Romano-British Writing Tablets

Excavations at Vindolanda and Carlisle, Roman military posts to the south of Hadrian's Wall, have yielded a remarkable collection of Roman writing-tablets, both ink writing-tablets and wooden stilus tablets. Based at the Centre for the Study for Ancient Documents in Oxford, a major interdisciplinary project on Romano-British Writing Tablets is under way, with the support of the British Academy and others. **Dr Alan Bowman FBA**, *project director, describes the aims of the programme.*

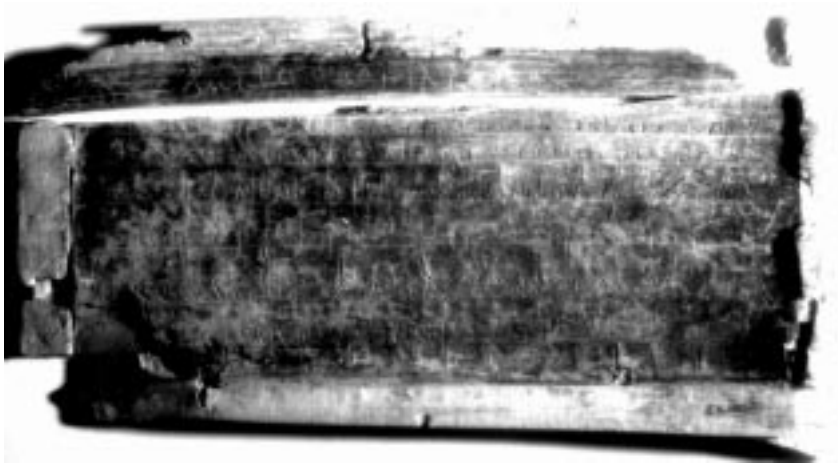
The documents from Vindolanda and Carlisle represent the most important body of written evidence for Roman Britain to have emerged this century, and are a unique source for understanding not only military affairs and life on the Northern Frontier of the Roman Empire, but also the development of the Latin language. The aims of the current project are threefold. One is to complete the publication of the remaining unpublished ink writing-tablets from Vindolanda and Carlisle, following on from the publication by Dr A.K. Bowman, Professor J.D. Thomas and Dr R.S.O. Tomlin (1983, 1994 and 1998) of ink tablets discovered during the 1970s and 1980s. An additional aim is to develop further computer-based imaging programmes for the compilation of electronic catalogues of the ink-writing-tablets, and to develop new image-enhancement techniques for incised wooden stilus tablets. Thirdly, the project directors intend to use the new techniques that are being developed to produce editions, with commentaries, of Latin texts on stilus tablets from Romano-British sites, principally Vindolanda and Carlisle. Ultimately, these last will be incorporated in a *Corpus of Romano-British Writing-Tablets* which will be a standard work of reference.

Edition and publication of ink tablets

The preparation of editions of ink tablets from Vindolanda is being undertaken by Dr Bowman and Professor Thomas. This is essentially a continuation of the work which has resulted in two published volumes, mentioned above. The tablets found in the 1970s and 1980s, which date to the period between AD 90 and 120, proved to be exceptionally important for our knowledge of pre-Hadrianic Roman Britain. They provided information on such diverse topics as ancient writing materials, Latin palaeography, the organisation of the Roman army, the social and economic structures of the frontier provinces, and the development of the Latin language. Further excavations undertaken between 1991 and 1994 yielded several hundred more ink tablets from the same periods and the same archaeological context as the earlier examples. A rough estimate is that the 1990s material amounts to between 60 and 70 substantial ink texts. Many of the tablets were found in the courtyard of the fort commander's residence, where a bonfire had been made to destroy out of date documents when the time came for the unit to move on. Their survival is at least in part due to the probability that the fire was put out by rain before the tablets were consumed. The writing-tablets offer a wealth of detail on the lives of the officers and soldiers (and their families) stationed at Vindolanda in the period just before the construction of Hadrian's Wall. Seven tablets have already been published in preliminary editions (Birley and Birley 1994, Bowman and Thomas 1996).

The preparation of editions of the similar ink tablets from Carlisle has been undertaken by Dr Tomlin (published in 1998). The tablets come from two sites within the southern rampart of the Flavian fort, and come from waterlogged contexts of the period AD 70–117. They include an important account of wheat and barley, and a letter reporting on missing cavalry lances.

A wooden stilus tablet from Vindolanda, digitally scanned with directional lighting from the right, showing incisions left by the metal stilus where it penetrated the wax writing surface.



The project on *Romano-British Writing-Tablets* was adopted by the Academy in 1997. The project directors are Dr Alan K. Bowman FBA, Professor J.M. Brady FRS FEng, Dr R.S.O. Tomlin FSA and Professor David Thomas FBA. It is supported at the Centre for the Study of Ancient Documents, University of Oxford (further details can be found at the Centre's web site at www.csad.ox.ac.uk).

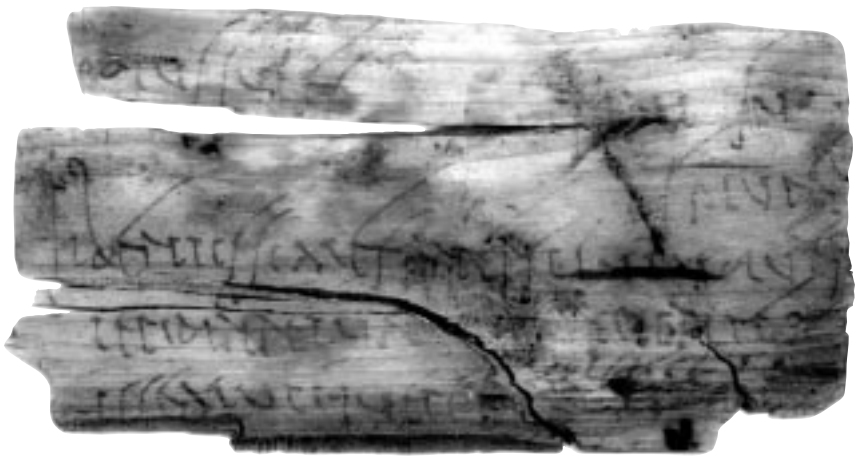
Digitisation and image-enhancement

The digitisation of the ink tablets involves the capturing and electronic storage of scanned images of the original tablets. The scanning is done with a digitising camera using infra-red filtration. This provides a basic image which is the equivalent of the infra-red emulsion film negatives previously used. The programme of scanning was begun in September 1996 when 400 scans of Vindolanda tablets from the excavations of the 1990s were made. The plan is to complete scans of all the Vindolanda ink tablets over the next three years.

The programme has two related purposes. The first is to provide high quality electronic images which can be used for primary research by the editors in preparing their publication of new texts. These images, which can be downloaded and/or written to CD-ROM, can be manipulated and enhanced using standard commercial photographic enhancement software, to provide better and more flexible facsimiles than standard photographic prints (which remain, however, an important complementary resource). This part of the project exploits the techniques of multi-spectral imaging developed by Greg Bearman and Bruce Zuckerman at NASA for the Dead Sea Scrolls.

The second purpose is to compile an electronic archive of images which can be linked to texts, commentaries and bibliographies and made widely available when the texts have been produced in their *editio princeps*. The archive will function as an easily accessible scholarly resource for researchers who wish to revise or reinterpret the published texts, or to bring them into relation with new material.

Part of an ink-writing tablet, discovered at Vindolanda in 1993, which contains a letter from Clodius Super to Flavius Cerialis, the prefect of the Ninth Cohort of Batavians.



The wooden stilus tablets

Image-enhancement of the incised wooden stilus tablets, of which there are some 200 examples from Vindolanda and over 70 from Carlisle, present much more complex problems, which are the subject of a programme initiated by Bowman, Brady and Tomlin and funded by a grant from the EPSRC. The aim of the project is to develop a completely new programme and it brings together for the first time expert readers of ancient documents and the most advanced research into computer vision and image-enhancement in a cross-disciplinary environment. The problems offer a new and very difficult challenge to the computer scientist.

The wooden tablets were manufactured with the central surface recessed, sometimes divided by a raised strip; the hollow panel was then filled with wax and the text was incised with a metal stilus. In virtually all cases of surviving tablets, the wax has perished, and the surface now presents only the scratches made by the stilus as it penetrated the wax surface to the wood beneath. Although parts of a few such texts from Vindolanda and Carlisle have been transcribed, most have proved indecipherable, owing to the following difficulties (either separately or in combination): (a) the scratches are very faint and incomplete and can only properly be seen, if at all, under intense, low-raking light whose position needs frequent adjustment for different portions of the tablet; (b) the background wood on which the scratches are made almost always has a comparatively heavy wood-grain which produces a distracting background texture and can be considered, in effect, as a distinctive sort of 'noise'; (c) incidental or casual pitting and scratching sometimes further complicates the image; (d) a single tablet was often used more than once, thus offering two or more overlaid texts which need to be identified and read separately.

Because the scratches are faint, the tablet needs to be imaged from a low raking angle (to emphasise contrast by deliberately casting shadows) and with very careful adjustment of lighting from a variety of directions. Since it is such a distraction to the process of deciphering the incised text, it is essential to enhance the image by 'removing' the wood-grain – and only the wood-grain – from the image. Attempts to do this by means of laser photography have not produced significant improvement. We have concentrated initially on the problems of woodgrain removal and identifying the incisions.

Luckily the wood-grain is usually more or less

uniform over the surface of a stilus tablet and it is relatively large compared to the incisions we are looking for. By aligning the camera appropriately when taking the pictures we arrange for the wood-grain to be aligned with the horizontal. This particular property is then exploited in our process of wood-grain removal, which is based on masking out low-frequency components in the vertical direction, keeping all high-frequency information corresponding to incisions. Currently the most efficient way to do this is to mask out the values along the vertical of the (local) Fourier transform of the image. The resulting images contain much less distracting information and are thus a great improvement for the human reader. During the course of the project we have succeeded in producing images in which the distraction of wood-grain signals is reduced very significantly.

The incisions of interest typically measure 0.5 mm across and are of varying but shallow depth, to a maximum of 1 mm. Visually, the incisions are of low contrast, often just a few grey values, i.e. they are very difficult to distinguish from background noise. Since the size of the incisions is very small compared to the distance between stilus tablet and indirect measuring tool such as stereo-cameras, and inherently unsuitable for direct measuring methods such as confocal scanning optical microscopy, another class of indirect ranging techniques, called shape from shading is used, in which three-dimensional surface shape is computed from shading variations.

The technique that we have developed so far on this project is based on the following observation, which combines the key properties of photometric stereo and shadows. Consider carrying a torch on a dark night. Slight movements of the torch in the hand occasionally induce rapid movements of cast shadows, so that the object casting the shadow seems to 'leap out' from the background. The extent to which it does so depends on the orientation of the light beam relative to the surface orientation that casts the shadow and its separation in depth from the surrounding background surface. Importantly, surface discolourations that can easily be confused with shadows in a single image do not move. A simple qualitative technique (movement or not) suffices to discriminate between incisions and surface discolourations, but more detailed information would be needed to discriminate between incisions from two distinct sources (e.g. two 'authors').

Imitating the 'manual' approach currently used by the historians, we take a couple of pictures of the same stilus tablet with a light source moving in an arc 'over' the stilus tablet, beginning at a very low-raking angle (say 10 degrees above surface) and moving up in 5-degree steps.

Once the key features are identified in the individual images the output from all processed images is then combined in order to detect (a) the movement of certain features which corresponds to a moving shadow-highlight combination which moves as the lightsource is moved up, and (b) the fact that certain features do not move although the light source is moving. These then correspond to 2D features such as discolourations rather than the 3D features we are looking for. To date, we have used a simple correlation technique to discriminate surface discolourations (stationary features) from incisions (moving features). The results are very encouraging, giving a good classification and greatly reducing spurious responses due to 'noise'. This, in our view, represents a considerable advance in technique compared to the standard edge-detector software which does not discriminate sufficiently between deliberate incision and casual damage to the surface of the tablet. In our future research we propose to develop this aspect further, incorporating both the phase congruency characteristics of the intensity transition of interest and recent developments in correlation-based stereo.

The aim is to produce editions, with commentaries, of the stilus tablets from Vindolanda and Carlisle in the first instance. At present it is possible to produce partial texts from some tablets. We hope eventually to be able to decipher many more. In view of the range and gradation of difficulty in seeing and enhancing the writing it is impossible to make any sensible prediction of the quantity. We would be disappointed if we could not ultimately read 50 or more from these collections. Such a number would offer the hope of reading examples from other sources, including those to be yielded by new excavations.

Successful development of our techniques will, of course, permit their application to other examples of Romano-British stilus tablets, many of which have remained in museums unread, partly read or perhaps misread for decades. They will also have applicability to other categories of incised material, including lead curse tablets, graffiti, inscriptions on metal and bone, as well as other three-dimensional artefacts. A wide-ranging analysis of the problems and progress will be presented in a symposium jointly sponsored by the British Academy and the Royal Society in December 2000, entitled *Images and Artefacts of the Ancient World*.