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Historic Wallpaper Digitally Remastered: Early Twentieth-Century Block-Printed English Wallpaper in the Yin Yu Tang House at the Peabody Essex Museum

ABSTRACT

In 1926 English wallpaper was imported to decorate a room in the c. 1800 Yin Yu Tang house in Anhui province, China, for the wedding of a Huang family member. Following the Cultural Revolution and Four Modernizations, the Yin Yu Tang house was found unused by a Peabody Essex Museum curator who arranged for the building to be dismantled, shipped to Salem, and reassembled by expert craftsmen. Messier was contracted to deal with all the paper artifacts for the Yin Yu Tang house. Among other projects, including the creation of forty digital surrogates that would remain permanently on room display, digitally recreating 350 square feet of historic wallpaper was one of the more complex projects. Vitale went to Boston, captured several images of the wallpaper using the highest resolution digital camera and lens available in 2002. The best pattern repeat unit on existing wallpaper was selected, digitally photographed, and digitally restored. The repeat unit was duplicated into ten-foot long panels and printed using Epson Ultrachrome pigmented inks on Hahnemuhle Structure 150 paper using the Epson 9600 inkjet printer at 1440 dpi. Messier, Diane Tafilowski, and Lauren Varga mounted the recreated wallpaper using Lascaux 498-20X on new masonry walls in the reconstructed home, in a new wing of the Peabody Essex Museum. The digital surrogate on masonry was blended with the original on the wood batten walls, beams, and ceiling using localized abrasion, pastels, and pigmented tile grout.

THE YIN YU TANG HOUSE

High style English wallpaper was imported to decorate a bedroom in the Yin Yu Tang house for the 1926 wedding of Huang Zhenzhi, during the end of the imperial era when imported Western goods were sought. The traditional Huizhou structure was built about 1800 by the Huang family in the Huang Cun village, Anhui province, about 250 miles west of Shanghai on the east coast of China. The main door and forecourt faced north, with the open courtyard oriented east-west. The structure was a mixture of post and beam timber frame interior, masonry exterior, and clay tile roof.

Following the Cultural Revolution (1966–76), the Maoists used parts of the house for various functions through 1982, the end of the Four Modernizations era. The disused structure was found in 1996 by Nancy Berliner, curator of Chinese art and culture at the Peabody Essex Museum (http://www.pem.org/yinyutang/). Seeking to increase international awareness of traditional architecture, the Xiuning County Cultural Relics Administration brokered a cultural exchange in 1997. Salem had been a major partner in the China Trade and thus had long-established ties with China.

The house was disassembled over four months in the last half of 1997 and shipped in seventeen containers through Shanghai, Tokyo, the Panama Canal, and New York, to Boston. Paul Messier was contracted to deal with paper artifacts for the Yin Yu Tang house, which was temporally being housed in a metro Boston warehouse. Along with repairing paper window coverings and the creation of forty digital surrogates, which ranged from hanging scrolls and Maoist posters to books that would remain permanently on display under uncontrolled environmental conditions, the digital recreation of the wallpaper was one of the more demanding projects involving a full range of conservation skills.

By 2000, the historic wallpaper existed in two forms: (1) on the major timbers dismantled and stored with other timbers; and (2) on the five-inch wide tongue-and-groove wallboards from the bedroom stored in a more stable location. These five-inch wide wallboards were reassembled

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and used as the original material for creating the surrogate wallpaper.

IMAGE CAPTURE

Vitale was brought in as a subcontractor to make the digital capture of the remaining originals, to digitally restore the wallpaper repeat unit image, and to print 350 square feet of surrogate wallpaper for hanging in the bedroom. Samples of the damaged original were captured onsite in a metro Boston warehouse using the BetterLight (http://www.betterlight.com/superModels. asp) Super 8K (12000 x 16000 pixels) digital scanning back in a Calumet Cambo Legend 4x5 body with a 180 mm Schneider Apo-Symmar lens. Two large (32 x 43 in.) Calumet Nova soft boxes at about 30° from the plane of the wallpaper, eight to ten feet from the wallboards, with 1000 W tungsten lamps, were used for illumination. As detailed surface texture is critical for a good digital surrogate, the lighting was arranged to show the fine texture of the surface, which was maintained throughout the creation process.

Focus was difficult due to the undulations of the wallboards. Soft focus ruined more than one image. An f-stop of 8 is known to be the most desirable for crisp digital focus, but does not include a significant depth of field; thus f-16 was used. Stopping down to f-16 produced 12- to 15-minute exposures. Several captures were made of overlapping sections during a six-hour session. The capture with the best focus and least damage was selected, after careful viewing in Adobe Photoshop back in the studio. The image file size was approximately 300 MB (8-bit), yielding a final resolution of about 475 ppi for the image area. Image processing was done at the native resolution in Photoshop.

CREATING THE NEW REPEAT UNIT

The wallpaper pattern repeat unit was found to be 18.5 inches wide and 12.45 inches high. The painstaking process of digital restoration began with the repair of the vertical rips every five inches that were created when the tongue-and-groove wallboards were dismantled in 1997. Photoshop's rubber stamp feature was the major tool used for the repair of water-damage stains, numerous holes, and small physical damages.

Occasionally, undamaged passages were pulled from other image captures to compensate for highly damaged areas in the selected image. This required careful resizing and color correction, all based on the inclusion of the Macbeth ColorChecker and adjustments to known RGB values. Generally, restoration of damage was accomplished using local color and texture samples on the level of a millimeter(s), because it was more efficient. Care was taken to not make the digitally restored surrogate more perfect than the original, which was printed with woodblock rollers using five colors.

A critical part of the process was to cut small bands from the opposite edges (top, bottom, left, and right) and copy them into new (temporary) Photoshop layers. In a series of back-and-forth, match and image adjustments, the image across the join was tweaked to match the adjoining edge when the wallpaper panels would be abutted in printing and on the wall. Some of the most significant problems were to match the local angle of the light cast by the ink texture on the background. While white, with only a slight green cast, the background contained valuable textural information that included small sand particles and thixotropic ridges remaining when the printing rollers were lifted from the paper during printing in the 1920s. Because of color issues described below, the light background was separated into a new layer that was color adjusted independently.

DIGITAL CAPTURE ISSUES

The GretagMacbeth 24-patch ColorChecker, an 8 x 11.5 in. ($70) color target with its 1.625-inch square, matte-surface patches, provided a consistent, well-characterized, gray scale, color reference, and size sample in each digital image. The value of the ColorChecker is that the six-patch gray scale is always neutral gray, and each patch is always the same density from target to target. Generally, the lower two rows of patches are included in the image frame. Experience shows the same patch in different targets vary only about 1 ΔE, depending upon age and use (fingerprints). The more recent ColorChecker targets have problems under polarized illumination. (Those contemplating the use of polarization with the Color Checker are encouraged to contact Robin Myers (http://www.rmimaging.com/) for advice and the availability of older targets).

When the image file is opened for processing, the first step is to adjust the tonal range using the gray scale. Use >Image >Adjustments >Curves >Red >Blue >Green (each curve independently) to adjust each step of the six Macbeth gray scale patches to the following RGB values: 243/243/240, 201/201/200, 161/161/161, 122/122/122, 85/85/85, and 53/53/53 (+/- 1-2 RGB units). If properly captured and adjusted, these values yield a known density range of 0.05 Dmin to a 1.5 Dmax at a gamma of 2.2. Gamma is the slope of the curve (line) between absolute white and black. Within 8-bit color, there is not much usable data beyond 1.75 D, even though there are still three RGB levels between 2.0-2.1 D; most inkjet printers have a 2.1 Dmax. Robin Myers, an Apple ColorSync color management software co-creator, developed the RGB values, and experience over the years has shown them to be correct and reliable. Other well-respected color workers, Bruce Lindbloom (http://www.brucelindbloom.com/; see the

CIE color calculator) and Bruce Fraser et al. (2003, 534), have published similar results.

For image capture using a flatbed scanner (Epson 1640XL) or a BetterLight scanning back, all automatic adjustments should be turned off to produce unaltered TIFF files. Sharpening by the capture device should also be turned off. Any sharpening should be completed using the Unsharp Mask filter in Photoshop. Likewise ICC profiles should not be used at the point of image capture. Use of these profiles will shift colors and compress the color scale, rather than capture the artifact accurately. Vitale can be contacted (tjvitale@ix.netcom.com) for an essay on the use of color targets and surmounting these and other problems associated with digital imaging.

ICC profiles must be used for achieving neutral grays in the printed image. However, the ICC profile will change the image colors. Therefore the output profile should be assigned to the file, but not embedded; thus the temporary changes are used only for printing. Achieving a set of known neutral grays is fundamental for digital printing and shows that the profile is good. Color hue and saturation are built on the neutral gray (L) axis. If the grays are not neutral the colors will be off by uneven chromatic shifts from the base RGB curves. Non-neutral grays make achieving color correction along a hue angle impossible. A well-made profile ($300–$700 profiling software packages are incapable of this goal) ensures neutral grays and that the colors in the image file fit within the gamut of the output device. GretagMacbeth ProfileMaker Pro (v4.1.5 or v5) is an excellent profile-making tool. Most workers choose Adobe RGB (1998) as their working color space. This ICC profile should be embedded in the file and used as the working space in Photoshop.

Using a printing profile introduces color problems that need to be overcome to so that printed output matches the original colors. The first of two problems to be overcome is that the profile forces conformation of the image colors to the color space of the output device (printer inks). All the colors in the image are compressed, but darker and more saturated colors are compressed the most. Experience shows that most historical artifacts with historical colorants undergo only modest compression. If shifts are noticeable, they are shifted to lighter values.

The much larger problem caused by ICC printer profiles occurs within the heart of the profile, beyond the access and control of the user. For all the virtues of ICC profiles, they make achieving accurate color reproduction of the original difficult. To make adjustments in the file's colors so that the image will print well, the profile converts the working space (RGB) colors into CIELab colors and then processes the profile numbers using a set of look up tables (LUT). The RGB-to-CIELab conversion shifts the colors in a non-uniform manner, because Lab (any form of Lab, CIELab included) is a non-uniform color space. Lab angles of constant hue (radials) are not all straight—some curve—so that (1) some blues go purple, (2) red-oranges go to more yellow reds, and (3) some greens go blue-green. In addition, the shapes of the Lab rings-of-constant-chroma (saturation) are not circular, but egg-shaped. Thus, all yellows and greens are desaturated when they are converted. The problems with the non-uniform Lab color space are explained in detail on the Bruce Lindbloom website under the Uniform Lab Color Space link (http://www.brucelind bloom.com/index.html?UP Lab.html). After processing within the profile, the CIELab colors are converted back to RGB device colors for printing.

The solution to this problem is to print a proof of the image using the profile and then measure the critical colors of the proof against the original, using a colorimeter. Recording the colors and their differences, using the CIELab color space with its -a to +a and -b to +b color axes, facilitates making color alterations in the image file. Because the color corrections are for the print, not the screen, the actual on-screen colors may shift away from the actual color one is trying to achieve. At this point follow the color numbers rather than screen colors. The screen colors will, however, show the direction and degree of change. A side-by-side comparison of the proofs with the original is critical for selecting the colors that will drive the color adjustment process.

The first correction is often to resaturate the yellows; then a new proof is created. Knowing where the problems exist (certain blues and red-oranges, and all yellows) will guide the process of identifying colors that need attention. Often one correction has to be balanced against another. Use the Photoshop Hue and Saturation/Adjustment Layer features to make changes to specific colors. This procedure allows the possibility of going back to readjust the color over and over, starting from the last adjustment that is held in memory, but does increase the file size. With the adjustment window open, the Info pallet shows both the RGB and Lab values, before and after changes simultaneously, wherever the cursor is placed, so the effects of intended alterations can be checked mid-correction. Depending on the number of critical saturated colors, three to five proofs will do the job, but up to fifteen can be required to solve difficult, interrelated color problems.

In the case of this project, the light greenish-white background ink had to be separated from the more saturated colors so that the larger changes in the saturated colors did not affect the more subtly colored background. The background was selected and cut into a new layer. Changes to the saturated green passages would have unduly influenced the green tint in the white, just as the adjustment to the saturated reddish-orange, rust-colored ink, would have introduced an unacceptable red tint to the background.

The GretagMacbeth EyeOne colorimeter with iShare software was used to measure, record and determine the difference (ΔE) between target and proof colors. A match with 3 ΔE a difference is quite acceptable, below 1.5 ΔE is almost impossible to achieve.

The EyeOne colorimeter uses the D50 standard illumination (5000K color temperature), just like most other modern color measurement tools. However, the actual display lighting on the surrogate influences the final viewing color. Allowances have to be made for the color of the display lighting.

Metamerism is the difference in color based on the color of light being used to view the colorants. The Epson Ultrachrome pigmented inks have low metamerism issues, as low as any on the market. However, the printed colorants are different from the original's colorants, so differences in the display lighting color temperature will influence the various colorants differently when viewed, as opposed to being measured at D50. Tungsten (2850–3400K) or dimmed tungsten (1500–2500K) will have a significant yellow component compared to the D50 lighting being used by the colorimeter. Therefore, once colors are matched as closely as possible using a colorimeter, a final color proofing process should be performed through visual comparison under lighting approximating the intended display conditions.

PRINTING THE WALLPAPER

The texture of the wallpaper's ink was captured in the photographic process and the detail was kept in the image throughout processing using large file sizes and resolution beyond the final print resolution. Additional texture was added to the image by printing on Hahnemuhle Structure 150 paper (0.007 in. thick) that has a very slight, irregular, hummocky texture on a 2–3 mm scale. The *trompe l'oeil* photographic effect with an indistinct paper texture produced a pleasing surrogate reproduction for this project. In some situations, experimentation with paper produces more pleasing reproductions. Matching gloss is critical, but experimenting with papers above and below the target gloss can solve problems when a paper with correct gloss yields under-saturated colors or other problems.

The panels were printed on the Epson 9600 (44 inches wide) using Epson Ultrachrome pigmented inks on coated paper. The ink and paper are expected to have a 75-to-100-year life on display, unless there is high ozone or industrial pollutants in the open air. While the Lascaux adhesive was used to minimize contact between the inks and water and to control the dimensional change of the paper, subsequent testing showed that the ink and paper combination were relatively impervious to water and could have more easily been adhered to the wall using conventional techniques including the use of wheat starch paste.

Because humans can only resolve 300 dpi at a normal viewing distance, the images were sent to the printer at 360 ppi (an Epson standard), downsampled from the 475 ppi, the native resolution of the image. The printer was set to print the at 1440 dpi, the second highest printing resolution. The highest possible print resolution, 2880 dpi, is only useful on glossy papers, which are capable of showing such detail, while matte surfaced papers cannot support such detail.

The 18.5 x 12.45 in. repeat units were composited into 124 in. long images and printed as 10-foot panels. A printing RIP (robust printer driver) was contemplated because a repeat unit could be set to print over and over, as a continuous roll, but the virtues of the Epson print driver would have been lost. The Epson print-dot dither pattern, developed for the 7600/9600 series printers, is renowned for its smoothness and quality and would have been lost in favor of the RIP manufacturer's dithering process. In most RIPs the user cannot control the use of profiles. Commonly, profiles are supplied by the RIP manufacturer as opposed to selection of profiles by the user. Direct comparison between the best RIPs on the market with the Epson printer driver, using the Bill Atkinson ICC profiles (built using the GretagMacbeth ProfileMaker 4.1 engine) supplied on the Epson website, showed the superiority of the Epson driver.

DISTRESSING THE WALLPAPER

In the planning for the project it was thought that minor physical damage and staining in the original wallpaper would be kept and the only the major flaws repaired. An early mockup showed that the repeat of these flaws from unit to unit was unacceptable, thus all damage was removed in the digital domain. This increased the scope of the project markedly. Not only was more digital restoration required, but the "new" looking wallpaper had to be distressed to match the condition of the various remaining historic passages on the wooden beams, lintels, and wall boards.

Messier and staff found that the surrogate wallpaper could be distressed to the level of adjacent original wallpaper that remained attached to existing wood components by using pastels and pigmented tile grout powder. The grout powder was use in simulating broad passages of dirt, while pastels were most useful for localized adjustments and matching existing, adjacent, water stains. In some cases, cloth bags of the colorants were pounced on the wallpaper after it had been hung in place. In some cases, physical damage was simulated by scuffing the wallpaper with sandpaper and other abrasive tools.

ATTACHMENT TO THE WALL

Messier, Diane Tafilowski, and Lauren Varga mounted the surrogate wallpaper using Lascaux 498-20X, a butyl-methacrylate aqueous dispersion thinned with 20% xylene. The area where the panel was to be attached to the wall was taped off and the Lascaux 498-20X was rolled onto the plaster-surfaced masonry wall. The adhesive was allowed to reach a tacky state, and then the panel was aligned and pressed into place. A tacking iron, through silicon release paper or glassine, was used to enhance the adhesion and seal the attachment. The heat did not affect the inks or the paper.

This method proved to be a very good choice, allowing for removal and refitting when necessary, and for reattaching lifted bubbles introduced by weather conditions or damp walls. During hanging, a day with particularly damp weather caused bubbling of a previous day's work. These lifted areas were set down easily using a tacking iron and did not reappear on subsequent days.

Because the Yin Yu Tang house is exposed to year round weather of Salem Massachusetts, and Bedroom 16 has one exterior masonry wall with the room door opening onto a courtyard that communicates with the weather, it was thought that a non-aqueous adhesive would be desirable. In addition, it was not known that the Ultrachrome inks on coated Hahnemuhle paper would be as waterproof as they showed themselves to be by the end of the project. As mentioned, experience has now shown that the ink and paper combination is impervious to water and could have been applied to the wall using the traditional starch paste adhesive.

The Ultrachrome pigmented ink particles are wax coated. In their carrier liquid, the pigment particles are absorbed directly into the coating on the inkjet paper. Upon dry-down, the pigments appear to be locked into the paper. The wax coating acts as a hydrophobic barrier and also slows the intrusion of pollutants.

CONCLUSIONS

The Lascaux 498-20X was an excellent adhesive for an application with extreme weather conditions. In a room with better climatic controls, the use of water-based adhesives would be completely acceptable. The ink and paper system is stable in water.

To capture the original's paper and ink texture in the imaging process, proper lighting and the use of digital equipment with enough resolution (greater than 400–600 ppi) proved essential.

Inclusion of a color target in each image frame, usually the lower two rows of the GretagMacbeth ColorChecker, was critical for achieving the actual tonal range of the artifact.

The use of Epson Ultrachrome pigmented inks applied by the Epson 9600 inkjet printer produced output with high light and water stability. For this project, printing on a paper with a modest, indistinct, non-regular texture on a 2–3 mm scale, with the *trompe l'oeil* effect in the photographed image, produced a very pleasing surrogate recreation.

Due to the effects of using ICC profiles in the printing process, certain saturated blues, reddish-oranges, greens, and yellows caused predictable color shifts. These shifts were corrected using colorimetric measurements of the original against the printed proofs. Despite the highly controlled color management process, it was essential that the final color match of the surrogate against the original be made under exhibition lighting conditions.

REFERENCE

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