

Giant sequoia: an extraordinary case study involving Carbopol® gel

Chelsea McKibbin, Lu Allington-Jones and Efstratia Verveniotou

Introduction

In 1891 a 'Big Tree' exhibition was commissioned for the American Museum of Natural History (AMNH) and the British Museum of Natural History (now NHM). A giant sequoia called 'Mark Twain', was selected from Kings Canyon National Park, California, USA. When felled, it was 1,341 years old, 101 m tall and just over 5 m in diameter. Two sections were cut for display. The bottom and slightly larger one was sent to the AMNH while the top section was split into 12 pieces: one central disc and 11 radial segments. These were shipped to Liverpool, UK, from San Francisco for the British Museum, and arrived at the South Kensington site in April 1893. The giant sequoia section went on display the following year, in one of the bays of the central hall. It was moved in 1902 to stand against the wall dividing the north and central halls, and again in 1971 to its current location on the second floor balcony (Tucker 2015).

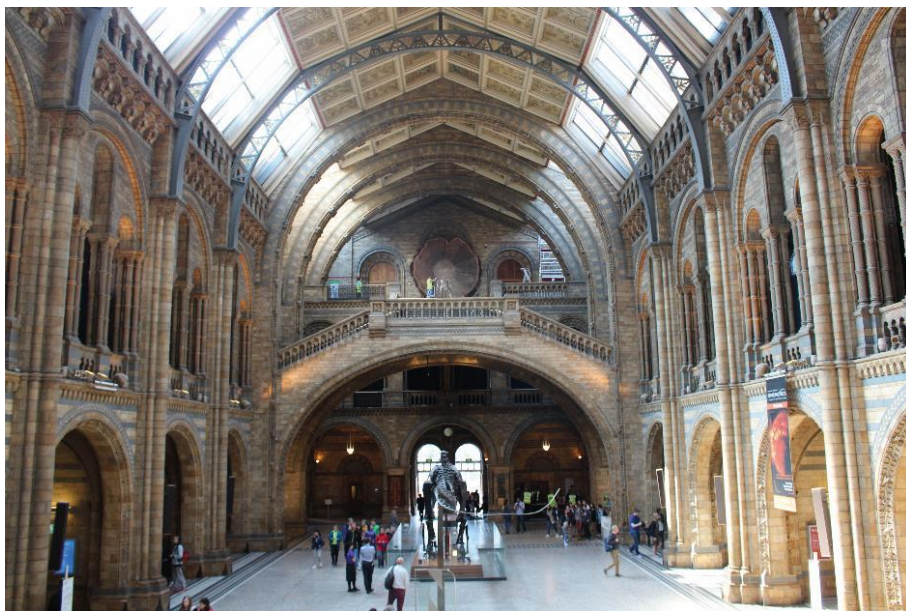


Fig. 1 The section of giant sequoia, on display in the central hall of the NHM, can be seen at the top of the image.

By 2016, a substantial amount of dust had accumulated on the horizontal surfaces of the specimen, the bark suffering the most due to its fibrous nature (Fig.1). The wood surface had previously been treated with a lacquer that had become discoloured, bloomed and cracked,

obscuring the growth rings. This was due to darkening with age, exposure to environmental elements and contact with moisture most probably from wiping down with damp cleaning cloths. Liquid and lacquer stains, and drips from adhesives, had greatly discoloured on the lower part of the trunk. Small cracks that appear fresh are evident at the lower part of the trunk possibly due to weight distribution. Nails used to keep the outer bark of the trunk in place are now actively corroding and protruding, and potential brown rot, a wood-decay fungus, has affected discrete areas. These agents of deterioration will need to be monitored in years to come to ensure they are no longer active.

The remit of the project was to remove the dust that had accumulated over the last 35 years, stabilize the friable bark, remove the coatings existing on the surface of the wood and apply a new layer of protective varnish. Before conservation work was undertaken, the curators were consulted and the treatment proposal agreed upon.

Risks to the specimen from conservation treatments included loss of material during dry cleaning, especially on the friable bark surface, abrasion or over-cleaning during the removal of the current varnish layer, loss of integrity to fills during the removal of current varnish layer, darkening of surfaces during the application of adhesives and consolidants and swelling or distortion of material, in particular the bark during consolidant application. The choice of solvent for removing the old varnish and as a carrier for a consolidant and new varnish resin was therefore a key consideration.

Varnish removal

Wood is a complex mix of components with diverse solubility parameters. Cellulose, hemicellulose, lignin, suberin, cutin, pectin, tannins, wood waxes, resins and oils are adversely affected in different ways by one or more of the following substances: water, ethanol, ether, hexane, benzene, alkaline solutions, acids, enzymes, butanol, methanol, benzyl alcohol, xylene, warm glycerol, sequestering agents and calcium binders (Florian 2012: 22–5; Gilberg 1986: 180; Kronkright 2012: 153,161, 170, 171; Norton 2012a: 85; 2012b: 221).

Petroleum distillates do not swell woody tissues (Kronkright 1981; Norton 2012b: 221) and, of these, xylene appears to pose the least risk to wood, whilst mineral spirits would be the most appropriate for treating bark. The location of the sequoia, within an open gallery, meant that xylene was unsuitable for health and safety reasons (even when fume extraction systems were deployed). Conservators decided that the best solution therefore was to remove the old varnish with a solvent gel, and to discover a suitable consolidation varnish that was soluble in mineral spirits.

Using a gel system reduces the rate of evaporation and diffusion of a solvent, enabling an increased contact period. It also ensures better control over solvent penetration, reduces toxicity, reduces levels of mechanical action in comparison with continuous rolling with free

solvents and provides a suitable method of application for a vertical surface. The reduction in volatility 'concentrates' the effect of the solvent, increasing the ability to dissolve the material on which it is working. It allows a solvent with a higher solubility parameter to more readily remove individual layers with potentially less hazardous solvents. The risks posed to the conservator (and the public) would also be limited due to the reduction in evaporation rate of the solvent.

Tests showed that industrial methylated spirit Carbopol® gel solubilized the old varnish layer. Carbopol® EZ2 (polyacrylic acid polymer) was used as the thickener, Ethomeen® C-25 (tertiary amine ethocylate) as neutralizing agent for the polar solution, and low concentrations of distilled water to aid the polyacrylic acid polymer to uncoil and form a stable network (Rivers and Umney 2003). As large quantities of the gel were required, the most effective method for mixing proved to be within polyethylene zip bags, which also minimized wastage and equipment cleaning. The gel was found to achieve optimum smoothness and viscosity after standing for a minimum of 24 hours. However, temperature appeared to have an effect on the resulting gel, particularly noticeable at the time of application. The environment in the gallery fluctuated during the three-month project: whenever the temperature reached 23 °C and above, the gel became 'wetter' and made application much more difficult as it tended to slip off the surface.

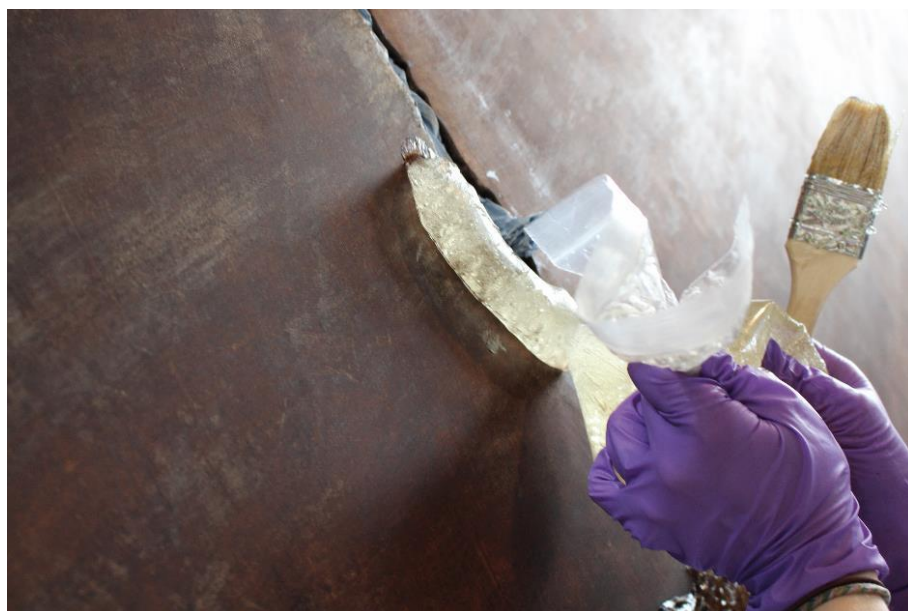


Fig. 2 Applying solvent gel directly from the mixing bag.

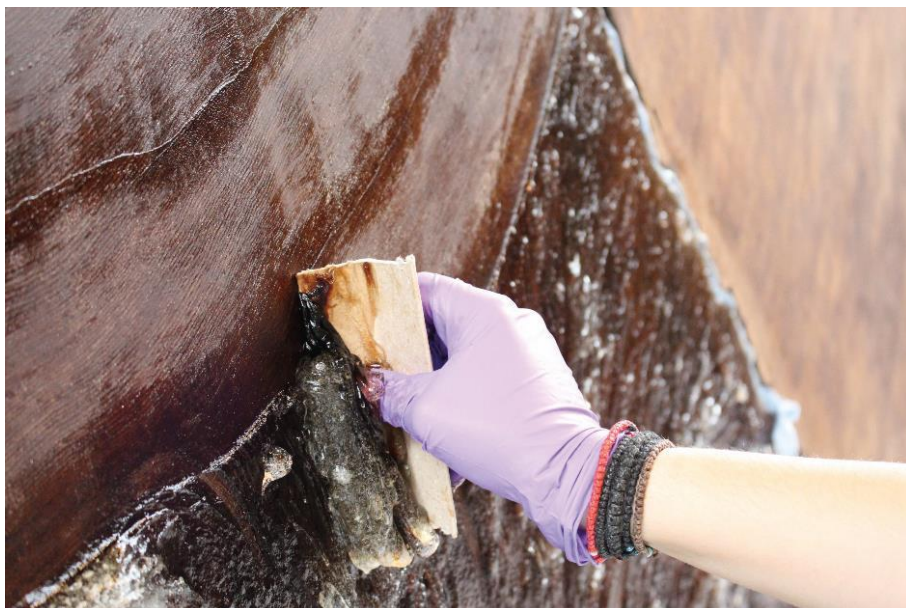


Fig. 3 Removing the solvent gel after treatment, note the discoloration from solubilized varnish.

The gel was applied directly from the bag by cutting one of the corners and using it to pipe onto the surface (Fig. 2). It was smoothed to a thickness of approximately 20 mm with wide bristle brushes to ensure sufficient contact and even distribution. Solubilization of the varnish became uneven if air pockets were present. The gel was covered with clingfilm to reduce evaporation, and to prevent slippage of the material, and allowed to work for a maximum of one hour. After about 45 minutes the gel became tackier which hindered the removal process. Once the varnish surface solubilized, it was drawn into the gel making it dark brown with saturation (Fig. 3). The spent gel was removed using rudimentary cardboard scrapers, following the grain of the wood. Cardboard was chosen as it was rigid enough to scrape the gel off, but soft enough not to cause abrasion to the wood surface. A second layer of fresh gel was applied to remove the remaining varnish. After the second scraping of spent gel, residue was removed by using IMS-saturated tissue poultices and wipes.

Although every attempt was made to ensure the gel was removed in its entirety, there is an understanding that there may be residual remnants. Attempts at using barrier materials to prevent the risk of contamination proved troublesome and ineffective. Several attempts of various tissue applications were trialed, but maintaining contact on the vertical surface was impossible, resulting in slumping of the material or full detachment. Prior wetting with IMS improved gel permeation but contact remained insufficient. In order to remove the varnish, complete contact was necessary, and the success of direct application outweighed the risk of

minimal residue.

As the varnish was removed it became apparent that an application of coloured wax had been applied to the top section of the sequoia. This had occurred sometime in the past 40 years as a consequence of various restorative works applied to the top and bottom halves of the section. This was removed by applying white spirit to the wax with a stiff brush, followed by a gentle application of soft steel wool following the grain of the wood to agitate the wax. Finally, using IMS-saturated towels, it was wiped until minimized.

Choice of resin

The next step was to evaluate conservation-grade resins that are soluble in white spirit or Stoddard's solvent: Paraloid B67, ketone resins (polycyclohexanes) and urea-aldehyde resins. Paraloid B67 is soluble in white spirit with the addition of an aromatic hydrocarbon but it crosslinks under ultraviolet (UV) exposure and may be prone to attracting dust and fracturing (Rivers and Umney 2003: 595). Ketone resins are used in paintings conservation in preference to more stable poly (vinyl acetate) or polymethacrylates due to their optical properties (de la Rie and Shedrinsky 1989: 9). Ketone resins, however, are susceptible to photooxidation and lose solubility, requiring more polar solvents for removal (Horie 1987: 116; de la Rie 1988). De la Rie and McGlinchy (1990: 168) suggest using a hindered amine light stabilizer (HALS) such as Tinuvin® 292 which acts as an antioxidant by scavenging free radicals (von der Goltz *et al.* 2012: 642). One ketone resin which has been used extensively in picture conservation (and formerly a component of BEVA® 371) is Ketone® N. This was discontinued but replaced by Laropal® K80 (Stonor and Rushfield 2012: 623), now also discontinued. Laropal® K80 has been replaced in BEVA® 371b with an unspecified aldehyde ketone resin (Ploeger *et al.* 2015: 220).

McIntyre (2011) suggests Laropal® A81 as an alternative to ketone resins (a low molecular weight urea-aldehyde resin created by a condensation reaction between aliphatic aldehydes and urea). Urea-aldehyde resins have been used as consolidants and adhesives for wood (Horie 1987: 177) and Laropal® A81 possesses excellent photochemical stability, resolubility after accelerated light aging, and good wetting capabilities (Leonard *et al.* 2000: 111; von der Goltz *et al.* 2012: 648). It was developed specifically for conservation, in conjunction with conservation scientists (Digney-Peer *et al.* 2012: 624), possesses lower gloss than similar varnishes and produces an even spread due to its low molecular weight (von der Goltz *et al.* 2012: 649). It is also supposed to promote the natural grain of wood (AIC 1998) and gives good colour saturation (von der Goltz *et al.* 2012: 648). Accelerated aging tests of Laropal A81 not only confirmed good photochemical stability but also, to a certain extent, a protective effect from photochemical deterioration of pigments (de la Rie *et al.* 2000). Arslanoglu and Learner (2001: 62; 63) and von der Goltz *et al.* (2012: 648) consider Laropal A81 to be the most stable commercially available aldehyde resin and one of the most stable resins known to conservators. Laropal A 81's solubility in aliphatic solvents such as white

spirit is, however, limited, forming a 2-phase gel and solvent mixture (von der Goltz *et al.* 2012: 648). Such solutions can be stabilized by the addition of 2–5% of an aromatic solvent such as Solvesso® 100 (BASF 2000). Leonard *et al.* (2000: 113) found a mixture of 1:4 isopropanol in mineral spirits, Arcosolve (propylene glycol monomethyl ether) or equal parts isopropanol, petroleum benzine and Shell® TS-28 to be effective solvents. De la Rie *et al.* (2000) used cyclohexane or acetone with toluene as solvent mixes.

Whereas it could be argued that any consolidant is not practically reversible from the bark, some consolidation of the sequoia is essential for continued preservation and stability (especially since the specimen will remain on open display), and choosing the most stable resin is essential. Continued re-solubility after aging tests is an indication that crosslinking, chain scission, oxidation and the formation of radicals and other forms of deterioration, which could lead to tackiness, colour change and an alteration in crystallinity (Cruikshank 1985: 55) have not occurred. This is especially important since these could lead to further forms of deterioration such as the attraction of dust, the formation of catalysts for different reactions, and a cracked surface that will trap harmful pollutants, oxygen and moisture (Cruikshank 1985: 57; 63). Therefore 8% Laropal® A81 was chosen for consolidation of the bark, dissolved in a 20% white spirit and 1% isopropanol mix.

Paraloid® B-72 has high chemical stability and is soluble in xylene, and would therefore be suitable for use for varnishing the wood, but it has high molecular weight which means it exhibits poor wetting on surfaces where old varnishes may have been unevenly removed, and it also may attract dust (Rivers and Umney 2003: 594–5). In addition it must not be layered with a resin in mineral spirits because fogging will occur (Rivers and Umney 2003: 594). The conservation team therefore decided to use Laropal® A81 (20%) as a varnish for the wood, which has the added advantage of reducing the number of chemicals introduced to the specimen.



Fig. 4 Working on the scaffolding tower within the gallery.



Fig. 5 The section of giant sequoia after conservation treatment.

Conclusion

The main challenges faced during this project derived from the sheer size of the sequoia transverse section. The specimen had to be treated *in situ* within the gallery, whilst the lower levels of the hall remained open to the public. The health and safety risks associated with using large quantities of hazardous chemicals, on a scaffold with a 6 m working height (Fig. 4), in a partially open gallery, with conservation of the adjacent mosaic floor occurring below, required careful consideration and management. The volume of solvent gel required was considerable, especially since two applications of a 20 mm layer proved necessary. The authors are very grateful to colleagues who gave up their time to help mix up the copious amounts of gel. The most effective method for making and applying the gel proved to be in zip-lock bags, and the texture of the gel itself improved the longer it was made in advance. The solvent gel was quite labour intensive to remove from the surface of the specimen, especially when it began to dry. An incremental approach to uncovering the solvent gel, scraping away the excess with cardboard spatulas and then cleaning the surface with IMS, before the gel residue dried, proved to be the most viable option. Once the varnish and waxy substance had been removed, the specimen face was sealed and the bark was stabilized using

Laropal® A81. The final phase was an application of microcrystalline wax using a microfiber cloth, to improve lustre and protection.

Overall the polar solvent gel proved extremely effective at removing the old varnish and revealed the growth rings which had been obscured for decades (Fig. 5). The gel system enabled use of a solvent that posed less risk to the specimen and to staff, and allowed this large-scale treatment to be undertaken within the public gallery.

Material and supplier

- Laropal® A81, Stort Chemicals Ltd, www.stortchemicals.co.uk

References

AIC 1998. *Paintings Conservation Catalogue. Volume 1: Varnishes and Surface Coatings*. Washington, DC: American Institute for Conservation Paintings Specialty Group.

Arsanoglu, J. and Learner, T. 2001. 'The evaluation of Laropal® A8: Paraloid® B-72 polymer blend varnishes for painted and decorative surfaces: appearance and practical considerations', *The Conservator* 25(1): 62–72.

Cruikshank, W.A. 1985. 'A comparative investigation of two polycyclohexane resins: Ketone Resin–N and Laropal–K80'. A report submitted to the Department of Art in conformity with the requirements for the degree of Master of Art Conservation, Queen's University, Kingston, Ontario, Canada.

BASF 2000. *Laropal® A81*. Available at: http://talasonline.com/photos/instructions/Larapol_A81.pdf (accessed 16 September 2015).

de la Rie, E. R., 1988. 'Polymer stabilizers. A survey with reference to possible applications in the conservation field', *Studies in Conservation* 33: 9-22.

de la Rie, E.R and McGlinchy, C.W. 1990. 'New synthetic resins for picture varnishes', in J.S. Mills and P. Smith (eds), *Cleaning Retouching and Coatings*. London: IIC, 168–73.

de la Rie, E.R. and Shedrinsky, A.M. 1989. 'The chemistry of ketone resins and the synthesis of a derivative with increased stability and flexibility', *Studies in Conservation* 34: 9–19.

de la Rie, E.R., Quillen Lomax, S., Palmer, M., Deming Glinsman, L. and Maines, C.A. 2000. 'An investigation of the photochemical stability of urea-aldehyde resin retouching paints: removability tests and colour spectroscopy', in A. Roy and P. Smith (eds), *Tradition and Innovation: Advances in Conservation*. London: IIC, 51–9.

Digney-Peer, S., Thomas, K., Perry, R., Townsend, J.H. and Gritt, S. 2012. 'The imitative retouching of easel paintings', in J.H. Stoner and R. Rushfield (eds), *Conservation of Easel Paintings*. Oxford: Routledge, 607–34.

Florian, M-L. E. 2012. 'Plant anatomy: an illustrated aid to identification', in M-L. E. Florian, D.P. Kronkright and R.E. Norton (eds), *The Conservation of Artifacts made from Plant Materials*. Los Angeles: The Getty Conservation Institute, 1–27.

Gilberg, M. 1986. 'Plasticization and forming of misshapen birch-bark artifacts using solvent vapours', *Studies in Conservation* 31: 177–84.

Horie, C.V. 1987. *Materials for Conservation: Organic Consolidants, Adhesives and Coatings*. London: Butterworths.

Hull, R. 2008. *Paraloid F10*. Available at: http://www.conservationresources.com/Main/uk_section_019/019_028.htm (accessed 26 July 2017).

Kronkright, D.P. 1981. 'New directions in Native American basketry conservation', *Preprints of the American Institute for Conservation 9th Annual Meeting*. Washington, DC: AIC, 95–108.

Kronkright, D.P. 2012. 'Deterioration of artifacts made from plant materials', in M-L. E. Florian, D.P. Kronkright and R.E. Norton (eds), *The Conservation of Artifacts made from Plant Materials*. Los Angeles: The Getty Conservation Institute, 139–93.

Leonard, M., Whitten, J., Gamblin, R. and de la Rie, E.R. 2000. 'Development of a new material for retouching', in A. Roy and P. Smith (eds), *Tradition and Innovation: Advances in Conservation*. London: IIC, 29–33.

McIntyre, C. 2011. 'Development of a pigmented wax/resin fill formulation for the conservation of paintings'. Available at: http://www.conservationcolors.com/documents/McIntyre_695_To_Gamblin_2014.pdf (accessed 14 September 2015).

Norton, R.E. 2012a. 'Technology of plant materials used in artefacts', in M-L. E. Florian, D.P. Kronkright and R.E. Norton (eds), *The Conservation of Artifacts made from Plant Materials*. Los Angeles: The Getty Conservation Institute, 83–138.

Norton, R.E. 2012b. 'Conservation of artifacts made from plant materials', in M-L. E. Florian, D.P. Kronkright and R.E. Norton (eds), *The Conservation of Artifacts made from*

Formatted: Font: (Default) Times New Roman, 12 pt, Font color: Auto

Formatted: Font: (Default) Times New Roman, 12 pt, Font color: Auto

Formatted: Font: (Default) Times New Roman, 12 pt, Font color: Auto

Plant Materials. Los Angeles: The Getty Conservation Institute, 195–285.

Ploeger, R., McGlinchey, C.W. and de la Rie, E.R. 2015. ‘Original and reformulated BEVA® 371: composition and assessment as a consolidant for painted surfaces’, *Studies in Conservation* 60: 217–26.

Rivers, S. and Umney, N. 2003. *Conservation of Furniture*. Oxford: Butterworth-Heinemann.

Stonor, J.H. and Rushfield, R. 2012. *Conservation of Easel Paintings*. Oxford: Routledge.

Tucker, P. 2015. *The Giant Sequoia*, Getting to Know the Collections series. London: Natural History Museum.

von der Goltz, M., Proctor, R.G. Jnr., Whitten, J., Mayer, L. and Myers, G. with Hoenigswald, A. and Swicklick, M. 2012. ‘Varnishing as part of the conservation treatment of easel paintings’, in J.H. Stonor and R. Rushfield (eds), *Conservation of Easel Paintings*. Oxford: Routledge, 635–57.

Authors’ addresses

- Chelsea McKibbin, The Conservation Centre, The Natural History Museum, London, UK (c.mckibbin@nhm.ac.uk)
- Lu Allington-Jones, The Conservation Centre, The Natural History Museum, London, UK
- Efstratia Verveniotou, The Conservation Centre, The Natural History Museum, London, UK