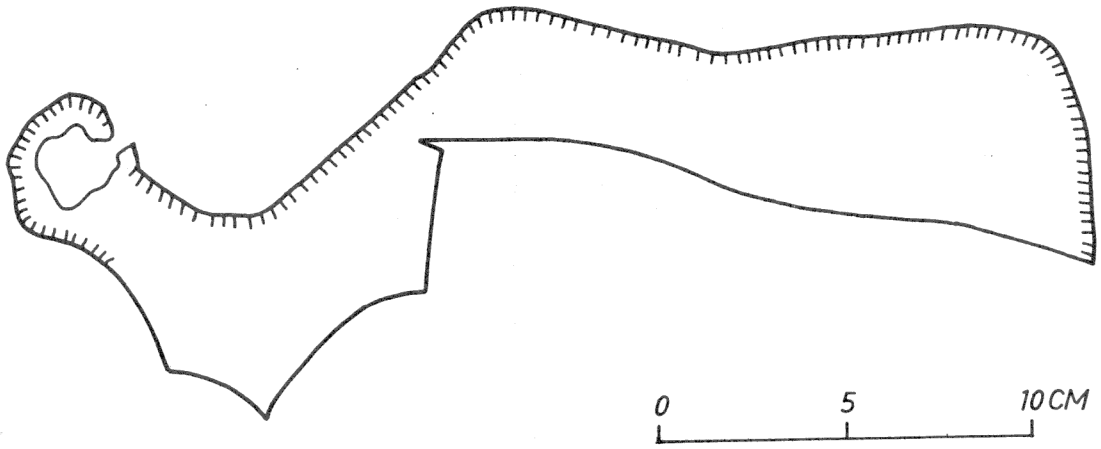


Fig. 1. a. Primary cutting lines marked on skin (not to scale).
b. Primary off cuts from Velsen with natural orifice (scale 1:2).

leather for horse harness was actually laid down in the current military specifications.[12] Any large-scale use of leather in clothing, as proposed by Gansser-Burckhardt must probably be discounted.[13] Not only are any positively identified examples extremely rare,[14] but it is also evident from the sources that the army looked primarily to textiles for its clothing.[15] Cuir bouilli might have been used for muscle cuirasses, but again, nothing has survived. Due to its low water resistance, alum tawed leather would have been unsuitable for out-door military clothing.

It will be clear that the Roman army in the first and second centuries must have required leather on a truly vast scale. Exact quantification is of course impossible, since we cannot assess replacement rates, but when it is realized that a tent for eight men requires about 70 complete goatskins, while the cover for each auxiliary shield demands a further 1½-2 skins, the amount is staggering. To fully equip a newly raised unit or to re-equip one at a time of emergency or following hostilities must have posed formidable problems of supply.[16] Furthermore, tanning is a relatively slow process and excessive slaughter of livestock for their skins alone will have severe repercussions on future supply.[17] By far the most satisfactory solution is to ensure the steady supply of raw materials, to hold adequate stocks and to keep equipment permanently in good repair - and this is exactly what the types of finds from military sites such as Bonn, Velsen and Valkenburg seem to show.

Before going into detail, we must first look at the evidence on which any hypotheses on the manufacture and maintenance of leather equipment must be founded. A basic misconception as far as the study of the manufacture of leather goods is concerned is that concentrations of finished products identify the presence of the craftsman making them.[18] Although this may sometimes be the case,[19] in general the converse will be true: the finished items are dispersed and ultimately end up, not back in the workshop but on the rubbish tip, where they reveal more about the processes of rubbish disposal than about manufacture. For questions of production we are dependent, not on the completed articles (although these can convey information on manufacture through details of technology and skin choice) but on the snippets of leather left after the completion of the item concerned. These off cuts are all too often ignored, yet it is these scraps which reveal whether a leather worker was present, whether he was making new items or only repairing old ones, what products were concerned, whether there was any craft specialization and what value was placed on the raw material used. Identification of the animal from which the skin[20] was taken allows further inferences as to the selection or availability of particular animals and the possibilities of import.

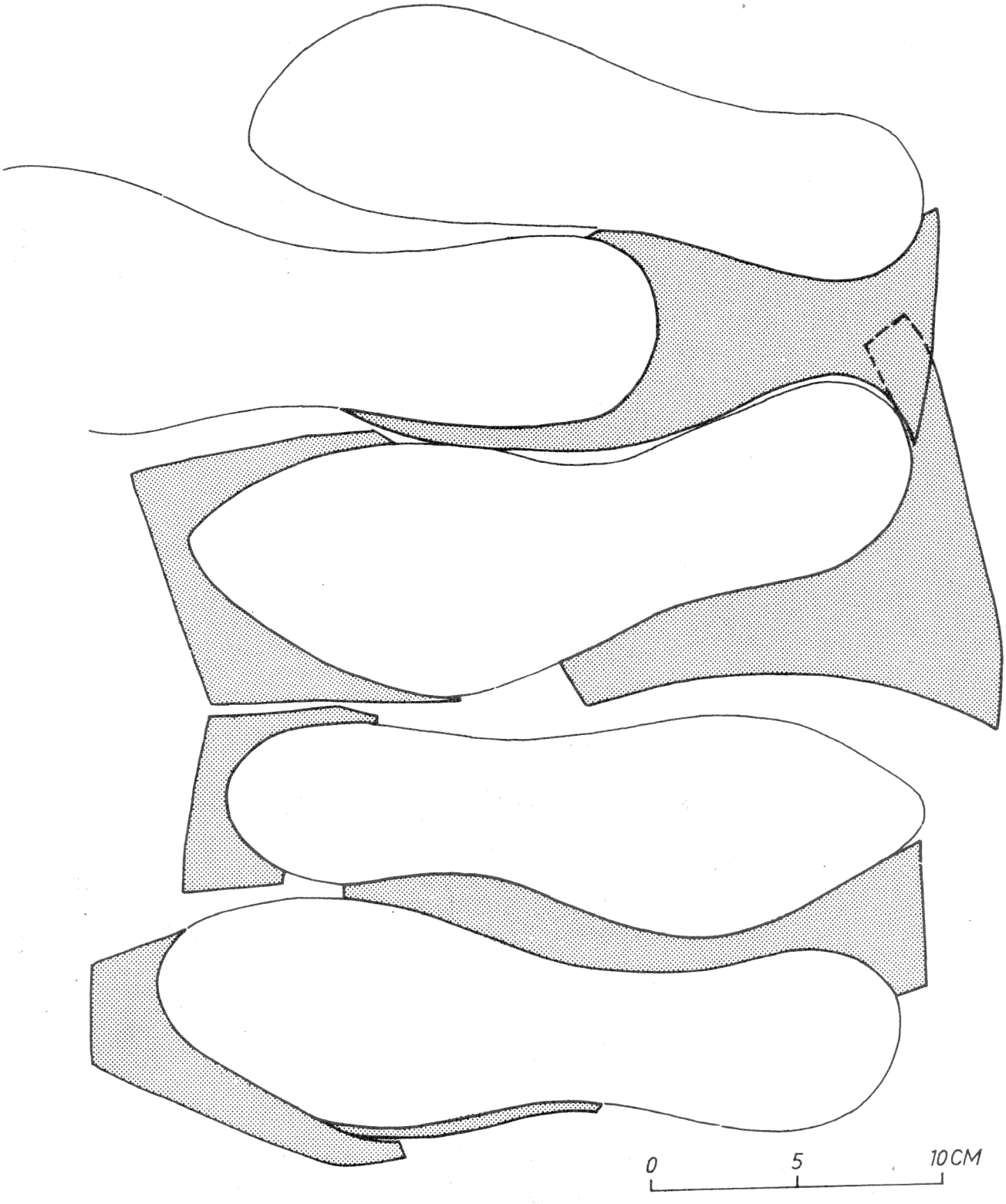


Fig. 2: Secondary off cuts from Velsen arranged in their relevant positions around sole shapes (also from Velsen). Note gaps where additional trimming would be required (scale 1:2).

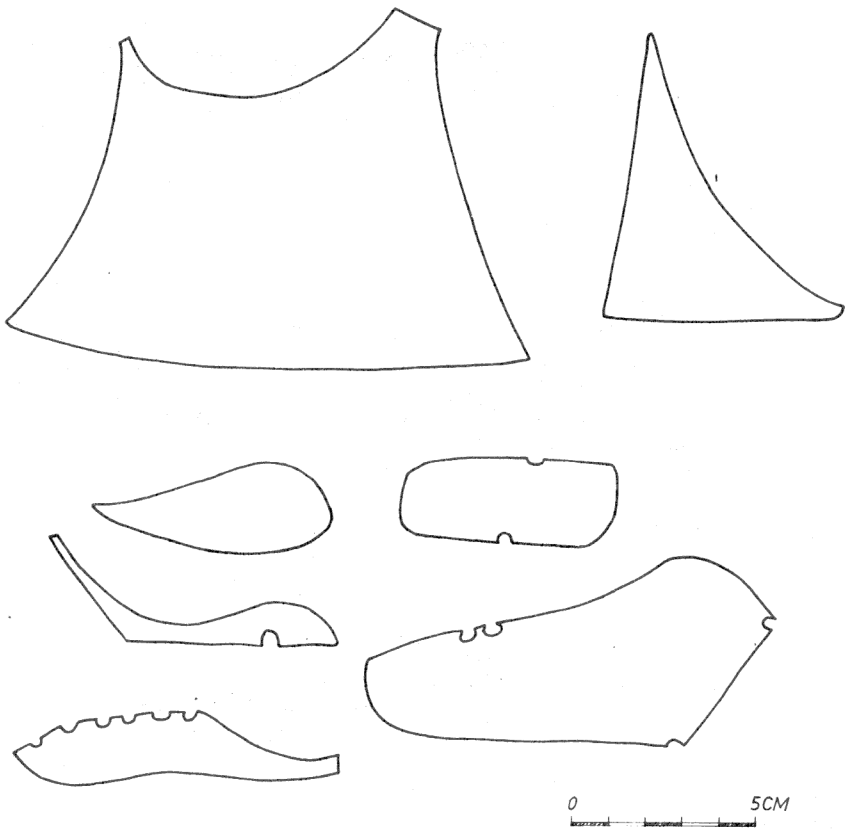


Fig. 3. Off cuts from Maastricht characteristic for the manufacture of single-piece footwear (scale 1:2).

It is perhaps worthwhile to look at these uninspiring fragments more closely. They may be divided into three categories, each reflecting a particular part of the manufacturing process:

1) Primary off cuts (Fig.1): useless or poor quality portions removed before cutting-out begins. This might also be done at the tannery to neaten the product, but Roman evidence from Xanten, Maastricht and Vindonissa[21] suggests that the skins were delivered entire to the leatherworker, with head, tails and even udders still attached. Characteristic are skin edges, cut away from the better parts in straight strips, and especially the heads and necks of goats, cut away from the shoulders in a straight line, as at Vindonissa and Bonn.[22]
2) Secondary off cuts (Fig.2): the pieces left between the cut out items, often as a silhouette. In fact, the distinction between primary and secondary off cuts is not always clear in Roman contexts, since articles tend to be cut directly from the unneatened skin, except where large sheets are required, as for tentage or shields. Smaller items were simply arranged around the less suitable or damaged areas which nowadays would have been removed beforehand. It is, however, the secondary off cuts which give most information on the type of items manufactured, and, because they often come from the better parts of the skin, these are also most suited for animal identification.
3) Trimmings: narrow slivers left after neatening a roughly shaped article, often done on completion of the item (e.g. removal of the excess from a made-up shoe sole, shown in Fig.2 as narrow white areas next to the soles).

By far the most distinctive are the off cuts from shoemaking (Fig.2) and these are especially useful in establishing the type of leatherwork being carried out in Velsen, Valkenburg and Bonn, which we will examine below. Although it occurs in a civilian context, a find consisting almost entirely of off cuts (and a single worn-out shoe) from Maastricht[23] provides a good illustration of the potential of a well-defined group (Fig.3). Here, the left over silhouettes were sufficiently characteristic - and the stratigraphy was sufficiently clear - to enable the identification of an individual workman, entirely specialized in the production of single-piece footwear (the so-called carbatinae[23a]) on the evidence of the off cuts alone.

Such restricted, individual, rubbish disposal as at Maastricht is rare. More usual is the situation at Zwammerdam and Vechten, with their extensive riverfronts, where the mixture of obviously military items with obviously civilian ones suggests that refuse from both the camp and its neighbouring vicus was thrown indiscriminately into the river. Apart from the intrinsic

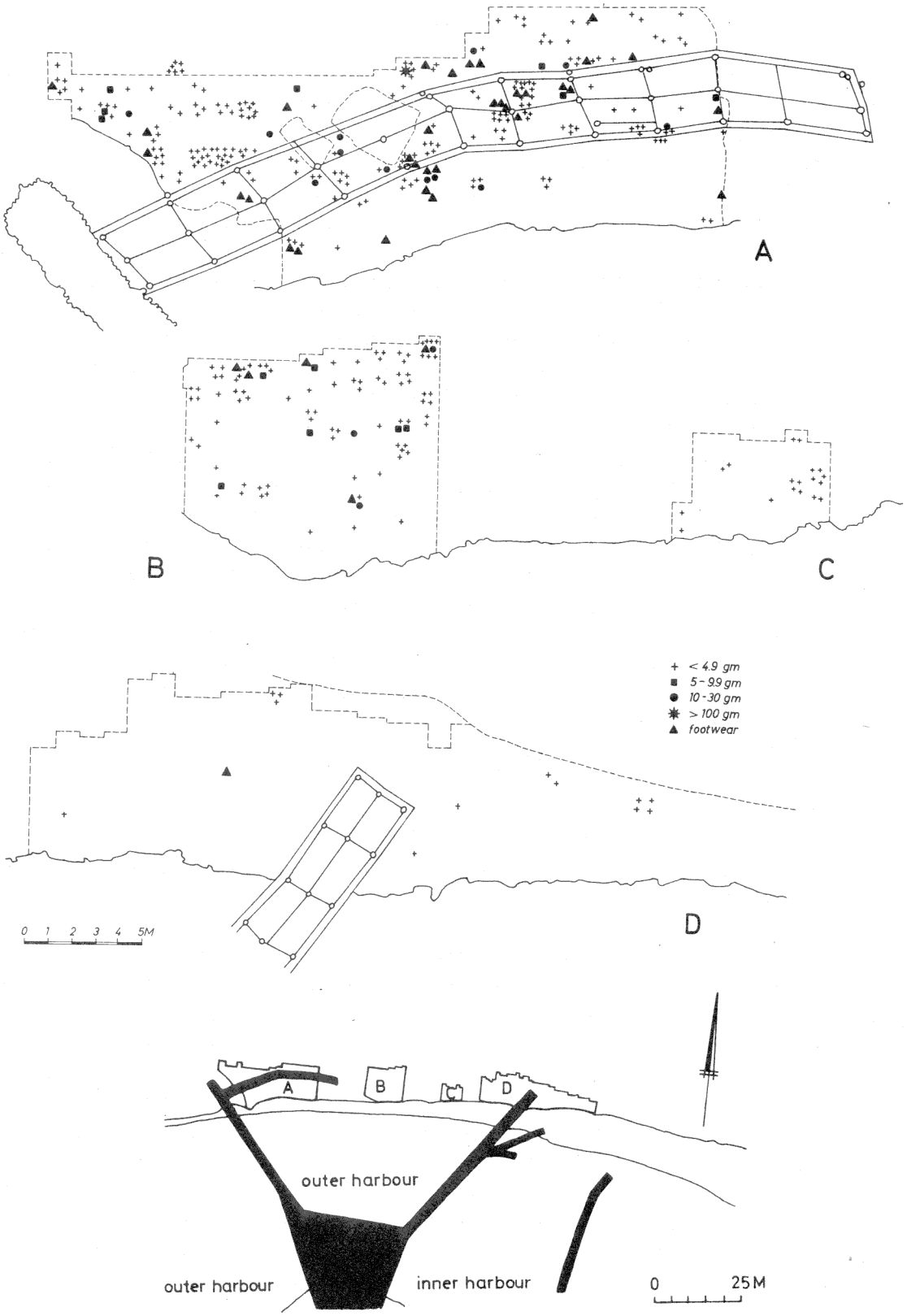


Fig. 4: Leather finds from Velsen excavated in one metre squares and plotted by weight.
Below: The harbour works at Velsen N.H. (plan, J.-M.A.W. Morel) with location of river-bed excavation trenches and the position of the jetties and moles.

interest of the objects recovered, there is little information on either production or supply to be gleaned from such mixed deposits. Similarly, along waterfronts, where the object is land reclamation, a concerted effort by authorities and/or individuals is likely to gather suitable material - including former rubbish dumps - from a wide area.[24] Plotting individual find concentrations might provide some differentiation in the 'primary' rubbish dumps (as opposed to re-deposited, 'secondary' rubbish) and could also lead to a better understanding of the way in which various categories of material were discarded.

Adverse conditions frequently hamper detailed work on waterlogged sites, but the distribution of leather finds from two of the first century sites in Holland, Velsen and Valkenburg, though not in themselves spectacular do illustrate two different processes of rubbish disposal which in turn clarify the system of manufacture and of the maintenance of leather equipment on these sites.

The actual site of the early fort at Velsen, occupied between c. A.D. 15-30 or a little later[25] is too shallow and too eroded for leather to be preserved within the defences. In the associated harbour, however, conditions are slightly better and due to the great care and precision in excavation, a quantity of poorly preserved leather was retrieved. When the finds are plotted by weight (Fig.4), the relationship to the westernmost pier and jetty is immediately apparent, with only occasional, much lighter items being washed further along by the current. A similar pattern emerges from the distribution of animal bone.[26] This implies that this particular pier was the chosen route for the disposal of camp refuse in open water, while the other piers were deliberately kept clear for shipping. The material found in this area is, therefore, likely to represent the range of activities undertaken in the camp, and might even reflect a concentration of rubbish-producing activities in the western half of the camp (see below, p.62 in connection with the evidence for an industrial quarter at Hofheim). The leather itself consists primarily of shoemaker's off cuts, sole trimmings and smallish fragments cut away from tents and shield covers, all of which suggests that manufacturing activities were restricted to the supply of the immediate necessities - footwear - while other equipment was merely kept in a state of good repair.

Although the leather from Valkenburg Z.H. was also clearly discarded deliberately, this is not a normal case of rubbish disposal. The preservation of so many virtually complete items of equipment can be attributed to the fact that a change in garrison coincided with the need to raise the site of the fort above the reach of sporadic flooding at some point in the occupation.[27] Presumably, damaged and even remotely

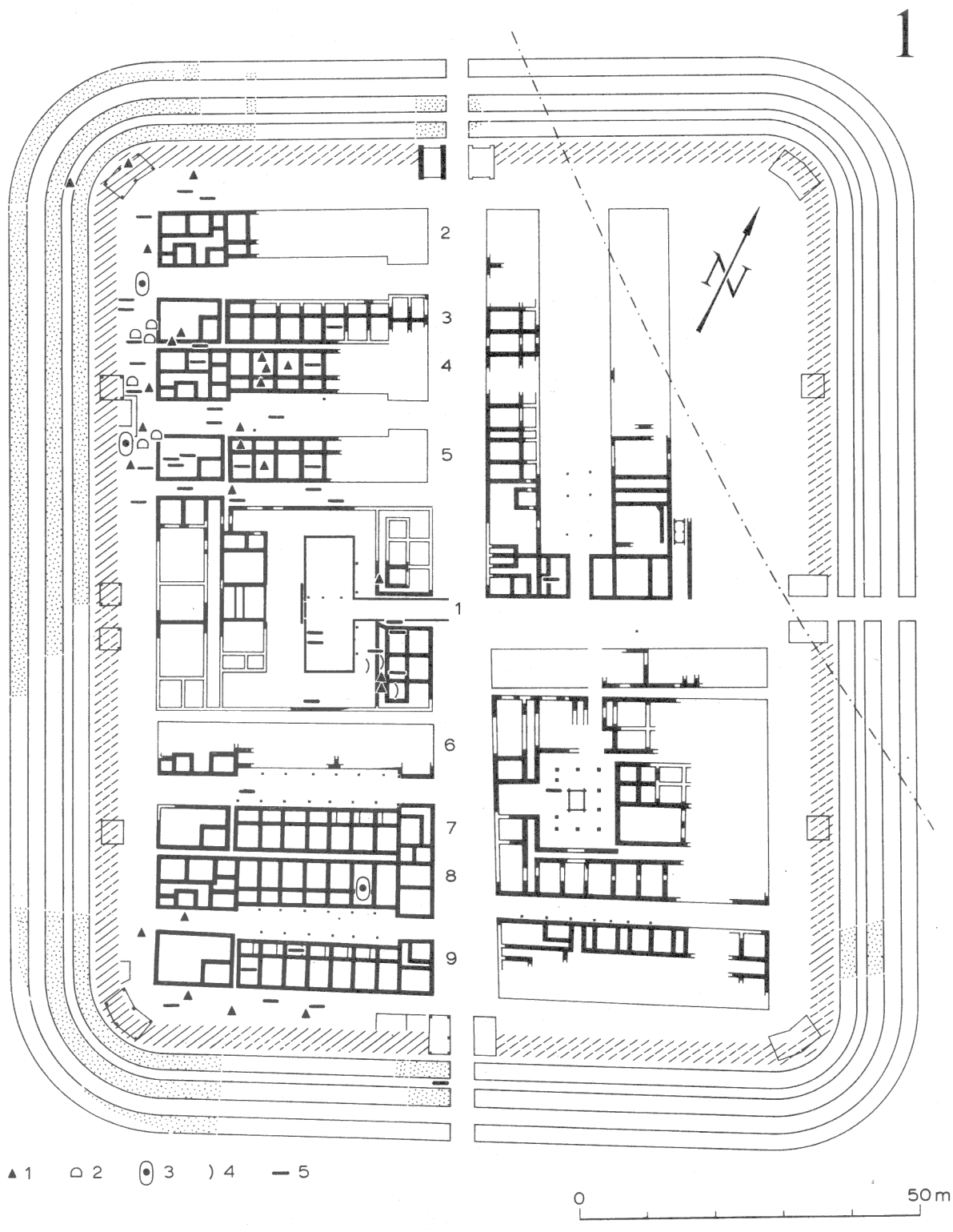


Fig. 5: Distribution of leather in Valkenburg 1 (location of find numbers based on GROENMAN-VAN WAATERINGE, 1967, fig.75a). 1. footwear, 2. tentage, 3. shield covers, 4. shoemaker's off cuts, 5. unclassified leather finds.

unserviceable equipment was abandoned to cut down on baggage. Here one might expect to find a fairly accurate reflection of the activities carried out within the camp, though not necessarily at the exact location (Fig.5). The shield cover in one of the arma of barrack block no.8 fits the context nicely, shoes scattered all over the site would reflect individuals sorting out their personal gear, while the concentration of tent and shield fragments at the western end of the barrack blocks 3 and 5 suggest the location of general stores for leather goods, from which new was issued and to which damaged items were returned for repair or rejection.[28] The fabrica-like function of the end buildings of barracks 3, 5, 7 and 9 became obvious when the structures in them were examined together with the finds,[29] but the distribution of leatherwork suggests a more specific function in terms of leather working and storage for the first two. Curiously, the concentration of large articles of equipment in these areas is maintained in the phase 2/3,[30] either because these two end buildings retained their function of leather stores, or because of the redistribution of rubbish from the earliest phase within this relatively short period of time (i.e. between c. A.D. 40-70). It is noteworthy that the find distribution suggests no other obvious candidate for a fabrica in the fort.

It should be pointed out, however, that although the find lists in the excavation records regularly mention the occurrence of 'footwear', other less obviously recognisable items are simply listed as 'leather'. Consequently, the distribution of footwear is likely to reflect the actual find pattern accurately, even though the other types of equipment, like shields, saddles and tents are under-represented on the plan.[31] The apparent concentration of shoemaker's off cuts in a wing of the principia presumably locates the camp shoemaker's shop[32] while a pack of leather from the same area, composed of pieces cut and discarded from items undergoing repair, suggests that general maintenance was also carried out in these wings. It looks as though these cubicles on either side of the principia entrance were in fact small workshops, and not actually part of the principia itself.[33]

The types of off cuts present in Valkenburg suggests a combination of shoemaking and general repairs, thus repeating the picture obtained for Velsen, but in marked contrast to the wide range of equipment produced at the legionary fortress Vindonissa. Here, the large and very varied collection of tools and off cuts attests not only to the manufacture of footwear, and the maintenance of equipment in general,[34] but also to the production of shield covers, tents, straps and other military paraphernalia. There is, of course, a considerable difference in size between the garrisons of Valkenburg and Vindonissa, which in itself might explain the relative scale of production, but in addition, the

early garrisons of Velsen and Valkenburg were presumably initially entirely equipped from a base camp, and may have remained dependent on it until sources of supply became more settled and the camps more permanent. We may possess a record of the relationship between fortress and forward position in the earliest stages of conquest in a wooden writing tablet from Vindonissa itself.[35]

> "...*soleas clauatas fac mittas nobis ut abeamus. Cum veniemus...*"
>
> "send us the nailed shoes so that we may depart. When we arrive..."

The text, which is probably pre-Claudian in date, implies ready stores in the fortress of the shoes we know (from the presence of the off cuts) to have been made there. Campaigning forces may have sent in their requests for supplies when necessary. Both Velsen and Valkenburg would represent a slightly more developed stage, since these forward positions were already manufacturing their own footwear.

The boots with which the soldiers were fitted out have been found at a large number of first century sites, straddling the length of the Limes from Switzerland to northern Britain. All follow a similar cutting pattern, with an openwork, strap-like upper cut in one with a middle sole and sandwiched between an inner and outer sole, the whole unit being nailed together. There is no discernible regional variation, and uniformity even extends to identical nailing patterns on boots from sites as far apart as Vindonissa and Velsen.[36] It looks remarkably like a standard military issue, made to central specifications at the individual camps. A work roster from Vindolanda[37] shows the system of manufacture as deduced from the finds in working. No less than one third of the day's workforce is detailed to make shoes in the workshops. Presumably a skilled shoemaker (immunis, soldier, slave?[38]) cut out the patterns required the unskilled soldiers made up the footwear under supervision, rather as in the Netherlands prisoners and paupers made up military boots from ready-cut packs (with thread, eyelets and tacks all included) supplied by army shoemakers from the 1830s onwards.[39] If the slightly enigmatic "ad calc" of P. Gen. Lat. 1 really does mean 'to the shoes' as both von Premerstein and Fink attractively suppose,[40] this Egyptian work roster of A.D. 90-96 may reflect a similar situation in a legionary context. The products of the day's labour would be stored in the camp - in the case of Valkenburg 1, perhaps in the tabernae at the entrance of the principia, or in the end building of barrack 3 - awaiting distribution. In an account of two soldiers from Egypt, covering the year A.D. 81,[41] the standard deduction of 12 drachmas (i.e. 3 denarii) for boots and socks in each of the three pay periods is highly suggestive of a thrice yearly issue of these items.

The evidence for manufacture at the auxiliary camps extends only to the production of footwear, which implies that more specialized and longer lasting equipment probably continued to be made elsewhere, perhaps at the former base camps, at least until fully stable conditions pervaded. As with footwear, the leather goods from all sites are highly standardized in form, arrangement of individual components and use of specific seam and reinforcement types. Workmanship is highly professional with careful use and selection of leather, a minimum of wastage in cutting and complex, finely made seams. A system of regional workplaces provisioning groups of forts in the immediate neighbourhood is attractive, but is not supported by any positive evidence, neither is it the only way of achieving uniformity, as we have seen with the military boots. It would not be justified on present evidence to assume that it was the legionary fortresses which were supplying the auxiliary forts in their region with leather goods.[42] To judge for the types and quantities of off cuts, Vindonissa would have been quite capable of meeting all its own requirements, but with the exception of a single fragment of an oval shield cover,[43] there is no evidence that it was involved in any way with either the manufacture or maintenance of auxiliary equipment.

The leatherwork recovered from first century sites seems to suggest that auxiliary forts drew on supplies from more established centres (not necessarily legionary), at least in the earlier stages of conquest and occupation. Footwear was soon made in every camp, although auxiliary forces may have continued to rely on their former base camps for certain specialist pieces of equipment: there may also have been some form of local specialization between neighbouring auxiliary camps. The uniformity of the equipment - over a wide geographical area and for such a long period in time implies a well developed central control over manufacture, which invites comparison with the standard models which were issued regularly to Dutch garrisons in the early part of the 19th century, and to which all equipment, whether made privately, on contract or in army workplaces, had to conform as regards style, manufacture, quality and colour.[44] Such a system of central specification would explain the remarkably close correspondence between equipment found at widely separated sites quite adequately, without the necessity of imposing central manufacture as such.

Perceptible changes in the composition of later leather complexes may be linked in part to what seems to be an overhaul of military affairs in the first half of the second century. The effects of the reorganization are seen not only in the introduction of new equipment,[45] but also in the acceptance and perhaps also the extension of trends in supply which were already apparent in the later first century.

In leatherwork, the changes seem to be reflected in a loosening of uniformity which is especially noticeable in the footwear. The standard, three-piece military boot disappears from the archaeological record early in the second century and soldiers turn to the normal closed footwear of the types used by civilians.[46] None of the typical military boots occur at the fabrica on the Bonner Berg. The shoes are all of ordinary civilian types, though concentrated in the larger sizes (sizes 38-42) and thus indicative of a predominantly adult male population.[47] Sites in northern Britain show the same variety and again, no standard military boot can be identified.

The type spectrum of leather finds from the second century legionary fabrica on the Bonner Berg contrasts markedly to what we have seen at first century sites. Although little documentation of the 1906 excavation remains, the leather seems to have been collected with considerably more thoroughness than the pottery, and so probably presents a fairly accurate picture of the activities on the site even though no exact find spots are recorded.[48] In contrast to Velsen, Valkenburg and, more especially, Vindonissa, there is little evidence for the manufacture of footwear (possibly only repair soles) and the fabrica seems to have specialized in the making and the repair of military equipment such as shields, tents and baggage covers. This site was in use for too long, and the place of the leather finds within the time range is too uncertain for the activities to be directly associated with the re-equipment of the Legio I Minervia after its return from the Dacian wars in 107, even though the fabrica was probably founded around this date. The leather finds therefore most likely represent the normal work of a fabrica in ensuring that equipment was at all times in top condition - with the exception of footwear. Since, in many respects, the refuse from the Bonner Berg is closely comparable to that from Vindonissa in its context, the absence of not only the standard military boot, but also of evidence for the manufacture of the footwear itself does suggest a modification of existing practices. The suspicion arises that for footwear at least, a different system of supply was developing, one in which civilian shoemakers, working within their established traditions and to their normal models were incorporated. The activities on the Bonner Berg, with its evidence for metal smelting and general repairs is closely comparable to the situation described in the work roster P. Berlin inv. 6765[49] (discussed by M. Bishop elsewhere in this volume, and to whom I am grateful for bringing this text to my notice), which reveals a combination of soldiers, immunes, civilians and slaves working on a variety of equipment, including shields, in an unspecified military fabrica. This incorporation of civilians in the workforce,[50] together with the tendency for manufacturing to move outside the confines of the

camp[51] already in the first century, prepares the ground from increasing civilian involvement with military supply. Furthermore, the growth of the vici may have made individual purchase, or the placing of contracts (or imposition of levies) more attractive, especially in smaller forts. From here, of course, it is but a short step to requisitioning.

The presents of shoes and socks received by an early second century auxiliary soldier in Vindolanda[52] may have been luxuries over and above the military issue, but the gift may also be a reflection of the increasing personal responsibility (and choice) which seems to be implied by the persistent requests from Egyptian soldiers to their family for food, clothing and money.[53] A 'privatization' of personal equipment might explain the variety in footwear as well as the more exuberant decorative schemes on armaments.[54] On the other hand, the military issue - of clothing especially - may have been somewhat on the short side to encourage thrift. The problems of keeping equipment in top condition whilst guarding against unnecessary expenditure exercised the ingenuity of Dutch military planners throughout the 17th and 18th centuries, eventually culminating in 1796 in a resolution stipulating a twice yearly issue of clothing, followed in 1807/08 by a detailed specification of the length of time each individual item of clothing and equipment was expected to be serviceable. This varied from six months for infantry shoes to 16 years for a saddle.[55] The material was military issue, and, as in the first century, a standard sum was deducted from pay to cover the cost of replacement at the fixed intervals. In the first century account of two soldiers from Egypt mentioned above (note 41) clothing seems to have been issued once a year, shoes and socks three times, although one of the soldiers is perhaps charged extra in the first pay instalment for additional gear or for replacements. In the Dutch system, clothing could be retained by the soldier on discharge if less than one quarter of its nominal life remained.[56] An additional charge was made for replacements betweentimes, however necessary, and it is perhaps in a like system that the requests for family aid should be interpreted.

Whether equipment such as shield covers, tents etc. was ever produced widely in the second century auxiliary camps is, in the absence of unambiguous contexts, difficult to say. Conditions for the preservation of leather are poor in the higher levels of Valkenburg (periods 4-6), while in Vechten and Zwammerdam the difficulties in both dating and disentangling military from possibly civilian production hamper the assessment of the activities represented by the finds. The possibilities open for variations in the methods of supply to individual camps will no doubt have depended to a great deal on the availability of local resources and skills. That some sort of control continued to be

exercised over the production of strictly military equipment made of leather is likely, since the variety of second century footwear contrasts markedly with the continuing first century standards of workmanship and uniformity of pattern and stitching on both tentage and shield covers. Footwear apart, there is still a very close resemblance between the leather from Velsen (early first century), Valkenburg (mid first century) and Vindonissa (first century) on the one hand, and the Bonner Berg (early second century), Newstead,[57] Birdoswald[58] and Bar Hill[59] (all early-mid second century) on the other. The manufacture of most of the items of leather required by the army lies well within the capabilities of the average leatherworker, especially if, as seems probable, standard patterns were available. Smaller camps, of course, may not have had a separate specialist for leatherworking at all: rather slovenly stitching and strange seam types at Zwammerdam might betray soldiers carrying out the necessary repairs themselves[60] on equipment originally made according to standard procedure by a specialist working at another camp: more a case of inter-camp cooperation than of 'central supply'. It is this rather than distribution from a legionary centre which might characterize the organization of supplies to the small, closely spaced camps along the Rhine Limes. It may be that the pressure of keeping up with running repairs compelled the shedding of one of the fabrica's tasks: the provision of footwear was perhaps one of the easiest branches for civilians to take over, especially in view of the growing markets for such products outside the camps.[61]

Thus in the first half of the second century we seem to have a dual system of provisioning. Supply of footwear seems to have moved into the civilian sphere, whilst some sort of military control still extended over the other items of leather equipment. Whether these were still manufactured by soldiers - in or outside the camps - or by independent civilians is, in the absence of suitable find concentrations unknown. Lack of well defined complexes for the later second century and beyond complicates the assessment of any trends which might otherwise be discernible in the earlier material. Did the military establishment continue to provide its own tents, shields and baggage covers or were these also handed over to civilians? Or is civilian involvement in leatherworking confined to the provision of footwear? It is perhaps noteworthy that there are no shoe factories listed in the Notitia Dignitatum, and in 311-312 it was necessary to requisition shoes,[62] even though (admittedly at an earlier date), hides were bought or levied for the purpose of making arms (by whom is not specified: at this time the military authorities could well have provided civilians with the raw materials for making up under contract or as an imposition).[63]

It is also significant that no obviously military leatherwork was recovered from the wells at the Saalburg, despite extremely good conservation and the very great interest of the excavator, L. Jacobi, in such perishable materials.[64] If the vicus was actively concerned with the provision of military leatherwork, we might have expected more evidence of this amongst the clearance debris dumped into disused wells after the destruction of the settlement in the 230s. The absence of military leatherwork here contrasts with the situation at Zwammerdam and Vechten (both sites extend into the third century), but it might also be the result of a general running down of the Saalburg garrison at that time and the fact that the wells for the most part represent a single clearance horizon c. 230,[65] while the dumps at the other two sites are an accumulation over a longer period and perhaps from a less restricted area of the settlement. Here again, the character of the leather-containing contexts at the Saalburg strongly influence the type of material recovered, and a direct comparison between destruction debris and normal refuse accumulation is impossible, unless far more is known about the distribution of activities within the settlements.

An additional aspect to be considered is the supply of the raw material itself. As leather is a by-product of meat consumption, the osteological evidence from military sites provides indirect evidence for the type, and possibly the quantity of leather available locally. Examination of leather from military sites along the Rhine Limes shows that cattle hides were used chiefly for footwear and the large rectangular shield covers[66], while goatskin was utilized for virtually all other equipment. Gansser-Burckhardt, who examined the leather from Vindonissa and who was the first to discuss the entire subject in any detail, considered that the goatskins were imported from Italy and even found some improbable 'Old Italic' inscription to prove it.[67] However, in view of the restricted use of land transport for bulk goods, mule trains carrying skins over the Alps seem an unlikely prospect, even in military contexts. In fact, local sources must have been readily available, for Switzerland to this day maintains large herds of goats. Further north, the situation is more complex, for the numbers of goats implied by the leather identifications fail to materialize in the osteological record.[68] It is possible that goat meat was not consumed in the urban and military settlements, and if the animals were raised primarily for milk (cheese) and skins on the least hospitable soils, they might leave little trace archaeologically. Goat bones continue to be infrequent in medieval domestic sites. They are, however, present in considerable numbers amongst the refuse of a medieval tannery complex at 's Hertogenbosch[69] and the discrepancy between the animal bones and the skin identifications at Roman sites may,

therefore, be a consequence of the lack of excavation on suitable industrial locations. The difficulty may also in part lie with the actual identification of the skins, which is based on the microscopic examination of the arrangement of the hair follicles on the grain side of the leather. Quite apart from the possibility of any structural change in the skins resulting from an additional 2000 years of control and breeding, it is difficult to distinguish between even modern sheep and goat skins.[70] The more primitive hairy breeds of (modern) sheep display a follicle pattern which approaches that of the modern goat, so the improved Roman wool bearing sheep would presumably produce leather closely comparable to that of modern average wool breeds.[71] So in a situation where goats, native sheep and improved breeds can be expected, the choice lies between a continuum of goat/hair sheep/wool sheep: difficult at the best of times and even more so with archaeological samples, which generally come from worn-out and discarded items which have been subjected to all kinds of secondary stresses. In addition, the structure of the follicles is not the same over the whole skin: neck, leg, axillia and belly portions may differ considerably from the best parts of the back. Some of the 'goats' may, then, turn out to be 'hairy sheep'. On the other hand, the leather from even hairy sheep is flabbier than that from goat, which would make it unsuitable for purposes such as tentage, while the tendency for complete dermal/epidermal separation which is a characteristic for all tanned sheepskins is observed only very rarely on Roman skins which would on other grounds be classed as 'goat'. Furthermore, the Romans themselves were well aware of the differences in quality between goat and sheepskins[72] and the military at any rate are unlikely to have been fooled by the substitution of sheep, however hairy. The necessity of identification is one reason why horns and hoofs are left on the skin.[73] Vast herds of goats were certainly kept in Italy[74] and the skins could have reached the Rhine forts by water, which would have been less expensive than overland. But even so, it is difficult to see the army as being entirely dependent upon long-distance and slow transport for such essential material, especially in view of the attempts to secure local sources for virtually all its basic requirements.[75] In sum, I would regard the incompatibility as an effect of the distortion introduced by policies of excavation: as in the medieval example quoted, the excavation of a Roman tannery would probably redress the balance.[76]

Meat consumption by the soldiers themselves would release a steady supply of cattle hides, but this may have been insufficient to meet requirements. To explain the observed wealth of Roman imports to Öland, Ostergötland and Västergötland, Hagberg[77] makes out a strong case for a flourishing trade based on the export of cattle hides to the Roman Empire. Although modern leather buyers are sometimes able to tell the country of

origin of particular hides, this is impossible with ancient material since there are so many variables (climate, breed, size, age, nutrition etc.) quite apart from the present condition of the surface of the leather. There are, however, two features which occur on the leather itself and which provide a more direct hint of some form of trade in hides and skins. On a very large number of off cuts from Velsen and Xanten swarms of shallow depressions occur on the grain side of the leather. These closely resemble the depressions on modern hides from Africa, which are caused by strewing raw salt or so-called 'salt earths' over the freshly flayed skins to preserve them until transportation to the tanneries in the towns.[78] These 'salt pocks' occur chiefly on cow hide and it would be tempting to associate them with evidence from ancient sources that hides not only formed an important part of the levies imposed on newly conquered areas, but were also a major item of export from unconquered barbarian lands.[79] Of course, salt preservation could have been practised within the empire as well, nor is it the only method of limiting putrefaction,[80] but it is interesting to note that Xanten is a frontier post, presumably active in trade across the Rhine, while Velsen is an outpost, dependent for materials either on support posts situated in the secured hinterland or on local tribute/exaction. At this particular site, the oxhides demanded by Olennius, which were the immediate cause for the rebellion of the Frisians in A.D. 28, take on a new significance.[81]

Another feature which may be associated with trading in hides and leather are the stamped inscriptions, often initials or names, occurring on off cuts from a number of sites, both military and civilian.[82] Certain marks were applied to the skins prior to tanning (hence often illegible: some of Gansser-Burckhardt's 'Old Italic' inscriptions are of this type). At Vindonissa the word TOTA occurs several times and it also appears on an off cut from Zwammerdam.[83] as skins were - and are - usually handled in bundles, TOTA might refer to a whole batch being claimed for official use.[84] Other markings may have something to do with toll payments and import duties. It is perhaps significant that letters are often well formed seriffed capitals, with names frequently in the tria nomina form, a status one could hardly expect for first or second century vicus tannery owners or stock farmers. These stamps do seem to place the supply of some hides and skins in a rather more official sphere of activity. Again, we may speculate on the import of both tanned and salt-cured or dried hides from Free Germany, with official stamps recording either the payment of tolls, sanction to trading activity or actual purchase for official requirements. Other marks applied after tanning probably identify the owner of the tannery and thus serve as quality controls in much the same way that medieval and modern tanners have individual marks so

that substandard products can be traced back to source.[85] The absence of any military markings and the fact that the same mark rarely occurs twice on the same site rather suggest that tanneries were small scale, private enterprises. Tanners, like potters and some tile makers may have worked entirely for the army, though not part of the force themselves.[86] In legionary camps at least there would have been sufficient demand to support such specialist civilians, and since the army itself was a major supplier of hides as well as a major consumer of the tanned product, a fairly close interdependence between army and local tanners is to be expected.

Whether the army itself was also involved in the actual tanning is unclear. Tanneries are particularly elusive in the archaeological record, in part because of the extreme simplicity of the equipment used, but also because they tend to be situated outside the settlements (downwind) in areas where they are less likely to be located by excavation. A large, industrial tannery at Pompeii had fixed vats, but wooden tubs and even pottery vessels provide suitable receptacles for the tanning liquor. A simple method of tanning, known as 'bag tanning' would require no containers at all, since the tanning liquor is poured into the sewn-up skin, which is suspended to allow the liquid to pass through it, thus simultaneously tanning the skin.[87] Unhairing and fleshing can be carried out with rib bones or wooden scrapers:[88] large, two handled fleshing knives are rare in the archaeological record and may be associated only with particularly large scale tanneries, or with the preparation of special thin leathers.[89] In the absence of the sort of environmental evidence from Vindolanda,[90] the surest evidence for the location of industries dealing with skins is the over-representation of horn cores and metapodials in the osteological record, since these are often taken off with the skin when the beast is flayed.[91] Once again, the industry is recognised, not by its products but by its characteristic refuse. However, when a tannery deals with salted or dried skins, even these signs may be absent, since horns and hoofs are frequently removed in the preliminary cleaning to avoid damage in stacking and bundling.

The published evidence for the location of a tannery at Hofheim[92] may be interpreted rather in terms of the preliminary treatment of skins. The whole north-west corner of the earthen fort was occupied by storage facilities and workshops, and that some activity concerning skins was carried out there is likely not only from the presence of water tanks but especially from the large numbers of cattle horn cores which were found in the rubbish dumps between the buildings R and T (Fig.6). Judging from the pattern of refuse disposal, an analogous industrial quarter, centred on two boat-houses, might be present at Velsen

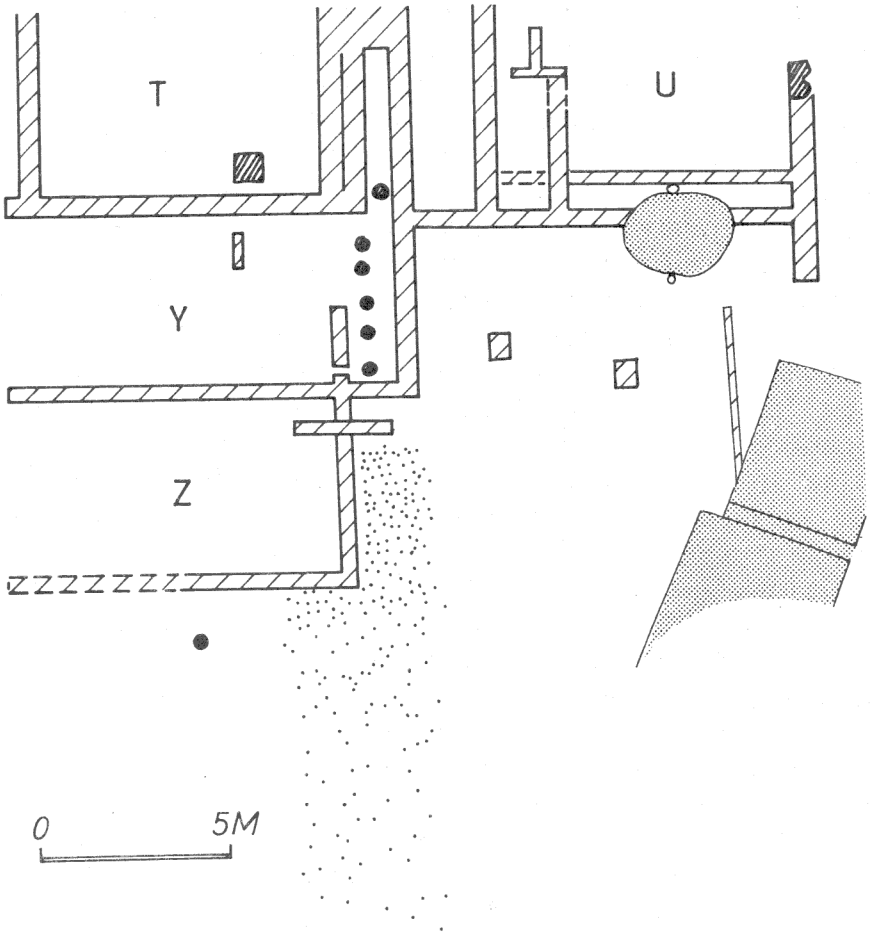


Fig. 6. Enlargement of Ritterling's plan of the industrial quarter at Hofheim with post holes of drying frames. Shaded areas represent water tanks (after RITTERLING, 1912, Taf.III).

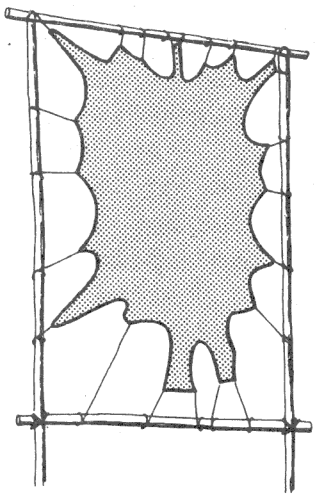


Fig. 7. Hide drying frame (from ATEN et al., 1955, fig.42).

(above p.51). The over-representation of cattle horn cores[93] from the riverine refuse dumps suggests that activities associated with hide processing were also a feature of this early fort. However, the forward position of both Velsen and Hofheim perhaps makes it unlikely that so lengthy a process as tanning was carried out there, but hides from cattle slaughtered for consumption were probably cleaned, prepared and dried or salted, ready for bundling and transport to the more secure hinterland. Later, with more settled conditions and the growth of the vici, the freshly flayed hides could be passed directly to local, civilian tanners. Ritterling remarks[94] on the formless swarm of post holes to the south of building Z and skirting the rubbish tips, tentatively suggesting that these posts may have had something to do with stretching and drying hides. The dimensions and depth of the posts seem excessive for simple flat pegging, and if the plan is to be believed, the posts appear to be set in pairs, about one metre apart. This suggests that the Romans used a system of post frames to which the fresh, cleaned hides were laced (Fig.7). Today, this method is advocated by the Food and Agriculture Organization of the United Nations, since it achieves more thorough and even drying, avoiding the very considerable loss by putrefaction which flat pegging brings to traditional tanning industries in the developing countries.[95] In addition, a roof can be thrown over a series of frames for protection, though the scatter of posts at Hofheim suggests rather the treatment of hides on an individual and irregular basis.

Environmental evidence from Vindolanda confirms that tanning was being carried out at this particular auxiliary fort[96] but the absence of similar exceptionally well preserved, in situ, contexts at other sites means that it is difficult to assess how common this activity was in the other permanent forts. In view of the general need for water and the tendency to site noisome industries away from the settlements, the lack of any specific osteological, environmental or structural evidence for tanning at Vechten, Valkenburg and Zwammerdam may only mean that it has so far eluded the excavators. At Bonn, Lehner may not have recognized the significance of bones and horn cores (though Ritterling did at Hofheim) but he would surely have mentioned them if they had been present in any quantity. For Gansser-Burckhardt it was obvious that if there had been tanneries, these would have been situated in the (unexcavated) valley below Vindonissa.[97]

Documents from Egypt seem to indicate that even quite small numbers of skins could be bought (or requisitioned) for military purposes,[98] and that supplies of leather might be levied from a town defaulting on its municipal dues.[99] In each case, the actual tanning was left to the civilians, which is what the absence of military marking on leather would already lead us to

expect. In detail, the sources of supply will have varied according to the local situation, but it is clear that the army exploited every possible method to meet its requirements.

SUMMARY

It is only fair to emphasise the shortcomings of leatherwork as evidence for the mechanics behind the production of Roman military equipment. The mere fact of preservation already introduces bias for there is little chance of finding leather at all outside waterlogged deposits, and these are perhaps the most difficult of all deposits to interpret or date. We are entirely dependent on refuse, so a clear definition of material leading to the location of workshops and identification of the specific products made there is simply not feasible. Even if it can be shown that leather equipment for military use was being made outside the camps, in the vici, this is not to say that production had passed out of military control, or that military personnel were not involved. Once camps were established on permanent sites there would probably be a tendency for the workshops to move outside the walls in any case, as seems to have occurred at the Saalburg.

In many respects, leather is an atypical product and the organization of supplies need not follow the trends established for other pieces of equipment. To start with, it is a perishable by-product of stock raising for consumption. The scale of the army's requirements was probably greater than for any other military essential apart from foodstuffs and textiles, which would tend to put the entire organization of manufacture on a different footing to that of, for instance, small bronzes. That leather is used in large quantities in several very basic and essential pieces of equipment which had to be uniform - shields and tents - would also favour central control or centralized manufacture.

All I can say at the moment is that the army probably obtained its leather via imports from outside the Empire or from small private manufacturers. In the first century the army was entirely self-sufficient in the manufacture of leather equipment, with workshops presumably concentrated around certain base camps. Only essential maintenance and - equally essential - the production of footwear was carried out at the auxiliary camps themselves, although the hides obtained via the food supply were processed and were presumably dispatched to the base camps for tanning and use in the production of new equipment (Fig.8). All equipment was highly standardized and was obviously made by professional craftsmen. During the early part of the second century, the standard issue footwear ceases to be used and

production of shoes seems to move into the hands of civilian shoemakers, though the exact form which the arrangement took is open to several interpretations. The continuing uniformity of strictly military equipment such as shields and tents suggests that the production of these remained under military control (Fig.9). Though central workshops could have been used, a closely supervised system of contracting out to civilian craftsmen cannot be entirely excluded. This might indeed form a better framework in which to fit the apparent extension of private enterprise and the increasing laxness in matters of uniformity and quality which is suggested by the less meticulous workmanship at Zwammerdam.

Since Roman leather complexes in the Netherlands cease entirely after 250, and large, datable groups are not available after even the mid second century, this review is of necessity incomplete. Future regional studies and an increasing density of finds spots are certain to clarify the processes of military manufacture and supply especially in the second century, as well as providing additional evidence for the range and development of leather equipment.

ACKNOWLEDGEMENTS

I would like to thank all those who read and commented on this article, and especially Drs J.G. Kerkhoven, curator at the Koninklijk Nederlands Leger- en Wapenmuseum 'Generaal Hoefer', Delft, whose assistance with the details of 18th and 19th century military provisioning was invaluable, and A. Visser, IPP, Amsterdam, who produced the drawings.

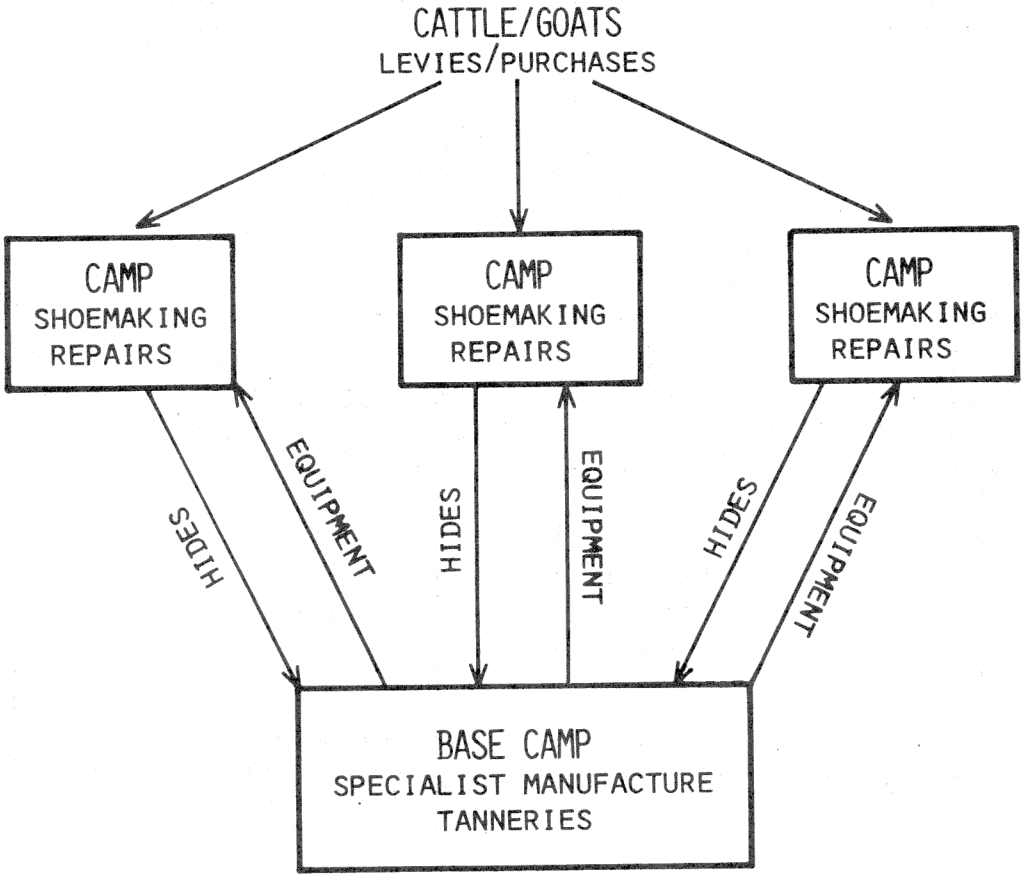


Fig. 8. Leather supply in periods of forward movement.

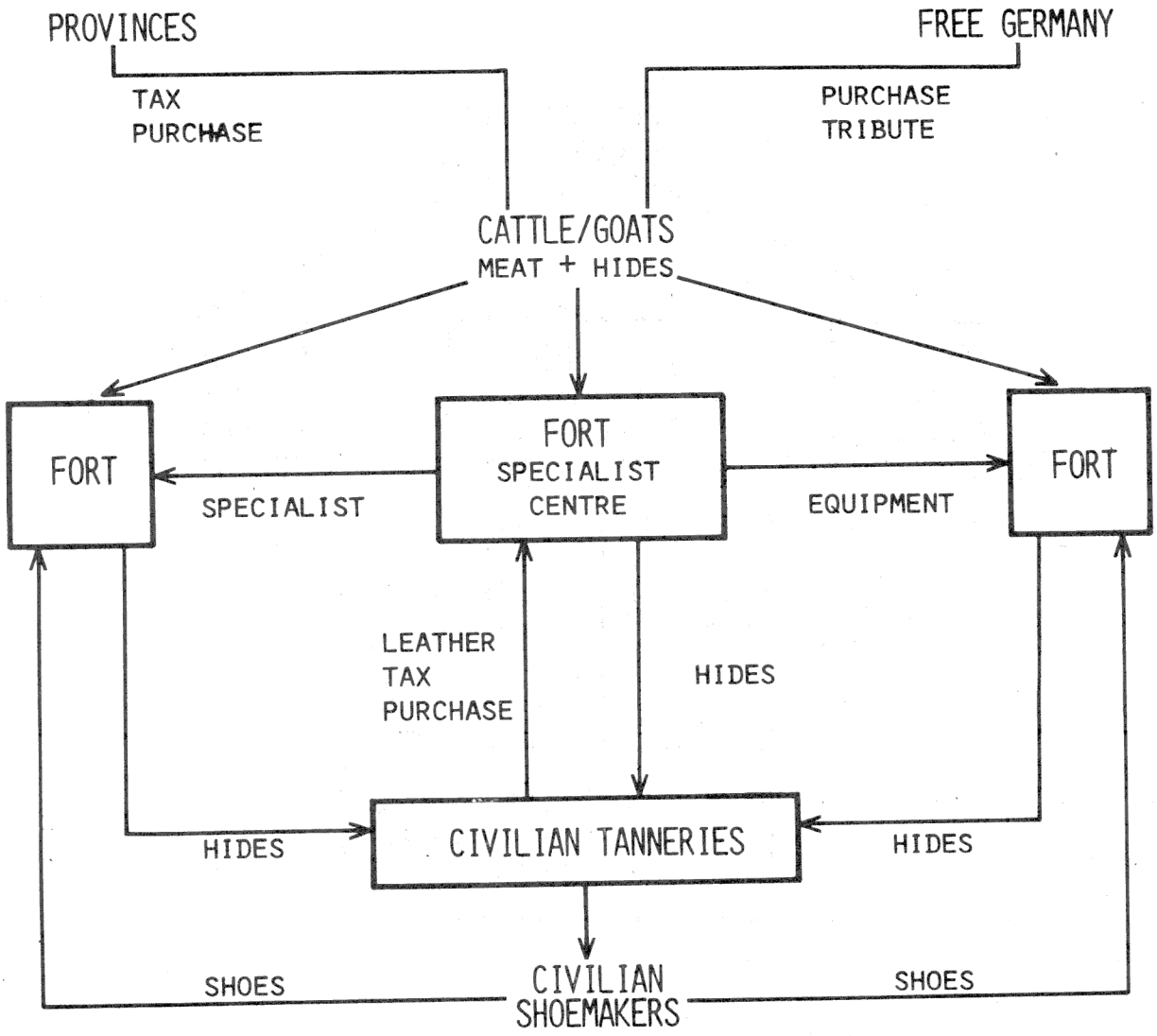


Fig. 9. Leather supply in periods of consolidation.

NOTES

1. Alum tawed leather, aluta (A. Mau in R.E. I (1894) under aluta, Pliny Nat. Hist. XXXV, 190), was known in Roman times. This mineral tannage produces a light, soft leather, white in colour (hence the medieval Whitetawyers) and suited to staining, though with a low water resistance (REED, 1972, 61-4). Alum production in Egypt was under a state monopoly, cf. JOHNSON, 1936, 387 no.242 (P.Oxy 2116).

2. GANSSER-BURCKHARDT, 1942, henceforth V.L.

3. GROENMAN-VAN WAATERINGE, 1967, henceforth Valkenburg.

4. Unpublished.

5. VAN DRIEL-MURRAY & GECHTER, 1984, henceforth B.B.

6. VAN DRIEL-MURRAY, 1977b, later material unpublished.

7. Unpublished.

8. For the problems of distinguishing leather from cloth on sculpture, cf. ROBINSON, 1974.

9. Most of these items are represented in the extensive leather complexes from Vindonissa (note 2), Valkenburg (note 3) and the Bonner Berg (note 5), all with further references. In addition, for writing tablet envelopes see BAATZ, 1984 and Valkenburg 126-9 and for saddles, LAWSON, 1978, 143-57.

10. V.L. 56-8, and reliefs such as that illustrated in GOLD DER THRAKER, cat. no. 493, 229-30.

11. DOPPELFELD, 1980, 299; CLOSE-BROOKS, 1977/8.

12. TEUPKEN, 1823 Sect. 4, 69-72, Sect. 5, 73-4.

13. ROBINSON, 1974; GROENMAN-VAN WAATERINGE, 1974, 80-1.

14. B.B. 24-5 for a summary.

15. WILD, 1970, 9.

16. Tents would be especially susceptible to long term storage and it is here that one might expect a crisis when it came to sudden unexpected campaigns after a long period in permanent forts.

17. The difficulties experienced by the Dutch authorities in

1914-1918 in obtaining sufficient leather of adequate quality, mainly for the manufacture of boots and harnesses, graphically illustrate a crisis situation. Even so, it was the rumour of inadequate footwear which virtually brought the cabinet to collapse, not the abysmal conditions in which recruits were housed. BOSBOOM, 1933, 105ff. and 164ff.

18. As for example in the earlier reports concerning the fabrica on the Bonner Berg. Since 1907 (LEHNER, 1907, 239 to VON PETRIKOVITS, 1974, 104) the site has been referred to as a shoemaker's workplace purely on account of the shoes and soles found there. All the off cuts and seamed fragments - some large enough to make their purpose as shield covers or tent panels obvious - were still interpreted in relation to the easily recognizable shoes and the true function of the fabrica in making and repairing items of military equipment was totally obscured. B.B. 3.

19. As for example where old leather is stripped off a wooden base which is to be re-covered, as is the case with the shields at the Bonner Berg, and, in a medieval context, sword sheaths from Leiden, cf. VAN DRIEL-MURRAY, 1980, 39.

20. Technically, 'skin' refers to small animals such as sheep and goats while 'hide' refers to large ones such as cattle, but here skin is also used for the untanned pelts of both.

21. V.L. 7-9, others unpublished.

22. V.L. 73, 74, Abb.2. B.B. 1-5, Pl.13.

23. Valkenburg 143; PANHUYSEN, 1984, 49-50 and VAN DRIEL-MURRAY, forthcoming.

23a. In fact a Greek word, but it is widely accepted to describe the single piece footwear of the Roman period: BUSCH, 1966, 166; CURLE, 1911, 152.

24. There are numerous medieval examples in the Netherlands, such as at the Boommarkt, Leiden, where individual, sporadic 'bucket fulls' of household and industrial rubbish were clearly visible amongst the centrally organized clay and sand fill of the reclamation. In another context, but illustrating the consequences for dating of the material in such levelling operations, see HARTLEY, 1972, 46 and M. Rhodes in MILNE & MILNE, 1982, 87-8.

25. Most recent survey, MOREL, in press; earlier summary, MOREL & DE WEERD, 1980.

26. MOREL et al., forthcoming.

27. Valkenburg, 195-7; GLASBERGEN & GROENMAN-VAN WAATERINGE, 1974, 20; DE WEERD, 1977, 271.

28. Before the fabrica-like function of the end buildings became clear, the distribution was seen rather as the result of the construction activities associated with the new lay-out of the camp, Valkenburg 212.

29. GLASBERGEN & GROENMAN-VAN WAATERINGE, 1974, 11, 25.

30. Valkenburg Fig.75b.

31. The composition of 42 of the 79 find numbers stated in the field notes to contain leather, and attributable to Valkenburg 1, can no longer be established since the numbers assigned became separated from the objects during storage. The leather survives as 'stray finds' and is described as such in Valkenburg 35-42. The same fate has overtaken many of the shoe soles, but these were readily identified in the field, so the distribution can be plotted from contemporary records, even if individual finds can no longer be correlated with their original find number. The majority of stray finds (nos. 1-78 and possibly 79-84) come from the 1941 and 1942 campaigns of excavation, when work concentrated almost exclusively on the north-western sector of the fort and on the principia. This suggests that at least 5, and perhaps 8, more fragments of shield covers could be added to the concentrations around the end buildings 3 and 5 and their barracks, as well as more tentage, purses and tablet envelopes (Valkenburg 35).

32. Valkenburg 196.

33. VON PETRIKOVITS, 1975, 49 for the varied uses to which the tabernae could be put.

34. V.L. 7-22, 98-109; GROENMAN-VAN WAATERINGE, 1974, 82.

35. BOHN, 1925, 14.

36. On the aspects of dating this and other types of footwear, as well as parallels and references, VAN DRIEL-MURRAY, in press. This true military boot (coinciding with the literary references to caligae as the typical soldier's boot) is illustrated in Valkenburg, Fig. 46 and LINDENSCHMIT & LINDENSCHMIT, vol. IV, Taf.37.

37. Tab. Vind. 1, BOWMAN & THOMAS, 1983, 77-9.

38. The slave Peregrinus, a sutor caligarius from Carnuntum (SWOBODA, 1964, 179) may have worked in such a mixed force, possibly in a skilled capacity.

39. KLAPPER, 1836, Sect. 977.

40. P. Gen. Lat. 1, verso, part V. Cf. VON PREMERSTEIN, 1903, 1-46 and FINK, 1971, 106-14. It seems hardly credible in this case that the P. Clodius Secundus mentioned in this roster spent two whole days polishing up his centurion's shoes: it is more likely that he was detailed to the manufacture of shoes for the use of Helius' century, in the manner described in the Vindolanda document, note 37. NICOLE & MOREL, 1900, prefer activities in the building trade.

41. P. Gen. Lat. 1, recto, part I, FINK, 1971, 243-9.

42. For a different view, VON PETRIKOVITS, 1975, 138.

43. V.L. Abb.54b.

44. TEUPKEN, 1823, 94-7.

45. OLDENSTEIN, 1976, 106-9; B.B. 4. Adoption of oval shields by legionaries, B.B. 4, 36 and VAN DRIEL-MURRAY, in press. The oval shields had been in use for long enough to require repairing at the fabrica of Leg. I Minervia at Bonn, which was in use from about A.D. 110-40.

46. VAN DRIEL-MURRAY, in press.

47. In view of the very mixed nature of the work force listed on P. Berlin inv. 6765 (ChLA 409), the small sizes could well have belonged to children or apprentices working in the fabrica, rather than to exceptionally young (or small) soldiers, as I previously suggested in B.B. 23-4.

48. LEHNER (1907, 239) clearly considered the leather as of exceptional interest and collected it with obvious care, even down to small snippets. He was much more selective with the pottery.

49. ChLA 409.

50. VON PETRIKOVITS, 1974, 17.

51. VON PETRIKOVITS, 1974, 7.

52. Tab. Vind. 38. BOWMAN & THOMAS, 1983, 132-5.

53. E.g. BGU 814, translation JOHNSON, 1936, 478 and P. Mich. VIII, 468, (CPL 251), where amongst other things, shoes are demanded.

54. MACMULLEN, 1960.

55. TEUPKEN, 1826, 51; HARDENBERG, 1858, 214-20.

56. The 20 denarii for his share in a tent credited to the account of a deceased soldier in P. Columbia 325 (GILLIAM, 1967, 238) might indicate that a similar system, with nominal scales of value related to the length of service left in major items of equipment, was also current in the Roman period.

57. CURLE, 1911, 150-3.

58. MACINTYRE & RICHMOND, 1934.

59. ROBERTSON, SCOTT & KEPPIE, 1975, 59-91.

60. Cf. WILD, 1977, 30 for a similar situation with textiles.

61. In the Dutch mobilization of 1914-15, army bootmakers were fully occupied with repairs, thereby compelling the enlistment of private workshops and even retailers for the provision of boots for the first time. BOSBOOM, 1933, 164ff.

62. All 700 pairs of them. How the problem of sizes was tackled is not recorded, PSI 886 quoted by JONES, 1964, 625 and note 35.

63. PSI 465 (A.D. 265?) translation, JOHNSON, 1936, 633, no.387, 106 hides 'for the manufacture of arms' levied on the town of Oxyrhynchus. Hides for military purposes are also mentioned in Tacitus Ann. IV,72.

64. JACOBI, 1897; BUSCH, 1965.

65. VAN DRIEL-MURRAY, manuscript in circulation, The Saalburg Wells. A context reconsidered.

66. V.L. 64-75, confirmed by later work on Rhine Limes sites.

67. V.L. 102, 106-8.

68. E.g. VAN WIJNGAARDEN-BAKKER, 1970; MAUSER, 1975; VERHAGEN, 1982, table 4.

69. PRUMMEL, 1978.

70. REED, 1971, 44.

71. Ryder in WILD, 1977, 34-7 and table 3; RYDER, 1983, 178, fig. 2.6; WILD, 1970, 5.

72. Reflected in price differences, Diocletian's Edict, VIII, 11-14.

73. SCHMID, 1973.

74. SHA Aur. 10.2 record 15,000 goats against 10,000 sheep being brought as booty to the estates of Valerian.

75. WILD, 1977, 30.

76. A line of research which I am attempting to follow up with Mrs. S.Y. Vons-Comis, a textile specialist, is the comparison of the kemp/wool ratio visible on the skins with that from textiles coming from the same site. This might give some idea of the range of possibilities which could be covered by the term 'sheepskin' in the Roman period.

77. HAGBERG, 1967, 122-5.

78. ATEN et al., 1955, 51ff.

79. Tacitus Ann. IV,72; CIL VIII,4508, tolls on hides from Numidia, both dressed and fresh.

80. Application of earth containing mineral salts and drying are also possibilities. For salted hides in Italy, cf. Cato De Re Rustica CXXXV,3-4.

81. Tacitus Ann. IV,72.

82. VAN DRIEL-MURRAY, 1977a.

83. VAN DRIEL-MURRAY, 1977a, and V.L. 99-102.

84. SHA Claudius 14.3 refers to hides in bundles of 10, for use in tent making. If only one in ten hides or skins were marked, this would account for the relative scarcity of inscriptions on leather.

85. EGAN, 1979.

86. VON PETRIKOVITS, 1974, 17.

87. MANN, 1960, 97ff. An off cut showing the edge stitching

appropriate to this method is perhaps visible on V.L. Abb.15, b & c.

88. Wooden leather scrapers, Diocletian's Edict, XIII.10; wooden scrapers and slickers from Vindolanda, BIRLEY, 1977, 123-4; possible medieval bone scrapers, PRUMMEL, 1978, 410, and bone slickers from Vindonissa, V.L. 21.

89. GAITZSCH, 1980, 63ff.

90. BIRLEY, 1977, 124.

91. GROENMAN-VAN WAATERINGE, 1970; PRUMMEL, 1978.

92. RITTERLING, 1912, 54-5, 61-62 and Taf.III.

93. Dr. L.H. van Wijngaarden-Bakker, pers. comm.

94. RITTERLING, 1912, 61.

95. ATEN et al, 1955, 43-51.

96. BIRLEY, 1977, 124.

97. V.L. 18.

98. P. Grenf. II,51 (translation JOHNSON, 1936, 628 no.375), recording the purchase of 4 goat skins.

99. PSI 465 (see note 63).

ABBREVIATIONS

B.B.	VAN DRIEL-MURRAY & GECHTER, 1984.
BGU	Berliner griechische Urkunden (Aegyptische Urkunden aus den königlichen Museen zu Berlin) 9 vols, Berlin, 1892-1937.
ChLA	Bruckner, A. & R., Marichal, Chartae Latinae Antiquiores, Olten and Lausanne, 1954-
CIL	Corpus inscriptionum Latinarum, Berolini 1863-
CPL	Cavenaile, R. Corpus Papyrorum Latinarum, Wiesbaden, 1958.
Valkenburg	GROENMAN-VAN WAATERINGE, 1967.
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