Map overlays from the First World War

A treatment option

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Abstract

The Australian War Memorial's Official Records collection consists of archival records of Australia's armed forces during periods of war and peacekeeping. The 'War Diaries' gathered during the First World War amount to 645 archive boxes of records, largely from active service units. The entire collection is currently being digitised for online access. The collection includes a substantial number of tracing papers, which are mostly resin-impregnated map overlays. These folded, brittle papers are a primary historical resource, but they have sustained considerable damage and some loss over the years. The current project has provided an opportunity to stabilise these materials for flat storage. The repair method used for stabilisation needed to consider the sensitivity of the material to distortion, the issues of media solubility, the need to maintain transparency for evidentiary reasons and the volume of material requiring processing.

Introduction

The Australian War Records Office compiled the day-to-day records of Australian actions in the First World War. After Armistice, these documents were assembled, indexed, classified and bound into volumes for preservation purposes, by Australian servicemen awaiting demobilisation from England.

Nearly 15 years ago, over 400 volumes of War Diaries were disbound for microfilming. The task of separating and rehousing the approximately 300,000 pages included the application of sufficient repairs to allow the pages to be safely handled and filmed by an external contractor. Given the scale of the task (and the number of impoverished conservation students

carrying it out) the repair paper of choice was a commercial heat-set tissue with an acrylic adhesive.

Recently the entire series, held in 645 archive boxes, was surveyed for digitisation. By and large the heat-set repairs have been successful, except for those repairs applied to specialised papers, particularly those applied to the resin-impregnated, transparent papers. The heat-set tissue has taken poorly to these papers and has partially released. Where it still holds, the acrylic appears to have largely fused with the thermoplastic resin. The repairs are ugly, unsympathetic and reduce the translucency of the document.

Characterisation of the tracing papers and the deterioration processes

The tracing papers encountered in the War Diaries fall into three broad categories:

- oiled papers and oiled linens
- resin-impregnated laid papers
- resin-impregnated wove papers.

The last of these is the predominant category. More modern forms of tracing paper do not occur in this series.

The oiled papers appear to have been prepared on site, by the user. Standard-issue stationery office papers, generally issued for hectographic or mimeographic reproduction, have been steeped in linseed oil. The oil has darkened and clearly gone through a tacky phase, sticking to adjoining papers and staining them badly. Heavily oiled papers have maintained some of that tackiness. The leaching out of much of the oil and its subsequent darkening has also meant that the transparency of the paper is now poor. The oil-impregnated linen has fared similarly but appears to have been less prone to sticking. The linen appears to be identical to the type generally used for blue linen drawing supports. Oiled papers and linens were, thankfully, uncommon in the collection.

The resin-impregnated laid and wove papers have distinct characteristics that accord with very different applications. These characteristics/differences are summarised in Table 1.

The resin-impregnated laid papers have been used for the production

Table 1.

Wove paper base	*Laid paper base*
Over 90% of the prepared tracing papers	Less than 5% of the prepared tracing papers
Basis weight about 62 gsm	Basis weight about 59 gsm
Very brittle and prone to fold fractures and brittle edges	Not badly damaged; damage is mainly fractured folds
Warm caramel hues	Generally a greenish hue
Paper colour after resin extraction is cream	Paper colour after resin extraction is generally a pale green
Custom-printed forms are common	No custom-printed examples found

of original maps, some of which are illustrated with a variety of coloured inks. The wove papers have generally either been used as a support for plans and similar designs destined for reproduction as blueprints or diazotypes, or, most commonly, for daily reports and status charts to be overlaid on standard maps. Many of this latter category were produced on preprinted and issued forms. The printing of these forms was carried out by a lithographic process impressed onto the prepared tracing paper; microscopic examination clearly shows that the printing is on top of the resin. Some of these forms have subsequently been overprinted with a hectographic image. The hectographic processes have generally resulted in blooming, an effect which was not reversed after lining treatment.

The brittleness of the resin in the wove transparent papers was evident where new folds had been added, and where pencilled inscriptions had been added to the documents. Such inscriptions give rise to distinctly lighter and more opaque regions due to the localised fracturing of the resin and disruption of the refractive index.

Samples of the laid and wove resin-impregnated papers were immersed in acetone and the extracted resins analysed. The resin-free samples were then pulped for fibre analysis and compared with two later-20th-century

Table 2.

Tracing paper type	*Fibre type and source*	*Resin analysis*
WWI wove pattern	Bleached sulphite softwood pulp	Canada balsam
WWI laid pattern	Cotton fibre	Canada balsam
WWII military issue	Super-beaten fibres (unidentifiable) with bleached sulphite softwood pulp for bonding strength	None
Vietnam War, 1966 issue	Super-beaten fibres (unidentifiable) with bleached sulphate hardwood pulp for bonding strength	None

tracing papers. All samples were stained with Selleger stain prepared as described in Browning (1969) and the pulps characterised. The results are tabulated in Table 2.

Canada balsam is an oleoresinous mixture of different terpenes, chiefly abietic acids, derived from the balsam fir *Abies balsamea*. Although its distinctive and strong pine fragrance led to its being labelled a balsam, it is more correctly a turpentine. The term 'turpentine' has, however, generally been reserved for the essential oil that is extracted from the mixture, leaving the brittle, solid resin behind. The solid is commonly also referred to by the generic term for pine resins, 'rosin' or 'colophony'. The dried resin, dissolved in xylene, is widely used as a mounting medium for microscope slides and as a cementing agent for lenses since its refractive index approximates that of glass. According to CAMEO (2006) it was briefly used as a varnish but fell into disfavour due to its tendency to bloom and darken. Its use as a transparentising treatment for paper is described in Dick's *Encyclopedia of practical receipts and processes* (1901: p194):

> Lay open a quire of paper, of large size, and apply with a clean sash tool [an angular sash brush] a coat of varnish, made of equal parts of

> Canada balsam and oil of turpentine, to the upper surface of the first sheet, then hang it on a line … If not sufficiently transparent, a second coat of varnish may be applied …

Here, oil of turpentine refers to wood turpentine, not the petrochemical substitute mineral turpentine.

Canada balsam is soluble in ethers, a range of aromatics, tetrachloromethane and chloroform. It is also soluble in acetone and mostly soluble in ethanol, but is insoluble in water. The tracing papers give off a strong aromatic resinous scent when dampened with water.

The options assessed

The binding of the First World War Diaries provided an extraordinary preservation environment for all of the records, including the map overlays. The tracing papers were at risk of damage because they were folded and needed to be folded out for access. However, many of them appear to have experienced very little use. These War Diaries, collectively known as the AWM 4 series had a parallel series, AWM 26. This latter series was produced in the 1920s and 1930s and was a chronological distillation of the War Diaries. Under Charles Bean's (the official historian's) direction, AWM 26 was generated to ease the task of the compilation of the Official Histories. The use of this series has perhaps taken some of the pressure off AWM 4 and its more fragile materials. The map overlays are often also quite separate from their reference maps and, being bound into volumes, would have been inconvenient to use. They were most likely neglected as a resource.

Examination of the binding edges and folds on these overlays was a useful indicator of what repairs were most likely contemporaneous with their battlefield use and what might have been later repairs to the bound pages. Almost all of the existing repairs on the overlays (excepting later heat-set attempts) were gum or starch repairs with various kinds of paper strips. Repairs with pressure-sensitive tapes were very rare; this might again be a result of their being bound. Many of the repair patches showed significant cockling, misalignment and distortion.

In examining repair options it was necessary to consider several criteria:

- the uses to which the material was originally put
- the uses to which the material may need to be put
- the sensitivities of the support and media.

For those papers where the purpose was to support designs for reproduction, a variety of options are available. The papers are a record of these uses but are no longer required for that purpose. In cases where the support is very fragile and where the media are stable to the solvent and relatively durable, the resin has been extracted in a bath of acetone and the item lined. Printed media, black inks and graphite pencil appeared unaffected by the extraction process. The added advantage of this method is that the support background is lightened, useful where pencilled details are indistinct. The increased suppleness and absorptiveness of the paper makes conventional starch adhesive lining a simple task.

In the case of the polychrome maps on laid paper, the reason for the use of this support is not clear unless it has been used as an alternative to blue linen or a similar drafting film. The repair options in this case are often somewhat limited by solubilities, however the papers are generally not as prone to cracking and fracture and are not as discoloured as the wove papers. Ultimately the treatment used for the laid papers was the same as that developed for the wove papers, as described below.

Developing a treatment method

The level of damage sustained by the wove papers renders most of them unusable. The sheets need a repair method which reintegrates the fragments and supports them sufficiently to allow their use as overlays.

The only practicable repair for the wove paper overlays is a lining; however, such a repair must satisfy certain criteria:

- The repair must reduce the transparency as little as possible.
- The repair must not disrupt the media.
- It must cause as little dimensional change as possible to maintain the relationship to the source map.

The moisture content of conventional starch paste and tissue repairs can cause an unacceptable level of distortion. A solvent-based adhesive would overcome some of this distortion but the Canada balsam is sensitive to

the solvents in many commonly used adhesives. The solution was to use minimal solvent and adhesive and to dry the items rapidly.

Solvent-based adhesives fall basically into those used wet and those prepared into heat- or solvent-reactivated films. The commercial acrylic heat-sets had been less than satisfactory and solvent-activated films require considerable preparation.

Susan Page, in her paper on 19th-century tracing papers (1997), describes the use of a prepared, solvent-activated, tissue lining paper. Her adhesive of choice was a hydroxypropyl cellulose (HPC), Klucel G, used as a reactivatable adhesive film on 19 gsm, machine-made *kōzo* paper. Given the numbers of linings necessary, this approach did not seem practical. Furthermore, some concerns have been raised regarding the long-term stability of HPCs. Feller and Wilt (1990) noted that accelerated aging of HPC resulted in a significant level of chain fracturing and discolouration. The most stable of the cellulose ethers examined in that exhaustive study were the methyl celluloses (MC) and the hydroxypropyl methyl celluloses (HPMC), the latter described by Feller and Wilt as possessing "excellent long term stability" (1990: p95).

A stock of HPMC from Aldrich Chemicals (now Sigma Aldrich) was trialed as a potential adhesive. This HPMC has a viscosity of 4,000 centipoises as a 2% solution, a hydroxypropyl content of 10% and a methoxyl content of 30%. Most commercially available HPMCs have a degree of substitution (DS) of 2–2.3, which is below the level where they would be easily soluble in non-aqueous solvent systems. Dow Chemicals (2002) and Aqualon/Hercules (2000) suggest in their technical information that methylene chloride in combination with isopropanol or methanol are suitable solvent systems. These may be appropriate industrial solutions but are clearly not practical in a conservation laboratory, particularly for process treatment on the bench.

Both MC and HPMC can be used in ethanol/water mixes; MC is generally soluble in mixtures of about 50% water. Because of its moderate degree of substitution, the recommendation is that HPMC be formulated in a minimum of 40% water. If initially made up with less than 40% water, the solution retains a grittiness which increases with decreasing water content. In practice, however, it is possible to make up solutions with

a much lower water content. One prepares a solution by dispersing the HPMC in pure ethanol, adding water to this to a proportion of 40% and then diluting the clear gel with an equal volume of ethanol. This method was used for this project: the initial 40:60 solution of 3% HPMC was diluted to a 1.5% solution in 20:80 water:ethanol. This solution remains clear, with no grittiness.

It was hoped that the adhesive solution in 20:80 water:ethanol might limit the solubilising effects of the ethanol on the Canada balsam whilst also limiting the distorting effects of the water on the support. Its use as an adhesive for thin film lining was worth investigating. In practice, the resin was slightly solubilised by the solvent, and slight relaxation of the support occurred due to the water content of the adhesive mixture. It was found to be practical to lightly humidify the tracing paper to anticipate the relaxation of the paper, and to provide some flexibility to work out the creases and persistent folds.

The choice of lining paper was an existing stock of warm white, machine-made *bib tengujo* (100% *kōzo*) tissue with a basis weight of 8.4 gsm.

The treatment process

The volatility of the solvent carrier for the HPMC meant that the process had to be well prepared for and rapidly carried out. Sheets of rayon paper and repair tissue were cut to the required sizes. The map overlay was humidified between lightly dampened blotters for the few minutes it took to prepare the lining tissue.

For each item a sheet of rayon paper was wet out and blotted to remove most of the free moisture. The *bib tenjugo* repair paper was then pasted out on the rayon paper support with the 1.5% HPMC adhesive (in 20:80 water: ethanol) using a broad house-painter's brush. The relaxed overlay was then positioned on the lining and tears slid into alignment, taking advantage of the slipperiness of the cellulose ether. As soon as it was aligned, the item was faced with polyester web (Reemay), flipped over, the rayon paper support peeled away, and the item was covered with a second layer of Reemay and placed in a screw press between blotters. The blotters were then changed when the next item was processed and ready to be pressed.

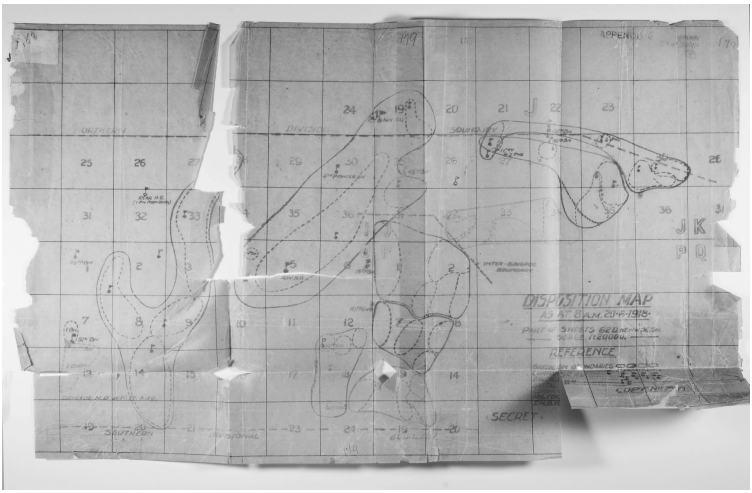

Figure 1. Before treatment of a resin-impregnated wove tracing paper.

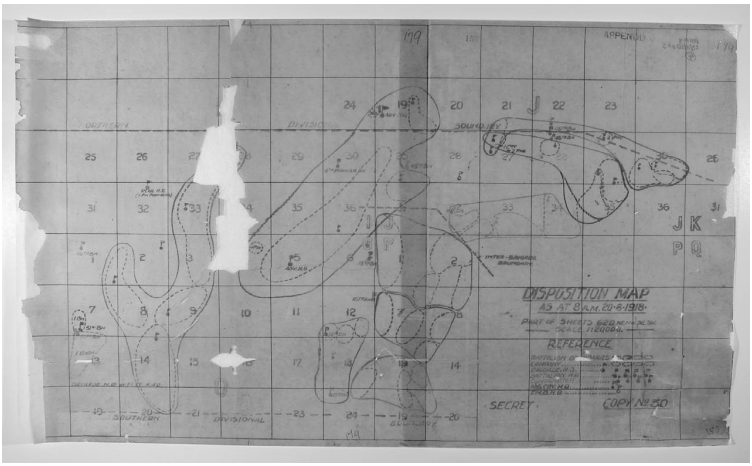

Figure 2. After-treatment image of the same item.

Figures 1 and 2 show before and after images of an object treated by this process.

Conclusion

This 'dry' lining method proved to be a fast and efficient way of integrating and supporting these fragile papers. However, the volatility of the solvent carrier for the HPMC meant that the process had to be well prepared for and rapidly carried out. Under such circumstances each item can take about fifteen minutes to process and is sufficiently dry to encapsulate within two to three days. The transparency is substantially retained (see Figure 3) and no dimensional changes have been observed. Although some solubilisation of the resin occurs, the nature of the item is maintained

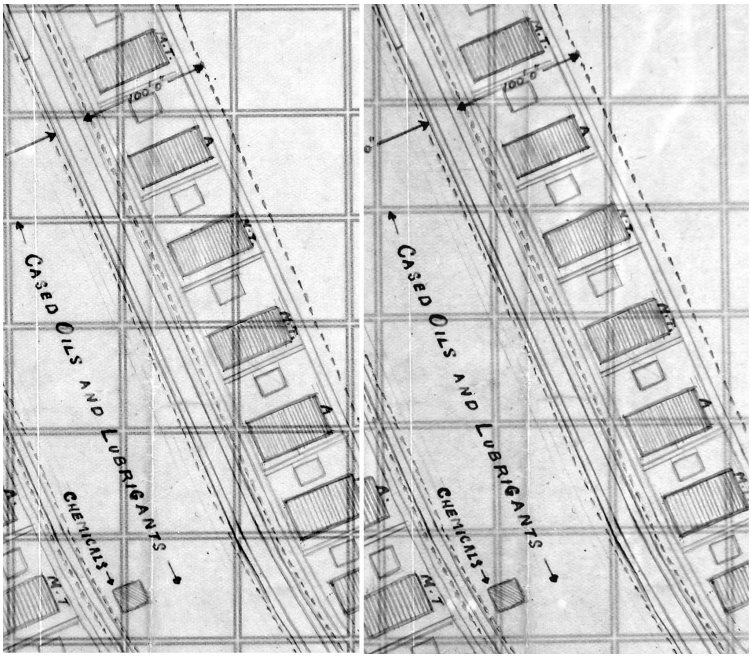

Figure 3. Before (left) and after treatment images showing the effect of the lining process on transparency. The items were identically illuminated on a copy stand with a laser-printed grid underneath.

without significant mobilisation of the media. The solubilising of the resin occurs on the verso of the object, but even soluble media on the verso such as stamp inks and coloured ink stains are minimally affected. The pressing and rapid drying helps to minimise any solubility effects. The use of pressure is essential to achieving a good bond. The resultant adhesive layer is of minimal thickness. The thickness of the wove paper overlays was, on average, 60 microns, the *bib tengujo* lining paper was 40 microns and the overall treated package was between 100 and 110 microns.

This technique has also been used satisfactorily on Second World War-era tracing papers, which have a totally different fabrication method and are much more reactive to water. The poorer-quality, over-beaten pulps used in the Vietnam-era tracing papers have proved to be very much more reactive and even more prone to distortion. They are, however, significantly easier to process using this method than with any water-based treatments. Again, the secret to a good bond is to dry them under pressure in a screw press. The adhesive bond on these papers is strong enough to support them for use as overlays, but the repair is mechanically reversible; it can be carefully peeled off. Since the papers are inherently stronger than the resin-impregnated papers, the light Japanese tissue can be peeled off.

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Author biography

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